UNECE

Developing Forest Information Systems

A Guide to Creating Effective Forest Information Systems

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ABSTRACT

The study provides an overview of forest information systems in the context of their application in forest policy and management. It outlines the Forest Information Systems (FIS) types and functions and analyses their application in the forest sector. It outlines how these technological advances can improve modern forest policy-making and natural resource management. It provides examples of FIS solutions and their implementation in selected countries. The study is complemented by a separate guide (ECE/TIM/SP/56), which details the needs, opportunities, and constraints for developing/improving forest information systems for the forest sector.

ECE/TIM/SP/61

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LIST OF ABBREVIATIONS

ASF	African swine fever
CoC	Certificate of Compliance
CSS	communication support system(s)
DFD	Data Flow Diagram
DGLP	General Directorate of State Forests (Poland)
DSS	decision support system(s)
FIS	forest information system(s)
FSC	Forest Stewardship Council
ICT	information and communications technology
ISS	information-sharing system(s)
IT	information technology
KRW	South Korean Won
NFI	national forest inventory
NFMS	National Forest Management System (Uzbekistan)
NGO	non-governmental organisation(s)
ODBC	Open Database Connectivity
RMS	resource management system(s)
SF	State Forests (Poland)
USD	United States Dollar
UZS	Uzbekistani Sum
WFS	Web Feature Service
WMS	Web Map Service
ZILP	State Forests IT Division

EXECUTIVE SUMMARY

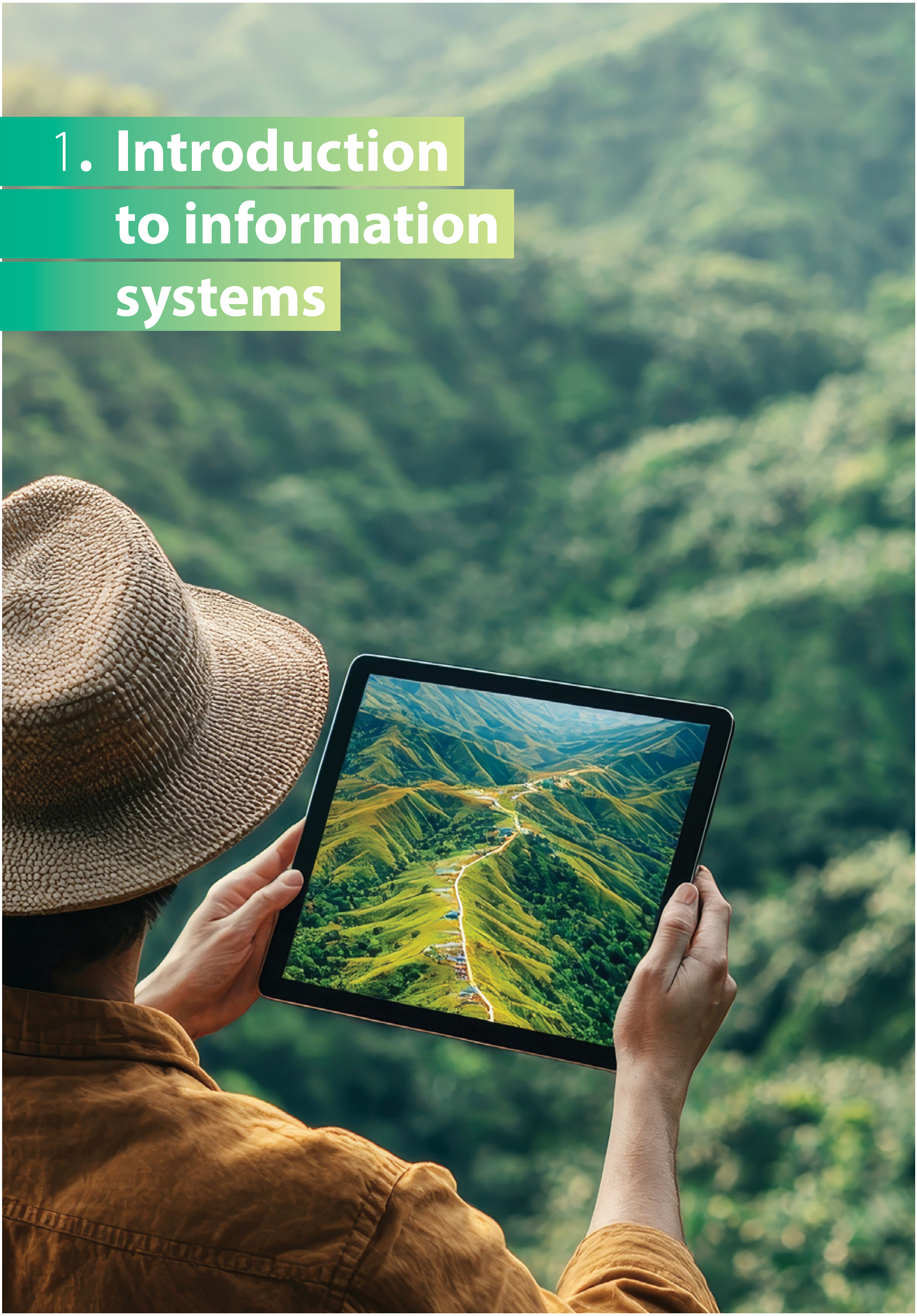
An effective forest policy requires appropriate decisions regarding the management and use of forest resources. Forest policy and management, however, are areas in which decision-making is considered as complex. Recent advances in information processing technologies, as well as an unprecedented ease of information exchange, provide new abilities for better management of forest ecosystems and the services they provide. Forest information systems (FIS) aim to facilitate this issue by providing tools to assist in gathering forest information, making them accessible for informed decisions, monitoring their results, and correcting existing policies. FIS can increase operational efficiencies, bring cost reductions, supply better information for decision-makers, and through this contribute to the improvement of forest ecosystem services and State governance. They can also be a strategic tool for economic development and a solution for increased transparency and participation expected by modern societies. This capacity-building guidance outlines how these technological advances can be used to improve modern forest policymaking and natural resources management.

The study provides an overview of forest information systems in the context of their application in forest policy and management. It presents the FIS types and functions and analyses their application in the forest sector. It outlines how these technological advances can improve modern forest policy-making and natural resource management. It provides examples of FIS solutions and their implementation in selected countries. The separate practical guide complements this study, which details the needs, opportunities, and constraints for developing/improving forest information systems for the forest sector.

MAIN POINTS

- **Good policy-making and best-practice management require tools for acquiring information, planning and the allocation of resources, decision-making, monitoring outcomes, as well as reporting and evaluation.**
- **Information systems are an indispensable part of modern environmental governance.**
- **Forest sector information systems should be aligned to forest management strategies, the institutional landscape, organizational and financial resources, and overall administration capacities.**
- **The development of FIS is a cutting-edge innovation. It significantly advances forest information management and brings numerous benefits to policymakers, managers, as well as all stakeholders and society overall.**

1. Introduction to information systems



1. Introduction to information systems

1.1 Data, information and knowledge

The term "information" is often confused and used interchangeably with "data". **Data** is a set of raw real-world *facts* describing physical objects or events, for example, the number of trees, timber volume, work hours, or sale value.

When facts are arranged in a meaningful manner, they become information. **Information** is a collection of organized facts. Hereby, the information has additional benefits beyond the value of the individual facts.

For example, data describing individual trees holds little practical value by itself. However, when it is enriched with relationships between individual trees (for instance in a single inventory sample plot), the informational value of the whole set increases and allows to draw conclusions on the whole forest in the plot. If individual plots are further linked together, the whole data set gets even more valuable, as it gains more information on the whole forest or even forest resources. Thereby, the user has the ability to convert data into information that enables efficient and informed decision-making[1].

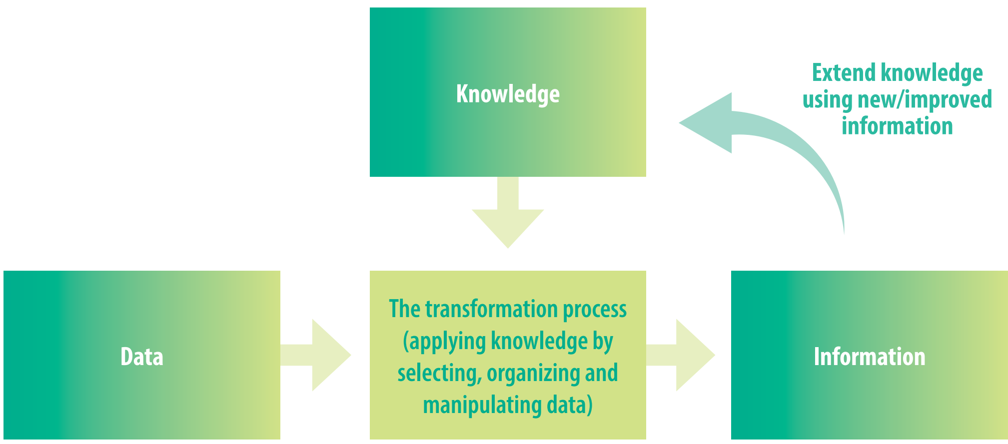
The process of defining relationships among data to create useful information requires **knowledge**, which is seen as the understanding of relationships between data items and how this information can be made useful for a particular task/objective (Figure 1).

1.2 information systems

The concept of an information system is often associated with computers and related technologies. While technology is currently an indispensable tool in information processing, information systems do not necessarily include computers.

Information systems are integrated sets of components that allow users to collect, process, store, organize, and distribute data for providing information, knowledge, and information products, as well as for providing a feedback mechanism to meet an objective. The feedback mechanism helps organizations achieve their goals, such as increasing profits, providing better customer service or improving public governance and accountability[2].

FIGURE 1
The process of transforming data into information



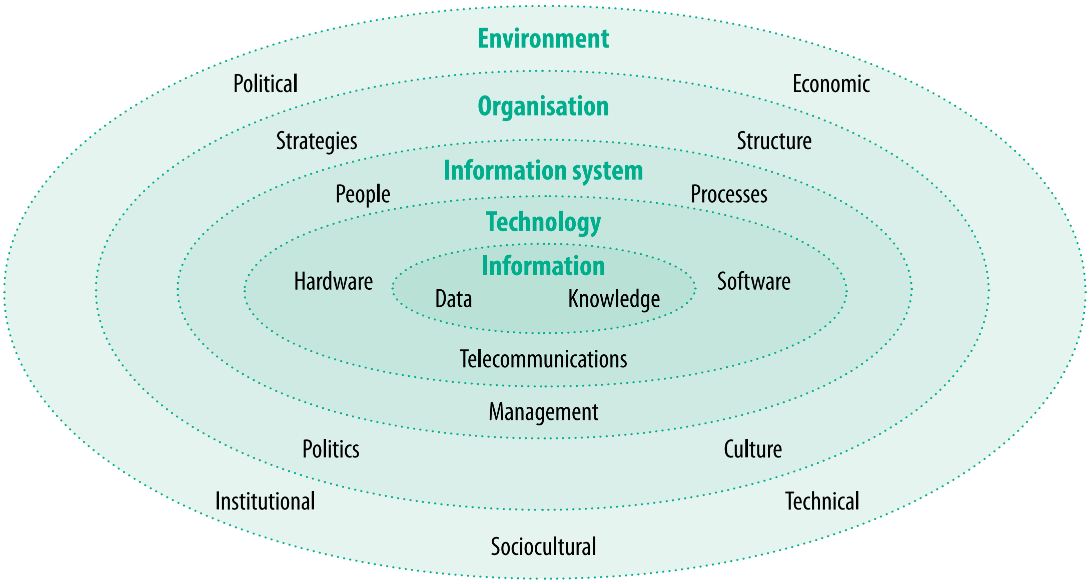
Source: after Stair and Reynolds, 2010, modified.

1 Vasant Dhar and Arun Sundararajan, Issues and Opinions—Information Technologies in Business: A Blueprint for Education and Research, Information Systems Research, vol 18, no. 2 (June 2007), pp. 125–41, https://doi.org/10.1287/isre.1070.0126.

2 Ralph M. Stair and George Walter Reynolds, Principles of Information Systems: A Managerial Approach, 9th ed. (Australia; United States, Course Technology Cengage Learning, 2010).

FIGURE 2

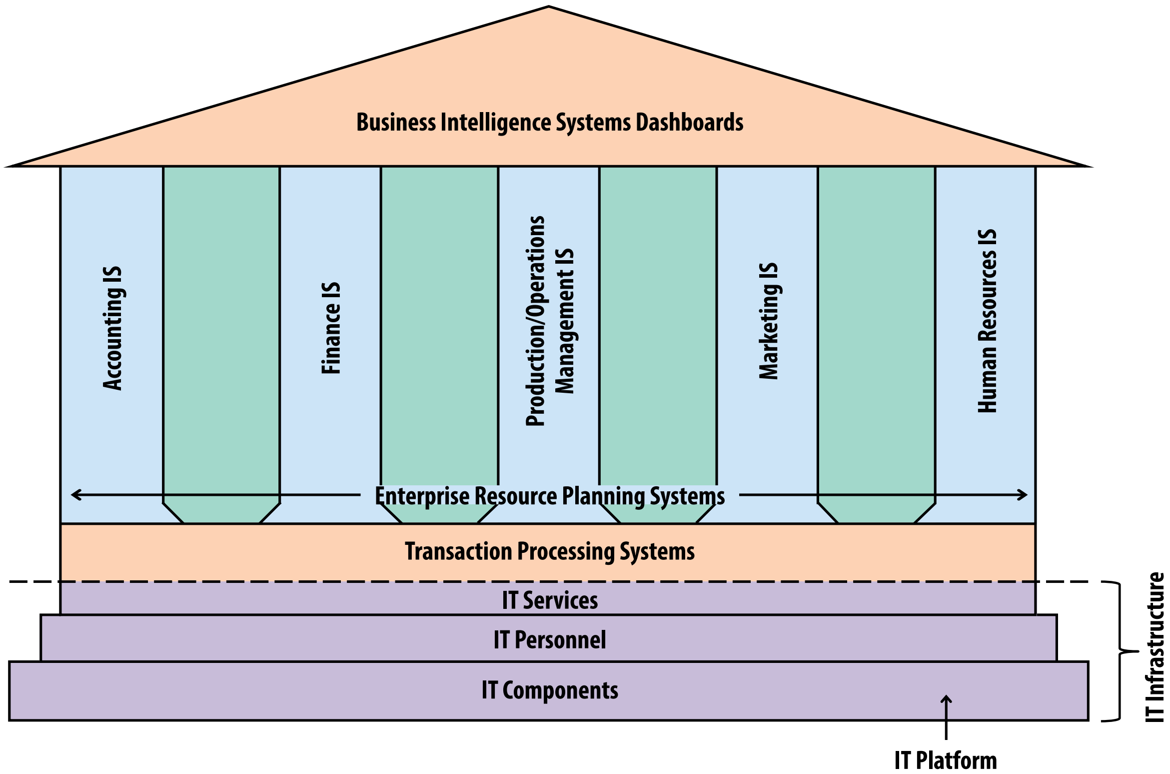
Information systems as social systems



Source: Heeks, 2007.

FIGURE 3

Information technology in an organization



Source: after Rainer and Prince, 2021.

Information systems can be seen as a type of social systems, embedded in a wider social and cultural context (Figure 2). In fact, they are often already existing systems of communication within the organization and/or society[3].

The main components of information systems are most often computer hardware and software, telecommunications, databases and data warehouses, human resources, and procedures[4]. The hardware, software, telecommunications, and database technologies form the **information technology platform of an information system**.

Information systems are a part of the information technology ecosystem in an organization. They are developed, managed, operated, and used by **Information technology (IT) personnel**. They provide **information technology services**. The IT systems, personnel and services constitute the organization's **information technology infrastructure** (Figure 3)[5].

1.3 Why do we need information systems?

1.3.1 Information systems such an important part of contemporary business and social life

An information system is a critical enabler of an organization's business processes. They facilitate communication and coordination among different functional areas and allow easy exchange of, and access to, data across processes, especially in (i) executing the process, (ii) capturing and storing process data, and (iii) monitoring process performance[6].

BOX 1
Societal needs for information

Non-Governmental Organizations (NGOs) require three particular types of information for their operation and activities:

- High-quality information about their work on the ground, which is crucial to ensure accountability, learn from experience, and develop and disseminate good practice.
- Information about wider contextual forces such as macro-economic policy, the national and local political climate, and the ongoing work of other organizational actors.
- Information about organizational inputs and outputs is essential for NGOs to make effective use of scarce human, financial, and material resources.

The value of information is assessed by decision-makers working towards achieving the organization's goals. Information systems are tools which help achieve goals set by organizations, decision-makers, politicians, voters etc.

Today we live in an information economy. IT is no longer solely the supplier of hardware and software. IT is just as relevant to service delivery as any other business function within an organization, like marketing and finance. Computer systems are widely used to create, store, process and convey information. Information itself has value, and trade often involves the exchange of information rather than material goods. Managers make decisions, plan, and execute complex and cost-effective production processes by using information systems. Digitalization will continue to transform businesses, public administration, and daily life[7].

Information collected and processed in information systems provides new capabilities for better resource and public service management and as a basis for better control mechanisms.

Different types of information might be needed by particular sectors and organisations (see box 1)[8].

3 Richard Heeks, Information Technology, Information Systems and Public Sector Accountability in Information Technology in Context: Studies from the Perspective of Developing Countries, Chrisanthi Avgerou, Geoff Walsham, eds. (Routledge, 2017).

4 Vladimir Zwass, Information System, Encyclopedia Brittanica, Available at https://www.britannica.com/topic/information-system.

5 R Kelly Rainer and Brad Prince, Introduction to Information Systems, 9th ed. (John Wiley & Sons, 2021).

6 Rainer and Prince.

7 Stair and Reynolds, Principles of Information Systems.

8 David Lewis and Shirin Madon, Information Systems and Nongovernmental Development Organizations: Advocacy, Organizational Learning, and Accountability, The Information Society, vol 20, no. 2 (April 2004), pp.117–26, https://doi.org/10.1080/01972240490423049.

1.3.2 Information systems in governance

A government can be seen as an information system wherein data is gathered, structured, stored, administered, analysed, and retrieved, with the final goal of informed decision-making.

Politics itself can be viewed as an exchange of information and opinions connecting all stakeholders in a dynamic system. It requires modelled processes based on existing information.

Information technologies help retrieve information, process it, and provide it to political institutions in an optimal way, leading to the effective administration of resources. The rise of the adoption of information technology in decision-making aligns with the growing demands for results-oriented management. This shift aims to enhance government efficiency by reducing administrative costs and improving service delivery[9].

Government officials must effectively handle information to minimize uncertainties and ambiguities related to objectives and cause-and-effect relationships in the decision-making process. This process extends beyond the technical aspects of decision-making and encompasses the political realm, where numerous stakeholders establish and assert their priorities. Moreover, the decision-making process transcends organizational boundaries and government levels, encompassing citizens, interest groups, the media, and elected officials. This underscores the idea that the utilization of information technology in government decision-making processes will be substantially influenced by the external environment surrounding the organization[10].

1.3.3 Information systems in business

Information systems in business are used to gain a competitive advantage in the market. They are employed for the three fundamental purposes[11]:

- Facilitation of business processes and operations.
- Assistance in decision-making for employees and managers.
- Support in devising strategies for attaining a competitive advantage.

Information systems are used in all functional areas of business, from sales and marketing, through manufacturing, management of human resources (HR), and product design, to accounting, finance, legal support, and governance.

9 Sharon L. Caudle, Wilpen L. Gorr, and Kathryn E. Newcomer, Key Information Systems Management Issues for the Public Sector, MIS Quarterly, vol. 15, no. 2 (June 1991), p.171, https://doi.org/10.2307/249378.

10 Seunghwan Myeong and Younghoon Choi, Effects of Information Technology on Policy Decision-Making Processes: Some Evidences Beyond Rhetoric, Administration & Society, vol. 42, no. 4 (July 2010), pp.441–59, https://doi.org/10.1177/0095399710362724.

11 James A. O'Brien and George M. Marakas, Management Information Systems, 10th ed. (New York, McGraw-Hill, Irwin, 2011).

1.4 Types of information systems

Information systems used in business and public administration can be classified into the following four types[12]:

- **Decision Support Systems (DSS)** – computer programs intended to find and execute efficient decisions. DSS process information to provide decision-makers with options, and information necessary for well-informed decisions. They include data visualisation tools, computer-assisted models and integrated solutions to present decision alternatives and possible decision outcomes.
- **Resource Management Systems (RMS)** – utility programs for resource accounting and distribution. These are commonly used in business, but political institutions use them to control resources on a continuous basis. Examples include human resources, private investment in public projects, and advanced budgeting and reporting.
- **Information-Sharing Systems (ISS)** – programs to arrange the internal structural operations of political institutions and encourage information exchange within and between public authorities, economic, research and engineering corporations, forest management bodies, private corporations, and other organizations. An ISS platform may contain variable databases with strategically useful information. Specialized ISS programs can therefore structure political administration more effectively, moving it from individual to system-based actions.
- **Communication Support Systems (CSS)** – specialized software for online use, and web resources providing interactive political processes to increase social engagement, thereby evolving a "network society". CSS are used to publicize strategic information, monitor political information, and make the law-development process transparent, thereby adding legitimacy.

This classification is used as a framework for further analysis in this document.

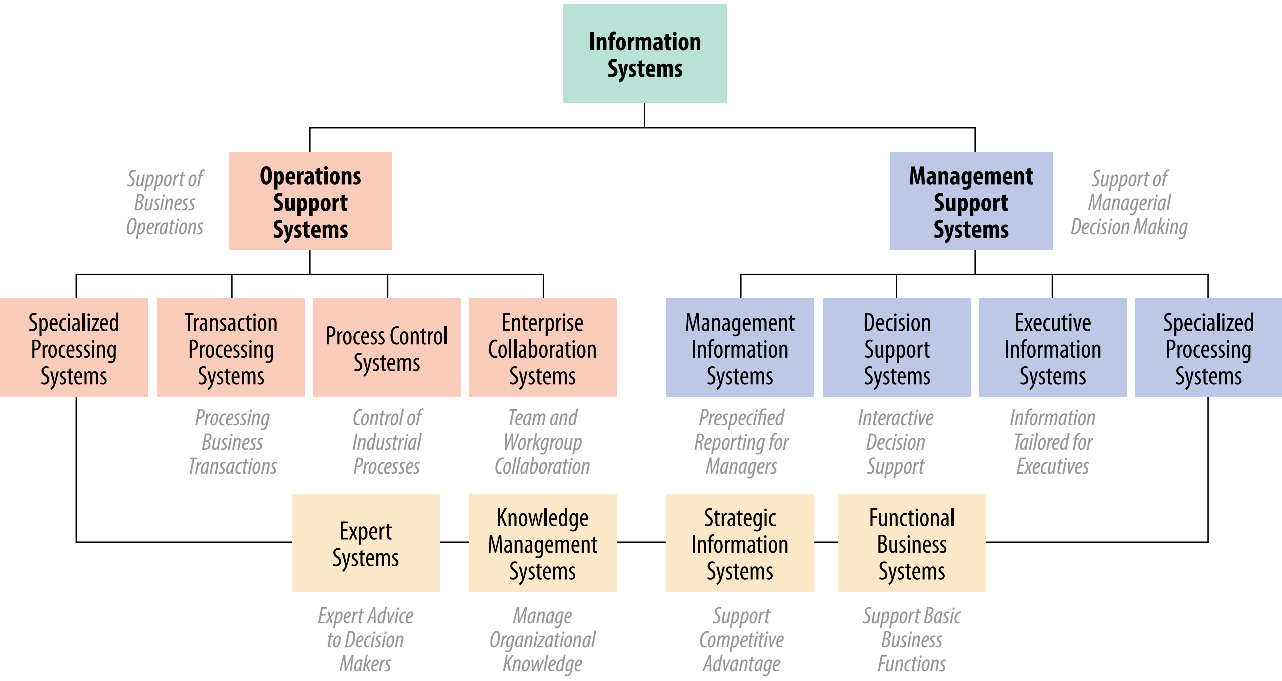
Other information system classifications have been developed for different needs. They vary in their complexity and concentrate on different aspects of information system usage. For example, O'Brien & Marakas[13] provide a scheme of the categorization of information systems into operations and management, underscoring their primary functions in aiding business operations and facilitating managerial decision-making (Figure 4).

12 A. V. Aleinikov, D. A. Mal'tseva, and V. P. Miletskii, Information and Information Technologies as Applied in Political Strategy Modeling, Scientific and Technical Information Processing, vol. 43, no. 2 (August 2016), pp.106–14, https://doi.org/10.3103/S0147688216020076.

13 O'Brien and Marakas, Management Information Systems.

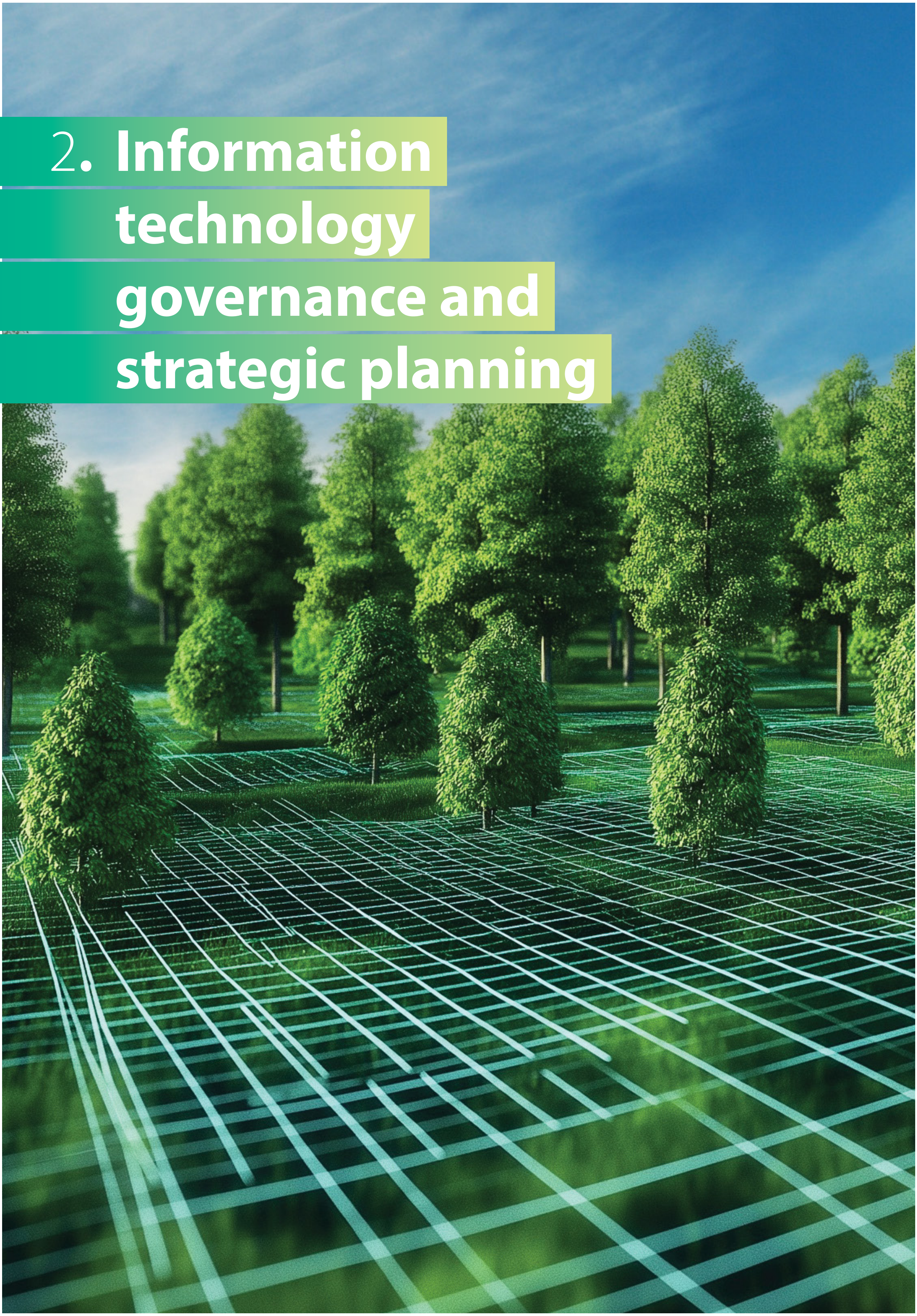
FIGURE 4

Operations and management classification of information systems



Source: O'Brien and Marakas 2011.

2. Information technology governance and strategic planning



2. Information technology governance and strategic planning

2.1 Information technology governance

Information technology governance is defined as an organizational skill, crucial to the strategic alignment and delivery of value through information technology. Implementing IT governance, however, usually poses a challenge to organizations. The main issues to be addressed are:

- The need for interaction and mutual understanding between IT and business areas to ensure strategic alignment.
- Influence of a wide range of contingencies.
- The need to construct a continuous, adaptive and interactive process for IT governance[14].

An additional factor is usually the heterogeneity of the environment and the influence of a strong human factor.

IT governance has several components which cover various aspects of this problem[15] (see Figure 5).

Good IT governance is important to develop: (i) trust and transparency among stakeholders, (ii) a better way to deliver results through IT projects and, (iii) desirable behaviour in using IT in alignment with higher-level priorities and strategies.

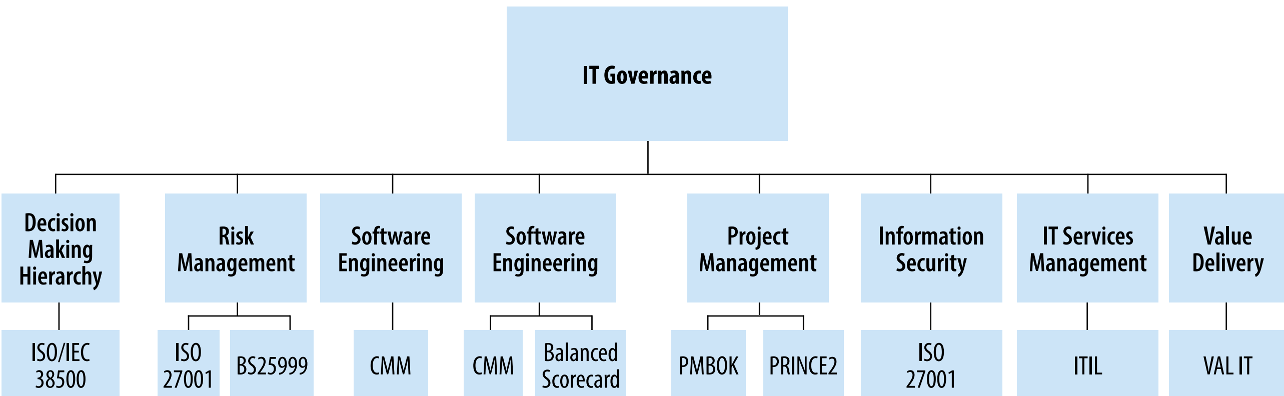
2.2 Strategic planning of digital transformation

Strategic planning is the process of defining a strategy, as well as deciding on the allocation of resources to achieve particular goals[16].

Policymaking in technology-related fields includes measures to enable or accelerate technology transfer and diffusion. Cantner and Pyka[17] introduced the concepts of mission- and diffusion-oriented policy designs. Mission-oriented systems

FIGURE 5

IT governance components



Source: after Alreemy *et al.*, 2016, modified.

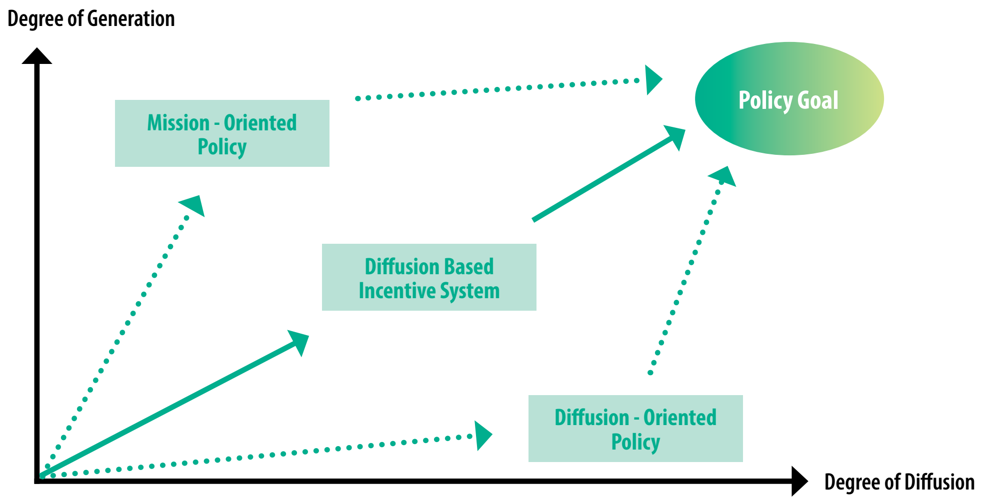
14 Henrique de Souza Bermejo Paulo *et al.*, Implementation of Information Technology (IT) Governance through IT Strategic Planning, African Journal of Business Management, vol. 6, no. 45 (14 November 2012), pp.11179–89, https://doi.org/10.5897/AJBM11.2097.

15 Zyad Alreemy *et al.*, Critical Success Factors (CSFs) for Information Technology Governance (ITG), International Journal of Information Management, vol. 36, no. 6 (December 2016), pp.907–16, https://doi.org/10.1016/j.ijinfomgt.2016.05.017.

16 Khadige Hassanlou *et al.*, Information Technology Policy Trends in the World, Technology in Society, vol. 31, no. 2 (May 2009), pp.125–32, https://doi.org/10.1016/j.techsoc.2009.03.005.

17 Uwe Cantner and Andreas Pyka, Classifying Technology Policy from an Evolutionary Perspective, Research Policy, vol. 30, no. 5 (May 2001), pp.759–75, https://doi.org/10.1016/S0048-7333(00)00104-9.

FIGURE 6
Policy designs



Source: after Hahn and Yu, 1999, modified.

are characterized by a top-down approach, focusing on a small number of technologies and points of intervention which are expected to bring desired results. On the other hand, diffusion-oriented systems present a bottom-up approach as they seek to increase modernization capacity by focusing on infrastructure, technology transfer and cooperation, and the formal and informal relationships between different actors.

Hahn and Yu[18] proposed the diffusion-based incentive system, under which two policy objectives of generation and diffusion are integrated and synchronized (see Figure 6).

Information technology strategies executed by the government or other public agencies are usually an example of the mission-oriented approach, as they have their roots in considerations of public policies, political priorities, national sovereignty, and international competitiveness. However, it is important to remember that diffusion-oriented policies, such as developing a general-use technical infrastructure, IT solutions, data dissemination, and communication means, may bring effects desired by public policies, by enabling different actors, creating new communication networks, and novel synergies.

2.3 The problem of accountability

Information technology in general facilitates the transmission of information from the source decision-maker to the recipient. However, it cannot by itself create accountability, rather it can sometimes undermine it if misused. To create accountability in addition to IT-based systems, wider components must be simultaneously introduced: people, management, and processes.

When an information system is introduced as a result of external pressure (e.g. donors demand), it can weaken existing internal information systems and information flows. External reporting of information in public institutions tends to consume a large amount of internal resources, yet it also tends to undermine internal information systems and internal management processes[19]. There are frequent pressures to falsify externally-reported information. Some organisations can even be driven to maintain two separate information systems: one for external consumption and the real figures for internal use. There are cases when the introduction of new information systems (especially IT-based) and the overflow of carefully crafted information items, press releases, regulations etc. helps divert attention from the fact that they do not provide information that allows decision makers to be held accountable[20].

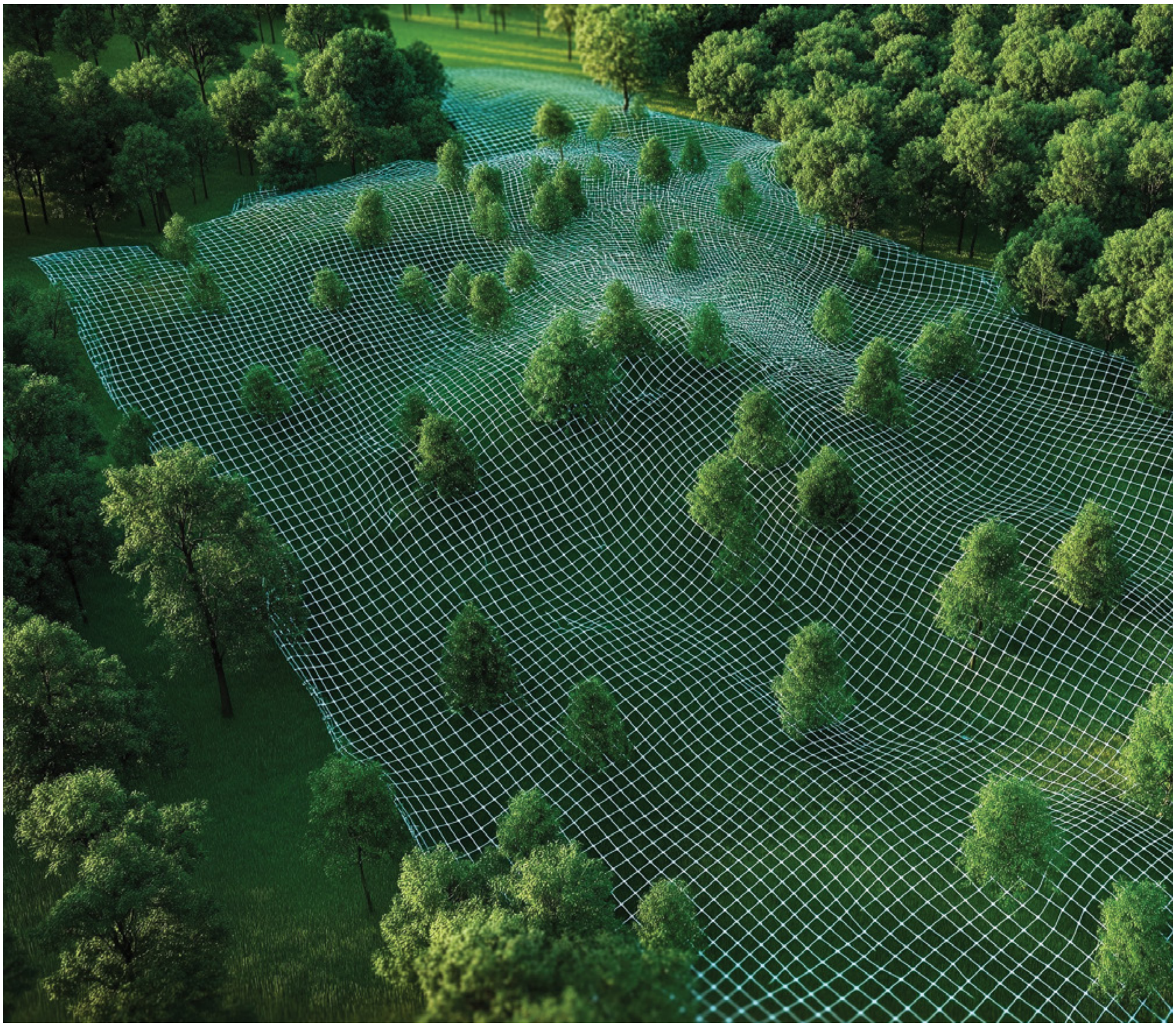
18 Yoon-Hwan Hahn and Pyung-Il Yu, Towards a New Technology Policy: The Integration of Generation and Diffusion, Technovation, vol. 19, no. 3 (January 1999), pp.177–86, https://doi.org/10.1016/S0166-4972(98)00096-0.

19 Henry C. Lucas and Margrethe Olson, The Impact of Information Technology on Organizational Flexibility, Journal of Organizational Computing, vol. 4, no. 2 (January 1994), pp.155–76, https://doi.org/10.1080/10919399409540221.

20 Heeks, Information Technology, Information Systems and Public Sector Accountability.

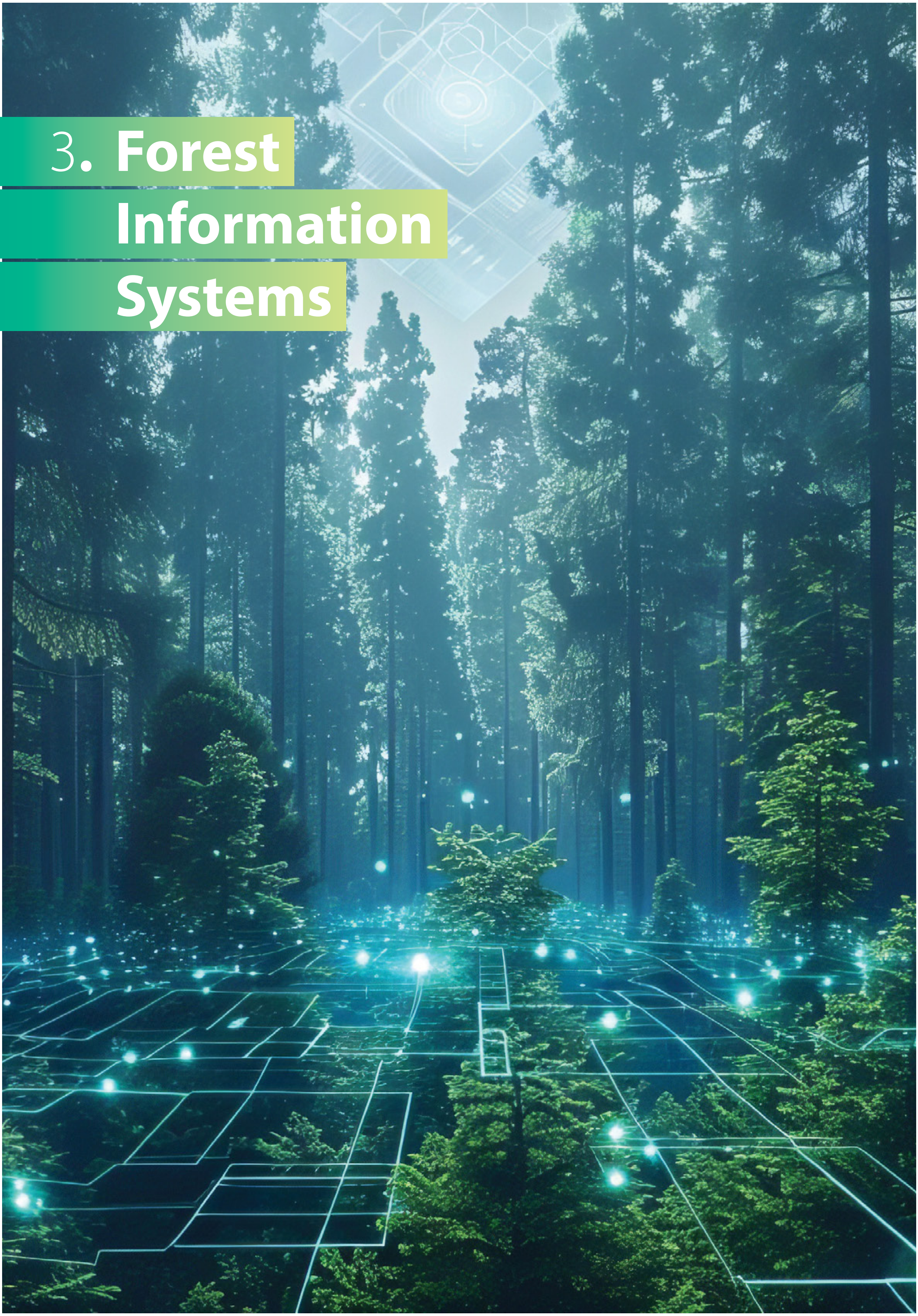
Faulty decisions made by using a management support system could derive from:

- Poor performance of the system (poor analysis, specification, or design).
- Implementation problems (e.g. Software bugs or inadequate training).
- Faulty hardware.
- Operational problems (e.g. Mistakes made by operators, virus infections).
- Usage problems (such as human error during the use of the system output)[21].



21 Heeks.

3. Forest Information Systems



3. Forest Information Systems

3.1 Information: a key driver of forest policy

Forest policy is a complex and multi-disciplinary subject. An effective forest policy needs informed decisions about the maintenance, protection, and use of forest resources.

Evolving forest policy is a complex process, guided by the principles of sustainable development. It is influenced by forest economics, ownership, management planning and law, climate change, bioenergy, afforestation, biodiversity, rural ecosystem services, land use policy, and infrastructure. Forest policy is strongly interconnected with other sectors and has been under many levels of public scrutiny, particularly in recent years.

Forest information systems help forest policymaking by gathering forest information to support informed choices, monitoring results, and refining policies.

The need of creating forest and land-use information systems is increasing owing to the mounting pressures on forests from activities such as forestry, agriculture, and mining. Additionally, there is an increased focus on monitoring greenhouse gas emissions, implementing climate and biodiversity related strategies, and assessing the progress of these policies.

The successful establishment of a forest information system isn't the ultimate objective. Instead, it serves as a method to attain broader goals, including the ability to monitor various forest-related policies, and to make well-informed and rational policy choices.[22]

Government officials and policymakers should handle information effectively to diminish uncertainty and ambiguity regarding goals and cause-and-effect relationships during the decision-making process. This task also involves the political process, where various stakeholders establish and advocate for their priorities. Moreover, the decision-making process crosses organizational boundaries and spans different levels of government, involving citizens, interest groups, the media, and elected officials[23].

Changes to policy have many high-stakes implications, they can be expensive, have lasting consequences, impact large groups of citizens or even the entire country, and often are not easily reversible. Moreover, the increasing complexity and uncertainty of decision landscapes become an additional challenge.

This shift is driven by advancements like open data, computational techniques for data analysis, sentiment analysis, simulation, and the visualization of large data sets. These developments are complemented by public involvement, social media, and collaborative tools[24].

The most frequent applications of modern information tools in decision-making are:

- Collecting and processing large amounts of data to generate evidence for proper decision-making. This includes data-based modelling to capture complex phenomena, deal with uncertainty and present alternatives.
- Visualising data and possible alternatives to facilitate involvement of non-experts and give them insights into the possible impacts of decisions.
- Enabling and encouraging the engagement of citizens through building communication platforms for collecting views and opinions on decision alternatives, thus reducing uncertainty and gaining additional insights into complex issues, as well as mitigating conflicts.
- Monitoring and assessing the results of enacted policies to ensure the policies are actually executed, examining their results, evaluating their effectiveness and identifying possible areas for improvement.

These are used in all phases of the policy-making cycle (see Figure 7).

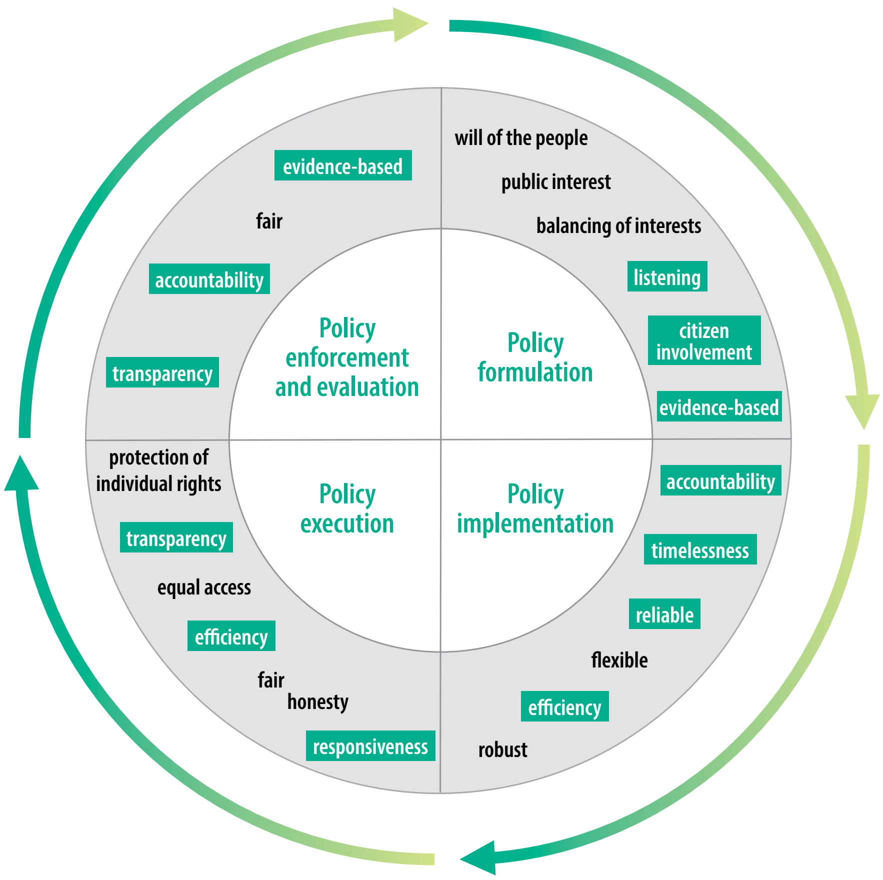
22 Loretta Cheung *et al*., Building National Forest and Land-Use Information Systems: Lessons from Cameroon, Indonesia, and Peru (World Resources Institute, 2014), Available at https://www.wri-indonesia.org/sites/default/files/building_national_forest_and_land-use_information_systems.pdf.

23 Myeong and Choi, Effects of Information Technology on Policy Decision-Making Processes.

24 Marijn Janssen and Maria A. Wimmer, Introduction to Policy-Making in the Digital Age, in Policy Practice and Digital Science, vol. 10, Public Administration and Information Technology, Marijn Janssen, Maria A. Wimmer, and Ameneh Deljoo, eds. (Cham: Springer International Publishing, 2015), pp.1–14, https://doi.org/10.1007/978-3-319-12784-2_1.

FIGURE 7

Policy cycle and values linked to each phase (values that can be supported by information systems have been marked)



Source: after Janssen and Wimmer, 2015, modified.

3.2 The main functions of Forest Information Systems

The typical forestry administration is divided into two or three levels, where the national agency is a government body which houses the supervising functions and some special departments, e.g. the planning and information and communication technologies (ICT) departments, a forest monitoring centre, etc. The regional level administration (if established) is composed of several offices with functions for management (delegated from national level) and support to the district offices. The district offices are spread over the forested areas of the country and house the staff that work in the field with supervision, protection, practical forest management, and related tasks.

Information systems can support tasks at all levels, from the collection of field data in the districts to the compilation of reports and all kinds of analysis at the national level and facilitate consistency and coordination among them.

The overall generalized objectives for information systems could be formulated as follows[25]:

- Timely access to consistent, accurate data.
- Sharing of data for collaborative decision-making.
- Improved communications across departments and levels.
- Reduced duplication of tasks and efforts.
- Fast, efficient service to both governmental offices and the public.

Table 1 shows a tentative classification of forest information systems based on their application areas and target users.

25 Anders Wellving, A Review of Forest Information Systems, MAR Working Paper (FAO, 9 February 2010).

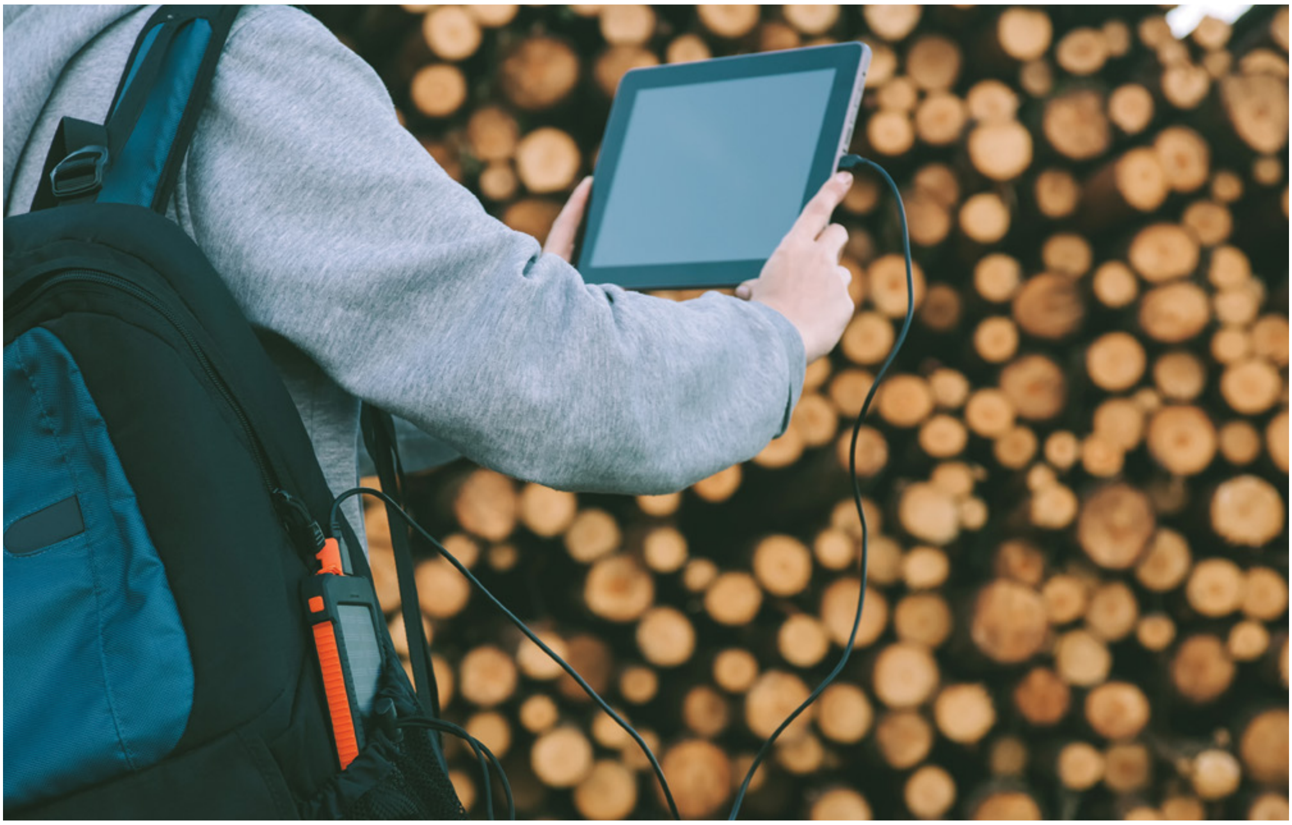


TABLE 1 Typical application areas of forest information systems

Application area	User group
Statistical and advanced analysis	Specialists at analytical units in the central administration
Field inventory	Specialists at various levels
Remote sensing and mapping	Specialists at various levels (analytical/monitoring units in the central administration, other national agencies, forest management specialists on local levels)
Reporting on forest condition	Officers at all levels
Other monitoring, e.g. fires, crimes, etc.	Officers at all levels
Forest management	Officers responsible for forest management, private forest owners
Watershed management	Specialists in the central administration, in other national agencies, on local levels
Transport planning	Specialists on local levels
Timber market analysis	Specialists in the central administration
Public information on forests and the forestry sector	NGOs, commercial entities, public administration, general public

Source: after Wellving, 2010, modified.

An information system is generally considered as a tool. It is designed to help a user perform certain recurrent tasks, keep track of various activities, events, and parameters, collect data about them, store the data, process it, edit, search for and select relevant information and report it, and exchange the data with other departments, institutions and systems.

Using the information system typology introduced earlier, we may now analyse how different types of information systems (IS) are used in the forest sector (see Table 2).

TABLE 2 Information system types and their applications in the forest sector

Information system type	Applications in the forest sector	Examples
Decision support systems (DSS)	DSS are used for different levels of forest management and policymaking and can include information-visualisation tools for policymakers and forest professionals, growth models, systems supporting forest management planning, and forest disturbance models.	**Open Foris** (FAO)[26]: a set of free and open-source software tools that facilitates flexible and efficient data collection, analysis, and reporting. **SEPAL** (FAO)[27]: a system for earth observation, data access, processing, and analysis for land monitoring. **Forest Fires Remote Monitoring Information System (ИСДМ-Рослесхоз)**[28]: a system developed by the Federal Forestry Agency of the Russian Federation designed to monitor and track forest fires, ensuring the accuracy, and reliability of fire-related data. The system provides tools for detecting forest fires, assessing their scale, and forecasting fire risks based on current weather conditions. This capability enables timely responses and effective fire management across the Russian Federation's vast forested areas. **Sat-Monitor** (Taxus IT)[29]: a system for forest managers for data processing, storing and sharing, to provide information on the current state of the forest and predictions of potential threats based on the collected data.
Resource management systems (RMS)	In forestry, RMS help the operation of forest administration agencies, forest management enterprises, and forest operations enterprises.	**Unified State Automated Information System of Timber Accounting and Transactions (LesEGAIS)** (Единая государственная автоматизированная информационная система учёта древесины и сделок с ней (ЛесЕГАИС))[30]: the system is to ensure control over the turnover of timber and lumber, to combat illegal timber transactions, and to maintain accurate records of timber and timber-related activities in the Russian Federation. **Federal State Forestry Information System (FGIS FC)** (Федеральная государственная информационная система лесного комплекса (ФГИС ЛК))[31]: a unified platform to provide information and analytical support for forest-related activities. **Forest Information System of State Forests** (System Informatyczny Lasów Państwowych)[32]: a comprehensive IT system for management support in the State Forest Holding "State Forests" in Poland. **LasInfo** (Taxus IT)[33]: integrated management system for forest holdings.

26 Food and Agriculture Organization of the United Nations, Open Foris, n.d., Available at https://openforis.org/.

27 Food and Agriculture Organization of the United Nations, SEPAL, n.d., Available at https://sepal.io/.

28 Информационная Система Дистанционного Мониторинга Федерального Агентства Лесного Хозяйства. Блок Мониторинга Пожарной Опасности [Information System of Remote Monitoring of the Federal Forestry Agency. Fire Danger Monitoring Unit], ИСДМ-Рослесхоз, Available at: https://lesegais.ru/.

29 Taxus IT, Sat-Monitor, n.d., Available at https://www.taxusit.com.pl/sat-monitor.

30 ЛесЕГАИС [LesEGAIS], Available at: https://pub.fgislk.gov.ru/.

31 Федеральная Государственная Информационная Система Лесного Комплекса (ФГИС ЛК) [Federal State Forestry Information System (FGIS FC)], Available at: https://pub.fgislk.gov.ru/.

32 Wikipedia authors, System Informatyczny Lasów Państwowych, Wikipedia, n.d., Available at https://pl.wikipedia.org/wiki/System_Informatyczny_Las%C3%B3w_Pa%C5%84stwowych.

33 Taxus IT, LasInfo | Integrated Information System for National Parks, Nature Conservation and Forest Management, Rosewood 4.0 Forest Innovation Hub, n.d., Available at https://www.forestinnovationhubs.rosewood-network.eu/en/content/system-national-parks-supports-management-forest-land-and-protection-plan-execution.

Information system type	Applications in the forest sector	Examples
Information-sharing systems (ISS)	Information sharing about forests can range from a centralized data-sharing hub – a "forest data bank"– through data repositories divided thematically or geographically, to highly distributed systems with strong consistency and interoperability.	**Federal State Forestry Information System (FGIS FC)** (Федеральная государственная информационная система лесного комплекса (ФГИС ЛК))[34]: a unified platform to provide information and analytical support for forest-related activities. Unified portal of public services (**Единый портал госуслуг**)[35]: a number of forestry-related services are provided via this system. It is a portal providing access for individuals and legal entities to information on state and municipal services in the Russian Federation. **Bank Danych o Lasach** (State Forests Holding Poland)[36]: a web portal to provide information on forest management, forest condition, and its changes regardless of the ownership form. **Österreichische Waldinventur** (BFW)[37]: a website to access results of Austria's National Forest Inventory. **National Forestry Database** (Canadian Council of Forest Ministers)[38]: a website presenting results of Canada's National Forest Inventory. **Bundeswaldinventur** (Bundesanstalt für Landwirtschaft und Ernährung, Germany)[39]: a web portal to publish results of Germany's National Forest Inventory. **Inventaire Forestier** (IGN)[40]: a web portal to publish information from France's National Forest Inventory. **Inventarul forestier național** (IFN)[41]: a web portal to publish results of Romania's National Forest Inventory. **The Swedish National Forest Inventory** (SLU)[42]: a web portal with the results of the Swedish National Forest Inventory. **Bundesamt für Umwelt BAFU: Thema Forstwirtschaft** (BAFU)[43]: a part of the BAFU web portal devoted to the Swiss forestry statistics. **The National Forest Inventory** (Forest Research)[44]: a website with tools, methodology, and results of the National Forest Inventory in the United Kingdom. **Forest and Land-Use Atlas of Georgia** (MEPA)[45]: a web portal that provides access to transparent and precise data on Georgia's forest and land use, also ensures active use of the information and supports planning, implementation, and monitoring of activities in the forestry and land use sectors.

34 Федеральная Государственная Информационная Система Лесного Комплекса (ФГИС ЛК) [Federal State Forestry Information System (FGIS FC)].

35 Единый портал госуслуг (Unified portal of public services), Available at: https://www.gosuslugi.ru/.

36 BULiGL, Bank Danych o Lasach, n.d., Available at https://www.bdl.lasy.gov.pl/.

37 BFW, Österreichische Waldinventur, n.d., Available at https://www.waldinventur.at/.

38 Canadian Council of Forest Ministers, Welcome to Canada's National Forestry Database, National Forestry Database, n.d., Available at http://nfdp.ccfm.org/en/index.php.

39 Bundesanstalt für Landwirtschaft und Ernährung, Bundeswaldinventur, n.d., Available at https://www.bundeswaldinventur.de/.

40 IGN, Inventaire Forestier, n.d., Available at https://inventaire-forestier.ign.fr/.

41 IFN, Inventarul Forestier Național, n.d., Available at https://roifn.ro/.

42 SLU, The Swedish National Forest Inventory, n.d., Available at https://www.slu.se/nfi.

43 BAFU, Bundesamt für Umwelt BAFU, n.d., Available at https://www.bfs.admin.ch/bfs/de/home/statistiken/land-forstwirtschaft/forstwirtschaft.html.

44 Forest Research, The National Forest Inventory, Forest Research, n.d., Available at https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/.

45 MEPA, Forest and Land-Use Atlas of Georgia, n.d., Available at https://atlas.mepa.gov.ge/?l=en.

Information system type	Applications in the forest sector	Examples
Communication support systems (CSS)	CSS enable individuals and citizen groups to be involved in different levels of forest-related matters and to know the latest trends. They create transparent public communication from the forest sector. They are also used by lobbying groups to shape public attitudes and discourse, sometimes presenting skewed narratives.	**Bank Danych o Lasach** (State Forests Holding Poland)[46]: a web portal to provide information on forest management, forest condition, and its changes regardless of the ownership form. **INForest** (UNECE)[47]: data and knowledge platform for forests in the UNECE region. **Fakta o lese** (UHUL)[48]: a website presenting concise and visually appealing information on Czech forests. **Forestry in Ireland** (Department of Agriculture, Food and the Marine, Ireland)[49]: an information portal on forestry in the Republic of Ireland. **Valstybinė Miškų Tarnyba** (Lithuania's State Forest Service)[50]: a public communication portal of the government agency responsible for managing public forests in Lithuania. **Türkiye Orman Varlığı** (Orman Genel Müdürlüğü)[51]: the website of the General Directorate of Forestry with information on Turkish forests. **Florestas** (Instituto da Conservação da Natureza e das Florestas)[52]: a web portal with information on Portuguese forests. **Bundesamt für Umwelt BAFU: Thema Wald und Holz** (BAFU)[53]: a part of the BAFU web portal devoted to forests and timber. **Zanim wytną twój las** (Fundacja Lasy i Obywatele)[54]: a portal created by NGO activists lobbying against timber harvesting and running black PR operations against the State Forests Holding in Poland.

46 BULiGL, Bank Danych o Lasach.

47 UNECE, INForest, n.d., Available at https://forest-data.unece.org/.

48 The Forest Management Institute Brandýs nad Labem, Fakta o Lese, n.d., Available at https://info.uhul.cz/.

49 Department of Agriculture, Food and the Marine, Forestry in Ireland, n.d., Available at https://www.gov.ie/en/campaigns/a9d3c-forestry-in-ireland/.

50 Lithuania's State Forest Service, Valstybinė Miškų Tarnyba, n.d., Available at https://amvmt.lrv.lt/lt/.

51 Orman Genel Müdürlüğü, Türkiye Orman Varlığı, n.d., Available at https://www.ogm.gov.tr/tr/ormanlarimiz.

52 Instituto da Conservação da Natureza e das Florestas, Florestas, n.d., Available at https://www.icnf.pt/florestas.

53 BAFU, Bundesamt Für Umwelt BAFU: Thema Wald Und Holz, n.d., Available at https://www.bafu.admin.ch/bafu/de/home/themen/wald.html.

54 Maria Jagusztyn, Grzegorz Jakacki, and Fundacja Lasy i Obywatele, Zanim wytną twój las, Lasy i Obywatele, Available at https://mapy.lasyiobywatele.pl/zanim-wytna-twoj-las.html.

In some situations, several solution types can be implemented in one system. For example, in Poland there are two big example ICT solutions supporting the forest sector (see Box 2).

BOX 2
Distribute functions efficiently

1. **Information System of State Forests Holding** (SFH) performs the roles of (i) RMS for all SGH operations, including workforce management, external services, silvicultural activities, fellings, timber trade and tax calculations, and national reporting; (ii) DSS for short-term management; (iii) ISS for communication within the holding, producing official documents, and report for government agencies and national statistical reporting.
2. **Forest Data Bank** – a national information processing system gathering information on all forests in the country from various sources which serves as: (i) ISS – providing source data to various organizations and government agencies, and (ii) CSS – running a forest information web portal available to the general public, providing data feeds regarding forests compatible with the EU INSPIRE directive to other public and private entities, disseminating National forest inventory (NFI) results and various reports on forest condition and resources in Poland.

3.3 Components of FIS infrastructure

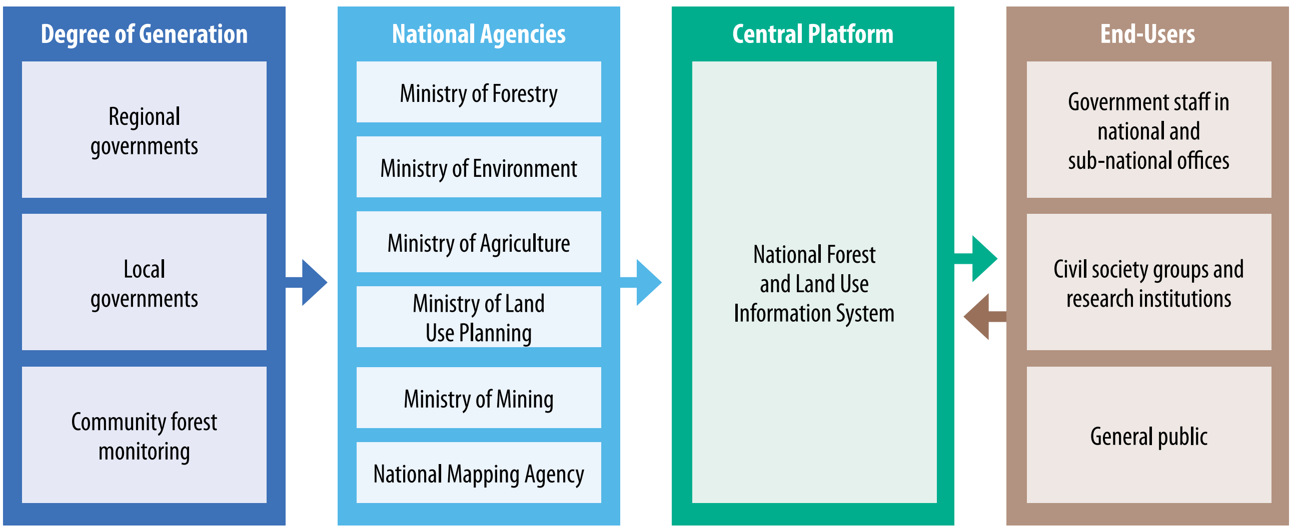
Due to different natural conditions, socio-economic circumstances, political practice, and other factors, forest policy and management frameworks are largely country specific. Therefore, information systems that support them should be aligned with a forest management strategy arising from existing forest policy, current institutional landscape, organizational capabilities, overall administration capacities, and societal needs[55].

Organisational functions of the forest sector are usually similar, although they may be executed on various administrative/management levels in different countries. Certain common elements in those frameworks have been shown to assist in carrying out effective forest policy and management processes.

Considering the level of centralization, two different structural approaches to the building of the FIS can be identified:

1. **One central information system**, collecting all key data on the forestry sector and forest management, which is fed and used by all stakeholders (see Figure 8).
2. **Multiple information systems**, devoted to processes of the forest sector and the needs of individual stakeholders; when needed these systems are interconnected by network links and/or data exchange protocols or procedures (see Figure 9).

FIGURE 8
Sample data flow in the case of a centralized forest information system



Source: adapted from Cheung *et al.* 2014.

55 Chrisanthi Avgerou, Information Systems in Developing Countries: A Critical Research Review, Journal of Information Technology, vol. 23, no. 3 (September 2008), pp.133–46, https://doi.org/10.1057/palgrave.jit.2000136.

In a centralized national FIS, many functions are realized by dedicated modules or subsystems, with varying degrees of integration. These systems are typical to the countries where the forest sector is small, with predominantly public forest ownership. Building a single FIS can indeed be rational from both organizational and cost-effective perspectives.

Typical advantages of a centralized FIS are as follows:

1. **Simplicity and manageability:**

   Managing and maintaining a single FIS is generally simpler than dealing with multiple systems. It reduces the complexity of the system and makes it easier to understand and update.

2. **Cost-efficiency:**

   Developing and maintaining a single FIS can be more cost-effective than managing multiple systems. It reduces development and maintenance costs, as there is only one system to design, implement, and update.

3. **Resource utilization:**

   Allocating resources, both human and computational, to a single FIS can be more efficient. This ensures that the available resources are focused on enhancing the performance and capabilities of a single system rather than being spread thin across multiple systems.

4. **Consistency:**

   A single FIS promotes consistency in decision-making and behaviour. This can be important in applications where uniformity and predictability are desired.

5. **Easier integration:**

   Integrating a single FIS into other, existing systems or processes is generally easier than integrating multiple systems. It streamlines the integration process and reduces compatibility issues.

6. **Training and expertise:**

   Training personnel and acquiring expertise in a single FIS is more straightforward. This can lead to a more knowledgeable and skilled team, facilitating better system performance and troubleshooting.

7. **Scalability:**

   A single FIS can often be designed to scale more easily. If the need arises to expand or modify the system, it can be done in a more controlled and organized manner.

It is essential, however, to consider the characteristics of the forest sector, ownership structure, diversity of stakeholders, and specific requirements in each country. In many cases, particularly in countries with large forest sectors, multiple independent actors, and prevailing private forest ownership, having multiple forest information systems might be necessary or advantageous, fostering efficiency, transparency, and improved service delivery. The key advantages are outlined below:

1. **Separation of responsibilities and control:**

   It is often necessary to have separate information systems for individual forest sector actors to have the necessary control over the data and functions. This is tightly coupled with the actors' accountability to shareholders (in the case of private entities) or society (in the case of public entities).

2. **Diverse functionality:**

   Multiple information systems allow for the implementation of specialized solutions tailored to specific functions. This diversity enables government agencies or private companies to address a wide range of tasks and services and their own unique requirements.

3. **Enhanced efficiency:**

   Different information systems can streamline various processes. For example, systems dedicated to finance, human resources, and logistics can optimize workflow, reduce paperwork, and increase overall operational efficiency.

4. **Specialization and expertise:**

   Specialized systems enable agencies and enterprises to focus on their core functions with greater expertise. This can lead to an improvement in service quality and responsiveness to the unique needs of different stakeholders.

5. **Customization for specific needs:**

   Each organization may have unique needs and workflows. Many information systems allow for customization to accommodate for these specific requirements, resulting in more effective and tailored solutions.

6. **Data accuracy and integrity:**

   Having dedicated systems for specific tasks can contribute to the integrity and accuracy of data. Specialized systems can enforce data validation rules, reducing the likelihood of errors and ensuring the reliability of information.

7. **Improved decision-making:**

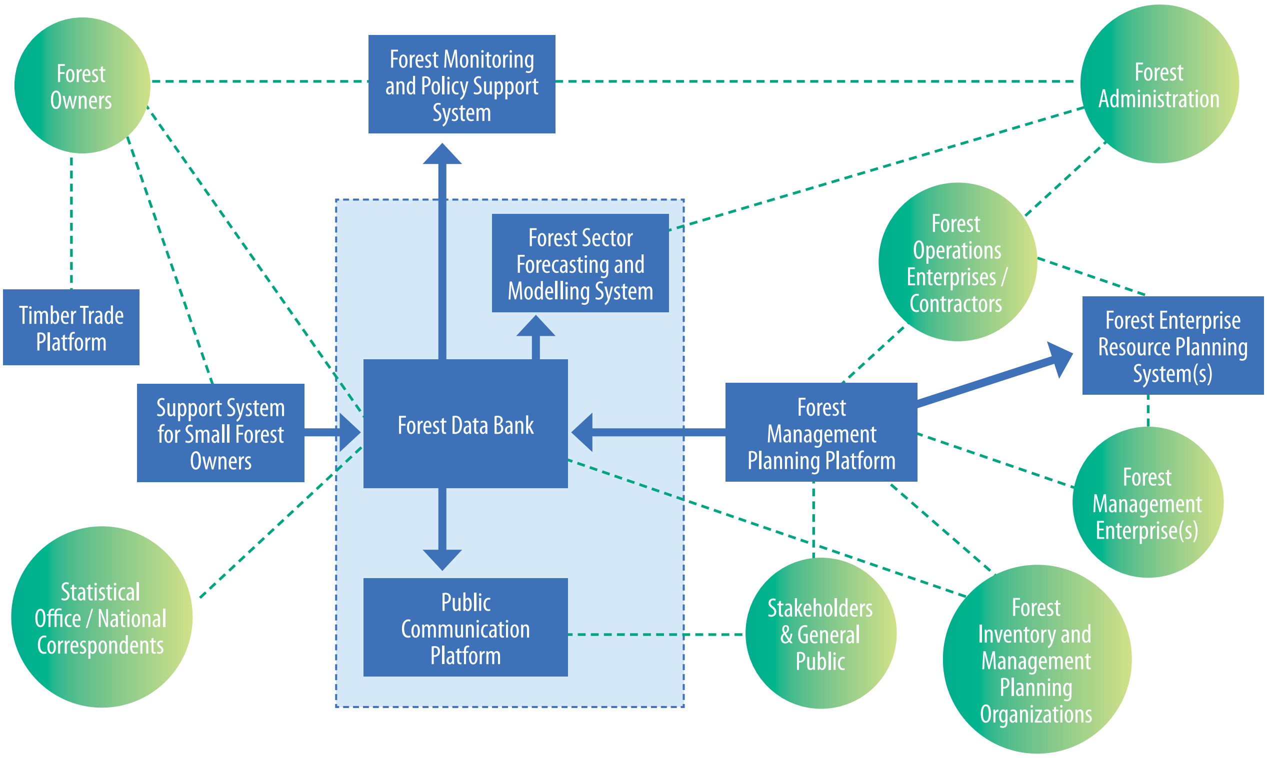
   Specialized systems often provide better data analytics and reporting capabilities. This empowers decision-makers with timely and relevant information, facilitating informed and strategic decision-making within specific domains.

8. **Interoperability:**

   If multiple systems are used, it is essential to ensure interoperability among them. A well-designed architecture allows different systems to communicate

FIGURE 9

Typical FIS components in a decentralized forest information environment



and share data seamlessly, preventing information silos and enhancing overall system efficiency.

9. **Better citizen services:**

   Specialized systems can contribute to the delivery of improved services to citizens. For example, dedicated systems for forest monitoring, firefighting and fire prevention, support of recreational activities, and public safety can lead to more targeted and responsive services, ultimately improving the quality of life for citizens.

10. **Compliance and regulation:**

    Different types of activities may be subject to different regulations and compliance requirements (e.g. certification of forest management, tax regulations, reporting duties). Specialized information systems can be designed to adhere to these regulations, ensuring legal and regulatory compliance.

11. **Incremental upgrades:**

    With multiple systems, upgrades and improvements can be implemented incrementally. This approach allows for a more manageable and controlled evolution of the information infrastructure, minimizing disruptions to ongoing operations.

Whether dealing with a single centralised forest information system or multiple systems in a decentralised environment, functional parts need to be compartmentalised for the FIS to work properly. The individual components (or systems) perform different organisational functions (see Table 3) and can be of various types (the FIS types have been outlined earlier in this publication).

Typical FIS functions include:

- Forest management operations (resource planning, accounting, reporting).
- Forest management planning.
- Forecasting and modelling of forests and changes in forest resources.
- Timber trading.
- Forest sector statistics.
- Forest management support for small owners.
- Forest monitoring, fire monitoring and prevention, management of disturbances.
- Forest policy support.
- Communication with forest sector stakeholders and the public.

TABLE 3 Common elements of FIS (blue) and their role in executing various organizational functions (brown) of the forest sector. Component types are marked with background colours

FIS component / Organizational function	Forest Data Bank	Forest Sector Forecasting and Modelling System	Forest Monitoring and Policy Support System	Forest Management Planning Platform	Forest Enterprise Resource Planning System	Support System for Small Forest Owners		Timber Trade Platform	Public Communication Platform
Forest administration / service	Supply of information to decision-making processes.	Timber resources forecasts. Forest damage and fire models. Economic models.	Real-time monitoring of removals and SFM compliance. Information for decision-making.	High-level information for policy decisions regarding forest management planning.					
Forest management / use				Medium- to low-level information and data for decisions regarding forest management planning in a forest enterprise.	Operational support and control of all processes of a forest enterprise.	Assistance with decisions regarding forest property.		Operational support for timber trade processes. Access to timber market for all forest owners.	
Forest operation performing					Operational support and control (if not done by contractor).	Operational support and control.	Knowledge base & information exchange with other owners.		
Forest operation supervision / control					Operational support and control of supervision processes over forest operation contractors.				

Forest supervision (including timber supply chain supervision)	Data gathering and integration about fellings, timber trade, forest condition, calamities etc.			Providing up-to-date information for supervision of forest condition and forest-related processes.				Data and tools for proper supervision of forest estate.	Operational support for timber supply chain supervision.	
Timber consumption and trade	Gather and share data about economic aspects of forest utilization, including timber trade and consumption.							Easy access to timber market for small forest owners.	Providing easy and equal access to timber market.	
Social dialogue / participatory processes	Provide all necessary background information for participatory processes on various forest-related issues.				Provide transparent information regarding forest planning process and facilitate feedback and discussion.	Facilitate information exchange between stakeholders of forest management. planning process.				Provide the public with the means to interact with political and administrative bodies in matters regarding forests and forestry.
Public communication	Provide extensive, detailed, accurate and transparent public data about forests as a feature of open society.	Provide extensive, detailed, accurate, and transparent public data about forests for reuse.								Provide transparent and accurate information for the public about forest ecosystems, including real-time information (fire danger, entry bans, etc.), forest sector-related policies, and legislation.

Decision support
Information sharing
Resource management
Communication support
Resource management and communication support combined

It should be noted that the relevance of these components depends on the local conditions in a country. For example, if the forest sector is small and of limited capacities (e.g. due to physiographic conditions or historical reasons), it is not reasonable to implement all the components shown in Figure 9. Typical FIS components in a decentralized forest information environment, and certain functions can be simplified and gathered in multi-purpose units.

Some of these components are often found in many countries (for example systems that help run forest management operations) because they support "traditional" functions of the forest sector. Other component types have only appeared recently (e.g. communication platforms, monitoring, and modelling systems) with the development of information technologies, climate change, certification requirements, changing societal attitudes and expectations etc. Some modules can also be country-specific, addressing individual needs of management structures. Each of these modules requires an information feed, which cannot always be secured for various reasons (political, economic, organizational, or other).

3.4 Benefits of having FIS

Information systems can improve operational efficiency, reduce costs, provide decision-makers with better, more complete information, and thereby improve forest ecosystem services and state governance.

In the last two decades of the 20th century, the focus of the information industry underwent a significant shift. Initially focused on enhancing the cost-effectiveness of administrative duties, the industry redirected its attention toward assisting executives, managers, and professionals - commonly referred to as "knowledge workers" - in attaining their business objectives. This pivotal transition marked a move from the "computer era" to the "information era," signifying a departure from prioritizing the cost-displacement advantages of automation to emphasizing the "value-added" benefits.

Cost-displacement benefits involve leveraging automation to perform tasks more efficiently, achieving comparable output with reduced input. The benefits from the implementation of an information system that are first to materialize are improvements in operations, in part due to their automation. Both internal and external communications are usually sharply improved.

On the other hand, *value-added benefits* appear when automated information systems empower organizations to make informed decisions and effectively fulfil their mission.

This shift underscores the importance of moving beyond the mere replacement of people with computers and instead, providing individuals with the necessary tools to yield superior business outcomes. The potential of value-added

benefits surpasses that of increased efficiency alone. Improved information can lead to critical insights or decisions. Moreover, the heightened decision-making capabilities of executives, managers, and professionals wield a substantial impact on the overall success of the organization[56].

Organizations, including business enterprises and public administration entities, that effectively manage digital technology can expect to see improvements in one or more of these three areas:

- Better stakeholder or customer experiences and engagement.
- Streamlined operations.
- New lines of business, services or business models[57].

Value-added benefits of information systems are optimal when these tools are created or purchased with the proper guidance from their future users, who are best qualified to decide which functionalities, procedural approaches, and design decisions align most with their, and their organizations', business needs.

A different type of benefits can be achieved and is of great importance in the case of public services. Government or other public agencies do not operate for profit but aim to manage the country and public property well, provide the public with efficient and friendly services and ensure transparency and accountability of actions and decisions of public administration.

The structure and activities of an organization are profoundly and increasingly shaped by its information environment. The appearance of online technologies has on one hand, increased the flexibility of operations, and, on the other, allowed for better control and integration. Technological advancements offer

56 Charles Hartgraves, The Forest Service Information System, in People and Technology in the Workplace (Washington, D.C., National Academies Press, 1991), pp.253–71, https://doi.org/10.17226/1860.

57 Michael Fitzgerald *et al.*, Embracing Digital Technology, MIT Sloan Management Review (October 2013).

management the chance to strategically combine optimal configurations of organizational structures and information environments, thereby facilitating the achievement of its objectives.

The key component of all information systems are the data. Data can also be a product of an organisation's operations, with its own business value.

FIS can provide the following types of data:

- Custom data for a specific task or decision-making process.
- Custom formats which can be tailored to the needs of their users, for example, lists and charts.
- Real-time data - particularly useful when rapid action is needed, like dealing with illegal logging or calamities.
- Historical data, which are particularly useful for reports, analysis, and business planning.

From a temporal perspective, FIS gives users the following advantages:

1. Improved **understanding of the existing situation.** ICT knowledge-management systems store data about the current state of a topic and provide tools to help acquire it. Examples of this include forest inventories and monitoring. They can also offer statistical analysis of this data.
2. **Predicting changes.** ICT tools can use existing information to provide predictive statistics, expert-based heuristics, and various modelling approaches.
3. **Formulating solutions.** ICT tools help in understanding the underlying reasons behind things. They can analyse data and support various levels of decision-making: landscape, forest, project/management unit, and forest management planning.
4. **Implementing solutions.** There is evidence that properly used ICT tools increase operational efficiency, for example by automating standard operations. They also improve process quality, promote synergy of actions, and help manage information flow. Therefore, they can optimise costs and improve results.

Information systems are a strategic resource for economic growth and a solution for the increased transparency and participation modern societies expect.

4. Organization and management of FIS development

4. Organization and management of FIS development

4.1 FIS Planning Phase

Regardless of the level of analysis and intervention, it is important to formulate a digital transformation strategy that will lead to the implementation of forest information systems. This strategy serves as a central concept to integrate the entire coordination, prioritization, and implementation of an information system in this level/area of the forest sector.

The exploitation and integration of digital technologies often affects large parts of organizations and even goes beyond their borders, by impacting products, services, business processes, communication channels, and other parts of the forest value chain. Given this wide scope and the far-reaching consequences, FIS development strategies should coordinate and prioritize multiple independent threads of digital transformation.

The optimal achievable extent of digitization is a key aspect of preparation strategies for building FIS. Technology should always be aligned, and subordinate to overall strategic goals. Thus, greater use of digital technologies may not always be desirable.

Starting from the objectives formulated at a general level, these strategies focus on the transformation of products, services, processes, and organizational aspects using new technologies. It is thus critical to obtain a close fit between digital transformation strategies, IT strategies, and all other organizational and functional strategies.

Elements of digital transformation strategies can be assigned to four essential dimensions (see Figure 10):

- Use of technologies.
- Changes in value creation.
- Structural changes.
- Financial aspects[58].

The *use of technologies* is a general attitude towards new technologies (vision, ambitions, determination), as well as the organization's ability to employ them. The use of new technologies often implies *changes in value creation*: how far the new digital activities deviate from the classical – often still analogue – core business and the traditional methods of operation. These deviations offer opportunities to expand and enrich the current products and services, but they are often accompanied by a stronger need for different technological and product-related competencies and higher risks due to less experience in the new field.

With new technologies and different forms of value creation introduced, *structural changes* are often needed to provide an adequate basis for the new operations. Structural changes refer to variations in organizational setup, especially concerning the placement of the new digital activities within the organizational structures and communication channels.

These three dimensions: use of technologies, changes in value creation, and structural changes can only be transformed after considering *financial aspects*. Financial aspects are both a driver and a bounding force for this transformation, particularly the economic urgency to act, and the organization's ability to finance digital transformation measures. While lower financial pressure may reduce the perceived urgency to act, organizations which are already under financial pressure might lack external ways to finance a transformation. Therefore, organizations should confront the need to conduct digital transformations and explore their options openly and in good time.

Despite the growing acknowledgement of the need for digital transformation, organizations struggle to see clear benefits from the use of new digital technologies.

The following obstacles have been identified[59]:

- Lack of urgency.
- Lack of vision.
- No clear roadmap towards digital transformation.
- Attitudes of older workers.
- Legacy technology.
- Innovation fatigue.
- Politics.

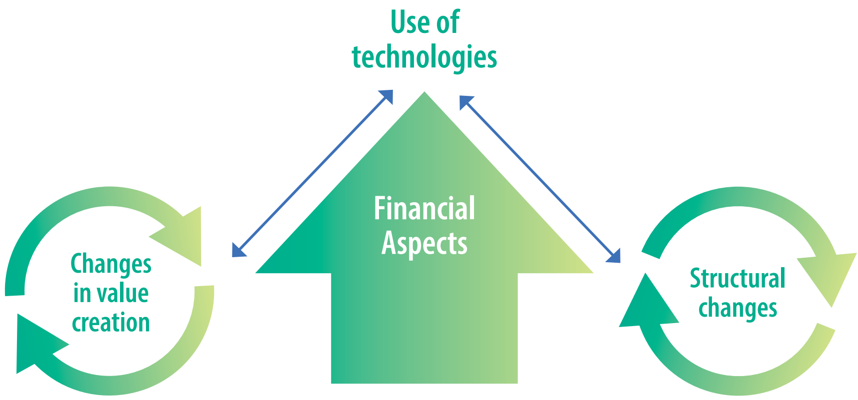
Digital transformations, as well as their implementation and operation, are often accompanied by changing and required skill sets. The recruitment and training processes must therefore be a part of the overall strategy and action plans. An appropriate Governance Framework is indispensable.

58 Christian Matt, Thomas Hess, and Alexander Benlian, Digital Transformation Strategies, Business & Information Systems Engineering, vol. 57, no. 5 (October 2015), pp.339–43, https://doi.org/10.1007/s12599-015-0401-5.

59 Fitzgerald *et al*., Embracing Digital Technology.

FIGURE 10

Four transformational dimensions of a digital transformation framework



Source: Matt *et al.* 2015.

FIGURE 11

Stages of the analysis (general approach)

Various strategic planning frameworks have been developed to structure the work of identifying objectives and actions, maintaining control and disseminating results. They are all based on a layered approach, from the general to the specific (see Figure 11).

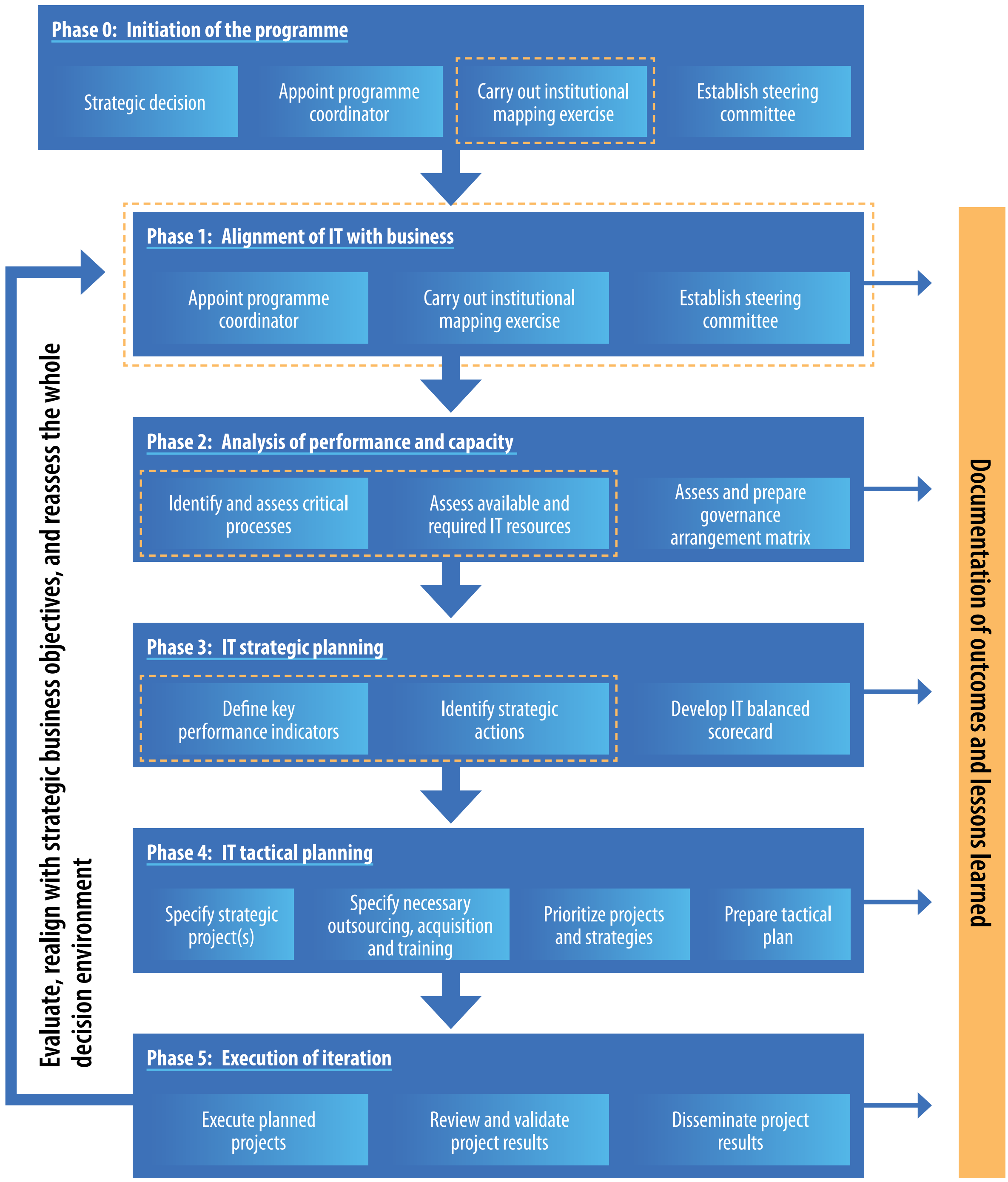
First the **(1)** external conditions are considered, then the **(2)** needs and opportunities for intervention are identified, followed by the **(3)** establishment of Key Performance Indicators (KPIs) and a **(4)** cost-benefit analysis, and finally the **(5)** formulation of individual projects and their execution.

The general strategy for building an information system can be devised and implemented at different levels. Therefore, the planning and implementation framework should be adapted accordingly. The common approach, however, can be defined[60], for example as presented in Figure 12.

60 Paulo *et al.*, Implementation of Information Technology (IT) Governance through IT Strategic Planning.

FIGURE 12

Phases of IT governance implementation approach



Source: after Paulo *et al.*, 2012, modified by A. Talarczyk.

Phase 0: Initiation of the digital transformation programme

Formulating, implementing, evaluating, and – if necessary – adapting a digital transformation programme is a complex endeavour and appropriate procedures must be identified and put in place first.

Proper governance of the programme is necessary to ensure full control and to prevent scope drift. Big development programmes often exhibit a tendency to become autonomous if they are not properly supervised, possibly losing sight of aligning their objectives and actions with general political and/or business goals. Additional support from experts from inside and outside the organization or administrative structure might be needed.

Activity 0.1: Strategic decision

Digital transformation involving the development of FIS should be initiated from the top and carried out within a general well-defined FIS creation or extension programme. A strategic decision establishing such a programme should be made on a policy-making level. One of the first decisions should be to define the scope of FIS development programme. This influences the subsequent definition of the programme's objectives, the stakeholders involved, and the methods and means of implementation.

The scope of the programme will depend on the organisational and technological maturity of existing forest information systems, the policy objectives behind the programme, the funding available, and the potential benefits.

For example, the programme may aim to (i) build a comprehensive national forest information system, (ii) create a system to support a specific part of the forestry sector, (iii) modernise and optimise existing processes, or (iv) build a well-defined system to meet specific needs.

Activity 0.2: Appointment of Coordinator

A coordinator with powerful prerogatives should be appointed. Their task will be to ensure cohesion and interoperability between systems, processes, and operating procedures, especially among different organizations. The coordinator can be based at the ministry responsible for forestry, the national forestry agency, or a dedicated inter-agency task force.

This coordinator must have strong support from decision-makers for change. Only this can lead to a good FIS design and optimal solutions.

Activity 0.3: Institutional mapping

One of the first steps is the institutional mapping exercise where relevant stakeholders are identified and convened.

Stakeholders are organizations and social groups of any size or individuals that act at different levels and sectors (domestic, local, regional, national, international, private, and public). These actors have a significant and specific stake in a given set of resources and can affect or be affected by resource management. The stakeholders should also include agencies which are not directly governing the forest sector, but that are making decisions that affect land use. These stakeholders should be engaged early in the FIS design process to help foster trust among the stakeholders and willingness to share data.

Stakeholder analysis is the process of systematically identifying, categorising, mapping, and analysing information to determine:

- Which groups have an **interest and/or influence** in a project?
- Which groups are typically **included or excluded**?
- Whether each group is **relevant to include**?
- Which **concerns** are shared by various groups regarding the project?
- Whether the groups **support or oppose** the project, or will the groups **benefit or be harmed** by it?

The process of identifying and analysing key stakeholders in a forest information system analysis allows users to know their interests, positions, functions, and roles, as well as their degree of involvement and ability or inability to affect policy change.

It helps managers and organizations (e.g. government agencies or forest management entities) to gain a better understanding of who their key stakeholders are, what their interests and concerns are, and how they can be effectively engaged or managed.

It enables the identification of potential conflicts of interest or areas of collaboration, allowing for the development of appropriate strategies to address stakeholder needs and expectations. Stakeholder mapping also facilitates prioritizing stakeholder engagement efforts and ensuring that communication and decision-making processes are inclusive and transparent.

Step 0.3.1: Identifying stakeholders

The first step in stakeholder identification is to create a list of groups that are known to have an influence and/or interest in the forest sector or could be affected by its policies and activities. This list serves as a starting point to further expand and analyse the identified stakeholders. To gather a comprehensive understanding of the stakeholders involved or impacted by the forest sector, a literature review is necessary. This involves conducting online and print searches of various sources, such as legal documents, websites, scholarly articles, company profiles, media publications, and government and NGO reports. Through this process, a wide range of stakeholders can be identified and analysed.

At the beginning of the stakeholder identification process, a provisional comprehensive list of all actors that *may* have a potential interest in forest information systems should be created. It must not be constrained by pre-existing knowledge and assumptions on their involvement in potential future projects involving FIS implementation. During the analysis and stakeholder engagement stages, there will be an opportunity to confirm the relevance of each group's stake.

Stakeholders can be categorized into the following groups (as outlined in the Stakeholder Analysis Worksheet, see the practical guide[61]): state entities, private sector, donors, civil society, international organizations, local NGOs, international NGOs, academia, local leaders or influencers, and others.

Step 0.3.2: Gathering information

The initial lists generated through stakeholder identification rely on secondary sources. However, to gather more comprehensive information, it is important to reach out to project actors directly. There are three primary methods to collect information directly from stakeholders: (1) electronic communication, such as email or online surveys, (2) interviews conducted via phone or in person, and (3) focus group workshops consisting of multiple stakeholders. These methods provide opportunities to gather more detailed and nuanced information on stakeholder interests, positions, and concerns, as well as to establish stronger relationships with key stakeholders.

The goals of the analysis must be clarified before engaging stakeholders and be clearly communicated to them before conducting an interview. Goals help to identify and target interests which need to be represented in the collaboration processes, and those which can be left out considering that stakeholders will have their own pre-existing biases during the interview.

When conducting interviews, a standard questionnaire can be used (see the practical guide[62] for an example) with the following questions:

1. What is the stakeholder's primary interest in the FIS?
2. To what degree is the stakeholder group relevant to developing FIS?
3. To what degree is the stakeholder group involved in the policy-making process?
4. Does the stakeholder group support or oppose the FIS development?
5. Will the developed FIS benefit or harm the stakeholder group?
6. What alliances exist with other stakeholders?
7. What conflicts exist with other stakeholders?

The specific type of interview questions should be tailored to the project or policy context, as well as the cultural context of the interviewed stakeholders. For example, questions may focus on stakeholders' positions on the issue at hand, inclusion or exclusion, alliances, conflicts, or other relevant topics.

To ensure consistency across interviews, it is recommended to develop a standard interview protocol which may include guidelines for how to ask questions, how to record the interview (e.g., notes or recording), and other relevant information. The use of a consistent interview protocol will facilitate the comparison and analysis of responses from different stakeholders.

In addition to collecting information from known stakeholders, conducting interviews during the outreach phase can be a useful way to identify additional groups who may have an interest in, or be impacted by, the project or policy. During the interviews, stakeholders can be asked to identify other groups who may not be on the initial stakeholder list but who may have relevant perspectives or concerns. This can help expand the list of stakeholders and ensure that all relevant groups are included in the stakeholder analysis process.

Step 0.3.3: Analysing stakeholder information

After gathering information on as many stakeholders as possible, the next step is to analyse the data collected. This analysis aims to gain a better understanding of each stakeholder group's interests, influence, positions, relevance, partnerships, and conflicts.

The scale of 1 to 5 is often used as a simple way to assign a numerical value to the set of criteria, based on the evaluator's opinion of the stakeholder group's characteristics. Opinions can vary; however, therefore, it is recommended to seek information and feedback from as many actors as possible to ensure a more accurate rating.

In addition, asking the question *What is the stakeholder's primary interest in FIS?* will help the analyst understand better the principal areas of interest of each stakeholder (or group of stakeholders). Furthermore, this question helps to understand which parts of the value chain they are linked to, and what might be their likely position toward changes in the value chain elements.

61 The United Nations Economic Commission for Europe, Developing National Forest Information Systems. A Practical Guide, UNECE Forest and Timber Section Study Papers (Geneva, United Nations, March 2024), ECE/TIM/SP/56.

62 United Nations Economic Commission for Europe, Developing National Forest Information Systems.

The purpose of the question *To what degree is the stakeholder group relevant to developing FIS?* is to analyse how important particular stakeholders are for developing FIS. An important issue is to understand what being "relevant" means for the participants of this exercise and to reach a common understanding. This might prove to be a challenging task as opinions may be influenced by social factors and individual interests.

To what degree is the group involved in the policy-making process? The answer to this question depends on the formal structure of governance, but also on the actual estimated influence in decision-making.

Each group should be assessed on whether they support or oppose the project or policy to build FIS (*Does the stakeholder group support or oppose the FIS development?*). In addition to classifying them into supporters, moderate supporters, neutral, moderate opponents, or opponents, it is important to look for the reasons for their position. It might happen that a group will be internally divided in their position, this should be described and, if possible, explained.

In addition to the perceived influence and position towards the project or policy, further analysis is recommended, with a focus on analysing whether the stakeholder group will benefit or be harmed by the project (*Will the developed FIS benefit or harm the stakeholder group?*). In particular, real or potential harm as well as financial or other benefit should be analysed.

The final issue is identifying any existing alliances with other stakeholders (*What alliances exist with other stakeholders?*). This form of linkage may foster collaboration and build support for the project or policy, but alliances might also be formed to oppose it (*What conflicts exist with other stakeholders?*). Therefore, if conflicts with other stakeholders exist (or could potentially appear) they need to be described.

Activity 0.4: Establishing steering committee

The most important stakeholders, especially key process participants, should be involved from the early stages of this analysis. They understand their business better than external consultants and have practical experience in evaluating needs, opportunities, and potential drawbacks of considered solutions. The analytical process should be coordinated by a moderator equally distant to all stakeholders, proving neutrality, balance, and fairness.

Stakeholder participation should be formalised, preferably in the form of a steering committee, to allow efficient management of the entire programme. The presence of a steering committee has a significant impact on governance and trust in the project. The most important advantages and functions include control and performance measurement, support, decision-making, relationship management,

reporting, resource management, risk management, and strategic focus[63].

All essential decision-makers should be included in the committee, as well as representatives of the main actors to be affected by the implementation of the programme's results. This will enable the involvement of all actors from the beginning of the project and will create networks among the forest owners, industry, decision-makers, researchers, community members, and civil society[64].

The required main actors will vary depending on the scope and objectives of the programme, how forest administration is organized in a country, as well as factors such as forest ownership structure, natural conditions, level of economic development, and social attitudes towards forestry.

For example, if a national forest information system will be built/improved, the set of actors involved will be quite large and include:

- Public administration – ministries responsible for forests and forestry (usually environmental or agricultural sector).
- Government agencies.
- Forest management organizations.
- Forest owners.
- National statistical offices and national correspondents for international reporting processes.
- Forest inventory and management planning groups, and research institutions.

As shown in Table 3, actors can be identified considering various types of activities occurring in the forestry sector.

For FIS development, specialists outside the forest sector should be included wherever possible. These should include business management experts and ICT strategic designers. They can provide options and insights from different perspectives.

63 Jan Terje Karlsen, The Project Steering Committee, Project Governance and Trust: Insights from a Practical Case Study, Management Research Review, vol. 44, no. 6 (1 January 2021), pp.926–47, https://doi.org/10.1108/MRR-12-2019-0540.

64 Namoudou Keita *et al*., Strengthening Equitable Health Systems in West Africa: The Regional Project on Governance Research for Equity in Health Systems, African Journal of Reproductive Health, vol. 25, no. 5 (May 2022), pp.81-89.

Phase 1: Alignment of Information Technology with business

Phase 1 aims to create the basis for promoting strategic alignment and IT value delivery. The results of Phase 1 are: (1) knowledge of the organizational context and (2) identification of IT objectives aligned with the business objectives. These results will guide the activities planned in Phase 2.

Activity 1.1: Understanding organizational context

The first step is to analyse how the forest sector is organized and determine the needs and opportunities for improvements. It is important to analyse how the forest sector is structured, what linkages and dependencies exist between various stakeholders and how they contribute to creating added value in the forest sector.

One of the techniques that could be employed, especially in large-scale programmes, is the value chain analysis (VCA). Its objective is to develop an understanding of how activities and actors that are involved in bringing a product from production to consumption are linked. A value chain is understood here as the set of activities through which actors get increased value from products or services. "There is a simple element at the heart of value chain analysis. The idea of a chain is a metaphor for connectedness. It highlights the point that most goods and services are produced by a complex and sequenced set of activities"[65]. FIS is always embedded in a larger network of activities, which create relationships and constraints that have to be addressed, and opportunities that can be utilized. Mapping of the value chain in which the FIS will be placed helps identify (i) existing components, (ii) linkages – both vertical and horizontal, (iii) actors and (iv) activities, and thus later facilitate a structured discussion about these opportunities and constraints, and possible optimal solutions (see Table 4)[66].

A range of methods exists that are commonly used for researching value chains:

- Desk studies.
- Interviews.
- Focus group discussions.
- Surveys.
- Document analysis.
- Participatory observations.

As there is not a single, universally appropriate method for studying value chains, usually a combination of these methods is used. However, it should be noted that the analysis should focus on the organizational context, not on the elements of the value chain structure and/or their performance, as these will be covered in Phase 2.

It is often beneficial to record the organizational context as a network diagram (graph). An example of such a stakeholder map is shown in Figure 13[67].

If the scope of the digital transformation programme is limited to a single part of the value chain or a single organisation, the organizational context analysis will be simplified.

Any FIS, especially at the national level, should be designed based on the forest management strategy, existing forest policies, institutional landscapes, organisational and financial capacities and administrative capabilities.

TABLE 4 An outline of the value chain analysis: creating a value chain map

	Steps	Task	Questions
1	**Activities**	Identify activities of the forest sector and place them on the map. Identify business objectives that are behind each of these activities and write them down.	What activities are carried out in the forest sector which are necessary for its proper functioning? What are the business objectives of each of these activities?
2	**Actors**	Identify actors and place them on the map	Who are the key actors involved in the forest sector?
3	**Links**	Draw linkages between actors and relate the actors to the activities	What links are important to understand how the forest sector operates and is governed?
4	**Context**	Write contextual factors on sticky notes and place them on the map	What factors outside the forest sector are important to consider?

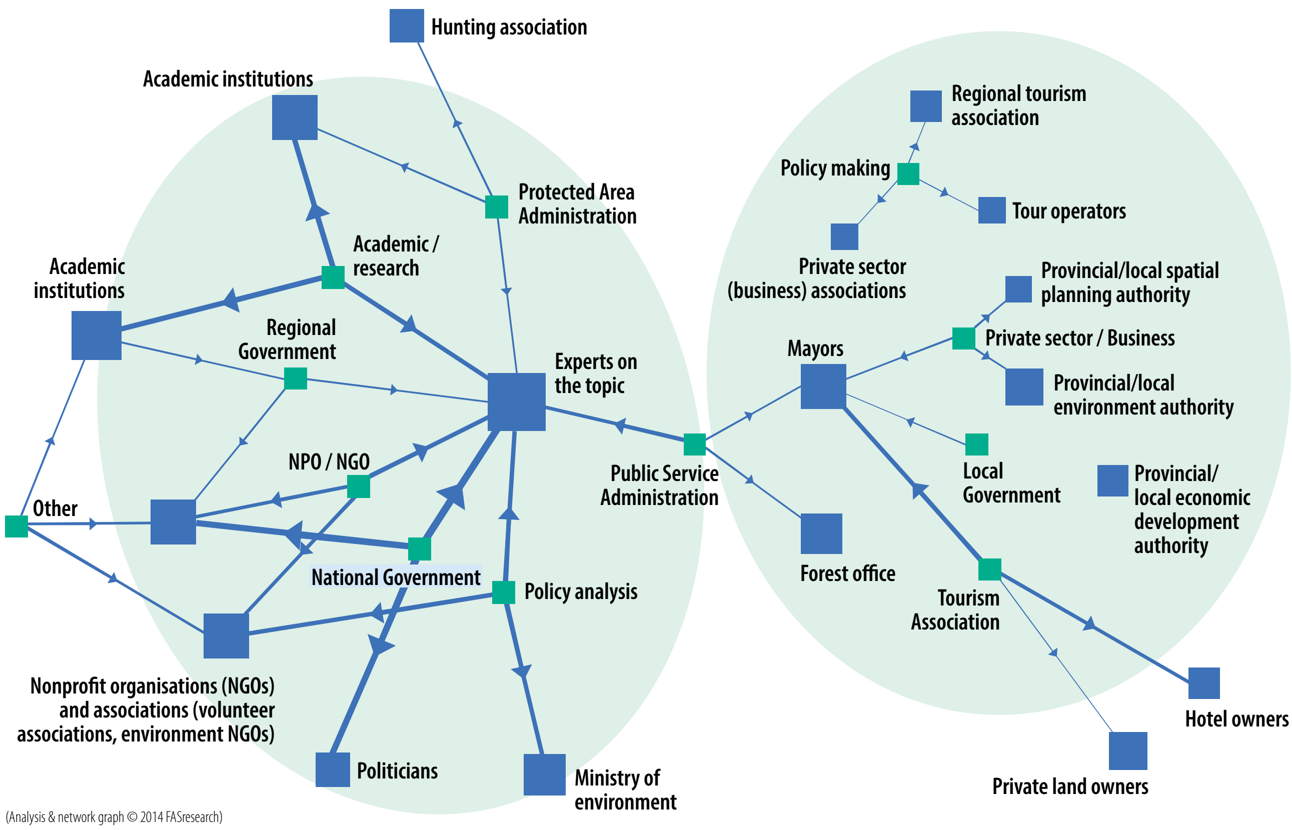
65 John Humphrey and Lizbeth Navas-Alemán, Value Chains, Donor Interventions and Poverty Reduction: A Review of Donor Practice, IDS Research Reports 2010, no. 63 (March 2010), pp.1–106, https://doi.org/10.1111/j.2040-0217.2010.00063_2.x.

66 C. Stein and J. Barron, Mapping Actors along Value Chains: Integrating Visual Network Research and Participatory Statistics into Value Chain Analysis, WLE Research for Development (R4D) Learning Series 5 (International Water Management Institute (IWMI); CGIAR Research Program on Water, Land and Ecosystems (WLE), 2017), https://doi.org/10.5337/2017.216.

67 Karin Svadlenak-Gomez *et al.*, Biodiversity Stakeholder Networks in the Alpine Space (greenAlps project/FIWI, November 2014), https://doi.org/10.13140/2.1.4695.8401.

FIGURE 13

An example of a network diagram of perceived stakeholder impact



Source: after Svadlenak-Gomez *et al.*, 2014.

Forest management and policy are complex domains, so they must be conceptually streamlined for efficiency and communication. Useful tools include criteria and indicators for sustainable forest management (C&I for SFM). These have several functions:

1. Outlining a country's area of competence or interest in SFM.
2. Providing a tool to measure SFM progress.
3. Providing a structure for forest inventory and national forest reporting.
4. Optimizing the number of parameters measured.
5. Facilitating the process which communicates information to the user.

They can therefore be meaningful representations of real conditions in forest ecosystems and the forest sector.

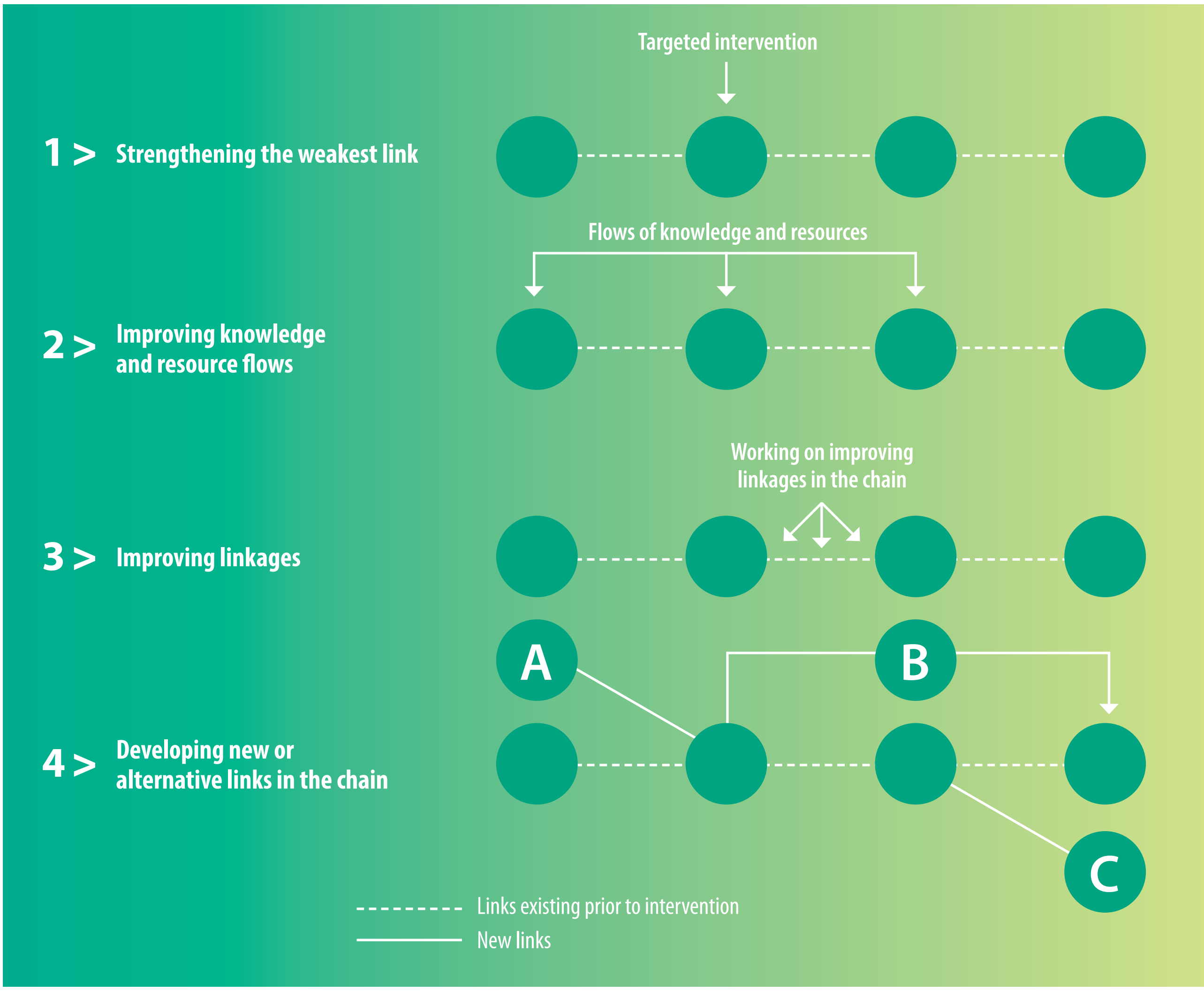
The country's criteria and indicator framework is a point of reference for forest policy monitoring and communication, and should be connected to a general model of the forest sector. This should integrate political strategies and forces present in the sector, as well as plans for management action and feedback on outcomes. Supporting tools can be arranged around it.

Having a C&I system for SFM linked to knowledge-management systems as well as modelling and planning platforms, enables managers and policymakers to make informed decisions based on a comprehensive, easy-to-grasp view of the current situation and its dynamics. It should be a central element, defining the scope and structure of the information system and linking major stakeholders, including professions such as surveyors, and the public.

Activity 1.2: Defining business objectives

The goal of value chain analysis and value chain mapping is to better understand the system to identify strategies for upgrading. Business objectives of the FIS programme depend to a large degree on policy objectives, but if the steering committee is properly composed and motivated, it can

FIGURE 14
Typology of objectives for value chain interventions



Source: Humphrey and Navas-Alemán, 2010.

identify important business objectives through a structured discussion informed by the VCA results and input from the committee members (see Table 5).

There are many types of value chain interventions leading to defining concrete business objectives. However, they can be classified into the following four types[68] (see Figure 14):

1. **Strengthening the weakest link.** This type of intervention addresses the issue of weak links in the chain. The efficiency of the chain depends upon the performance of each of the linkages. Sometimes, improving the efficiency of one (or a few) particular parts of the value chain will considerably improve the performance or resilience of the whole chain. A value chain intervention starts from a diagnosis of the impact of a particular link in the chain on the performance of the chain.
2. **Improving knowledge and resource flows.** Poor flows of knowledge are commonly found in value chains. Knowledge is either poorly communicated or not communicated at all. This leads to missed opportunities or inefficiencies in the value chain operation. One implication of targeting these flows is that knowledge deficits at one point in the chain may be addressed by interventions involving actors at other points in the chain.
3. **Improving linkages.** The efficiency of a value chain depends on the readiness of the actors to exchange information and collaborate. Poor linkages, e.g. lack of

68 Humphrey and Navas-Alemán, Value Chains, Donor Interventions and Poverty Reduction.

trust between parties involved, result in high transaction costs or even transaction failure. Value chain interventions address these problems in a variety of ways, including trust-building initiatives, providing indicators of company reputation, and setting up institutions to manage risk. While in practice improving linkages is closely related to the second objective, *improving knowledge and resource flows*, they are analytically distinct.

4. **Developing new or alternative links in the chain.** If the overall efficiency of the chain depends upon the functioning of each of the links, value chain interventions can identify alternative linkages. Linkage A shows the development of new sources of supply to overcome problems such as shortages of raw materials, or low quality. Linkage B shows how one link in a chain is replaced by another. This might be the brokering of new intermediaries to substitute a link that was malfunctioning, or non-existent. Linkage C shows the case of new market outlets being developed. In each case, the new link might substitute or complement the old one.

There is considerable underutilised potential in value chains that can be tapped into by improving flows of knowledge and resources, improving relationships, and establishing linkages, as well as by improving capabilities at specific points in the chain. Outside interventions may be needed to unlock this potential. In other words, strategies to improve the functioning of the forest sector should focus as much on linkages as on its assets.

For a limited-scope FIS development programme, there may be only a small number of strategies, with a limited number of business objectives.

TABLE 5 Defining business objectives and upgrading strategies: analysing and interpreting the value chain map

	Steps	Task	Questions
5	**Participatory analysis**	Identify possible points of intervention using the intervention typology and attempt to quantify the expected benefits that would result from each intervention. Mark them on the map.	What activities are carried out in the forest sector which could be improved/ changed in order to improve its functioning?
6	**Validation**	Summarize, discuss, and ensure coherency of emerging findings.	Does the map represent the forest sector's reality adequately? Is the map coherent?
7	**Identifying solutions**	Identify and rank strategies for improvement. Ensure that each proposed strategy has clear business objectives.	What strategies are most effective to improve the functioning of the forest sector?

Activity 1.3: Defining IT-related objectives

Business objectives defined in the context of the current policies and the forest value chain must be translated into actionable IT-related objectives. No technical solutions are expected to be defined at this stage because this would require a detailed process and resource analysis which will be done later, in Phase 2 (see further down). At this point, the steering committee should focus on identifying IT-related objectives (product or solution ideas) that will support the achievement of the business objectives.

For example, if the business objective was defined as *providing the general public with consistent, timely and accurate information on forest resources*, the corresponding IT objectives could be *create a national repository to collect, store, process and publish data on forests*.

Another business objective could be *have control over illegal logging and deforestation*. Its corresponding IT objectives would be: *(1) create a timber-tracking system, (2) create an early-detection deforestation monitoring system*.

In the context of forest information systems, defining IT-related objectives is a critical process that aligns IT projects with the overarching business objectives of the forest sector. This step ensures that the IT initiatives undertaken are purposeful and geared towards delivering specific outcomes that contribute to the achievement of broader goals. By clearly outlining the IT-related objectives, stakeholders can prioritize and plan IT projects effectively, optimizing resources and maximizing the impact of technological investments.

IT-related objectives serve as the bridge between the business objectives of the forest sector and the technical implementation of FIS. They define the specific technology-related targets and outcomes that need to be accomplished to support and enhance various activities within the sector. These objectives are framed in a manner that reflects the benefits that technology can bring to the sector's functioning and long-term growth.

By defining clear and measurable IT-related objectives within the framework of FIS, organizations can ensure that their technology projects are purpose-driven, aligned with business goals, and yield tangible benefits for the forest sector and its stakeholders.

TABLE 6 Analysis of performance and capacity of critical IT processes

	Activities	Results
1	**Identification and assessment of the maturity of critical IT processes, with reference to business objectives of IT to be pursued.**	A set of critical IT processes to be managed and controlled to achieve the goals of IT. Current status of critical IT processes to promote the achievement of IT objectives.
2	**SWOT Analysis of IT resources, identified as information, people, applications and infrastructure.**	SWOT analysis of IT resources applied to critical processes.
3	**Survey and analysis of the IT governance arrangement matrix currently practised.**	An IT governance arrangement matrix.

Phase 2: Analysis of performance and capacity

Phase 2 is intended to verify the current capacity of the forest sector in terms of information processing and communication. The activities of this phase are listed in Table 6. The results of Phase 2 are: (1) a set of critical IT processes to be managed and controlled to achieve the goals of IT, (2) the status of critical IT processes to promote the achievement of IT objectives, (3) strengths, weaknesses, opportunities, and threats (SWOT) analysis of IT resources applied to critical processes, and (4) an IT governance arrangement matrix. These results are exposed in the form of gaps between the current and the desired status, the latter being represented by the business and IT goals.

Activity 2.1: Map of critical IT processes

Starting from the business objectives and associated IT-related objectives, identified in Phase 1, it is essential to map IT-related *processes* that are critical to realizing these objectives, and to assess their current level of maturity (or development) and completeness. The purpose of it is to gain additional insight into the possible areas of intervention for developing or improving the information system(s).

Step 2.1.1: Identifying critical IT-related processes

Identifying critical processes starts with determining which IT processes are critical for achieving the defined business objectives. This could include processes like software development, data management, IT security and network infrastructure management. This should be done in collaboration with stakeholders across the organization, including business unit leaders, end users and IT staff. Their insights will be valuable in identifying which IT processes are essential for daily operations and strategic initiatives.

Next, the identified critical IT processes should be mapped to corresponding business functions (activities) and analysed on how they support these business functions. This mapping helps in identifying which IT processes are critical for the functioning of key business areas such as forest management, harvesting, sales, operations, finance, and customer service.

The impact of each IT process on the business should be evaluated. One needs to consider what would happen if a process failed or were interrupted. Processes that have a high impact on business continuity, or those on which multiple other processes depend are typically critical.

As a result, the IT processes that are essential for managing risks and meeting compliance requirements are identified. Processes that safeguard data security, privacy and regulatory compliance are often critical. It is helpful to analyse historical data regarding IT incidents, downtime and performance bottlenecks. Processes that have previously caused significant disruptions or frequent bottlenecks in performance are likely critical.

The processes are then prioritized based on the value they deliver to the business and their efficiency. Critical processes are often those that add significant value or require optimization to improve overall business performance.

This identification of the critical IT-related processes is the first step in ensuring that these processes are managed effectively, optimized and aligned with the overall business objectives.

Step 2.1.2: Assessing current and required process maturity level

Assessing the maturity level of IT processes from a business perspective is crucial for several reasons:

1. **Alignment with business goals:** A maturity assessment ensures that IT processes are aligned with the business's strategic goals. Mature IT processes are better equipped to support and drive business objectives, leading to improved overall performance and competitive advantage.
2. **Optimization of resources:** Mature IT processes often result in more efficient use of resources. This includes optimizing staff time, reducing wastage and making better use of technological investments, all of which can lead to cost savings and improved productivity.
3. **Risk management:** A higher maturity level in IT processes generally equates to better risk management. Mature processes have well-defined procedures for handling risks and contingencies, thus reducing the likelihood of disruptions to business operations.
4. **Quality of service:** Mature IT processes improve the quality of IT services and products. This results in higher customer satisfaction, increased reliability, and better service delivery, which are all critical for maintaining a positive business reputation.
5. **Innovation and adaptability:** Businesses with mature IT processes are often more agile and innovative. They can adapt more quickly to changing market demands, new technologies, or disruptions, which is vital in today's fast-paced business environment.
6. **Regulatory compliance:** Many industries and administrative environments have stringent regulatory requirements regarding data security, privacy and operational standards. Mature IT processes help ensure compliance with these regulations, reducing the risk of legal issues and penalties.
7. **Decision-making and planning:** Mature IT processes provide better metrics and data for decision-making. This supports more accurate and strategic business planning budgeting, and forecasting.
8. **Employee satisfaction and productivity**: Well-defined and efficient IT processes can lead to higher employee satisfaction, as employees have clear guidelines and tools to perform their tasks. This often translates into higher productivity and lower staff turnover.
9. **Market competitiveness:** Businesses with mature IT processes are often more competitive in the marketplace. They can leverage technology effectively, respond quickly to market changes and offer better products and services.
10. **Scalability and growth:** Mature IT processes are scalable, making it easier for organizations to grow and expand. Scalable processes accommodate increased workloads and organizational changes without a significant drop in performance or service quality.

In summary, assessing and improving the maturity level of IT processes is vital for ensuring that the IT function effectively supports and enhances business objectives, maintains competitiveness, and adapts to the ever-evolving business and technological landscape.

Various maturity models, such as the Capability Maturity Model Integration (CMMI) or the IT Infrastructure Library (ITIL), are widely used to assess the current maturity level of IT processes[69]. This assessment highlights areas of strength, identifies gaps, and helps in formulating a structured approach to elevate the maturity of IT services, ultimately ensuring they deliver maximum value to the business.

Here an example approach using the ITIL (*IT Structure Library*) framework is described. ITIL categorizes IT service management into several processes and functions, such as Service Strategy, Service Design, Service Transition, Service Operation, and Continual Service Improvement. Each area consists of specific processes (since ITIL v4 the term "practices" is also used which conveys a broader meaning as they can group several processes). An ITIL maturity assessment involves evaluating how well an organization has implemented these practices.

ITIL does not prescribe a specific maturity model but is often assessed using a simple scoring scale. This scale typically ranges from Level 1 (ad hoc activities) to Level 5 (highly organized and self-optimizing processes). The assessment involves determining how well an organization's IT processes and practices align with ITIL recommendations at each maturity level.

The capability levels of every process can be described as follows:

- **Level 1:** The process is not well organized; it is performed as initial/intuitive. It may occasionally or partially achieve its purpose through an incomplete set of activities.
- **Level 2:** The process systematically achieves its purpose through a basic set of activities supported by specialized resources.
- **Level 3:** The process is well defined and achieves its purpose in an organized way, using dedicated resources and relying on inputs from other processes that are integrated into a service management system.

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69 CMMI Product Team and others, CMMI for Development, Version 1.2, Software Engineering Institute, Pittsburgh USA, August 2006; Muhamet Gërvalla, Naim Preniqi, and Peter Kopacek, IT Infrastructure Library (ITIL) Framework Approach to IT Governance, IFAC-PapersOnLine, vol. 51, no. 30 (September 2018), pp.181–85, https://doi.org/10.1016/j.ifacol.2018.11.283.

- **Level 4:** The process achieves its purpose in a highly organized way, and its performance is continually measured and assessed in the context of the service management system.
- **Level 5:** The process is continually improving organizational capabilities associated with its purpose. Each capability level is based on the previous ones; they need to be achieved before the current level can be assessed.

The assessment process begins with collecting data on the organization's IT-related processes and practices. This includes reviewing process documentation, conducting interviews with IT staff and stakeholders, and analysing service performance data. The goal is to gain a comprehensive understanding of how IT services are managed and delivered. The full description of a comprehensive review process for an organization is beyond the scope of this guide. The reader is referred to the official ITIL Process documentation[70] or one of many books on the subject.

The collected data is then compared against ITIL's best practices. This analysis helps identify areas where the organization's processes do not fully align with ITIL recommendations. It is important to consider both the efficiency and effectiveness of processes in delivering value to the business.

For each ITIL process or function, the organization's current practice (i.e. the way the process is organized and executed) is rated on the maturity scale. This involves assessing aspects like process standardization, documentation, integration with other processes, performance measurement, and continuous improvement mechanisms.

For each process, the following properties should be defined:

- Name of the IT process.
- Owner of the IT process.
- IT objective the IT process is/will be helping/providing.
- Maturity level of the IT process.

IT processes which are currently inexistent but have been identified should be listed as required to fulfil some of the IT objectives from Phase 1.

70 ITIL, ITIL Open Guide, Available at https://www.itlibrary.org/.

Activity 2.2: Analysis of IT resources

In order to effectively plan strategic projects that lead to improvements defined in the business goals, it is necessary to identify what resources currently exist in relation to information processing in the forestry sector. This could be done as a SWOT analysis of each resource (Figure 15).

The following types of IT resources should be included in the analysis:

- Existing IT systems.
- Qualified personnel.
- Communication infrastructure.
- Servers and other backend infrastructure.
- SaaS (software-as-a-service) solutions at disposal.
- Available IT services.

Existing IT systems

Existing IT systems include all the software applications and hardware infrastructure that the forestry sector currently uses to process and manage information. It may involve data management systems, inventory tracking software, analytics tools, GIS (Geographic Information System), and more. These systems are critical as they form the backbone of information processing and decision-making within the organization.

Qualified personnel

Qualified personnel refer to the skilled and knowledgeable workforce responsible for managing, maintaining, and utilizing the IT resources. Having qualified personnel is crucial to ensuring the smooth functioning of IT systems, troubleshooting issues and optimizing processes to derive valuable insights from the data.

Communication infrastructure

Communication infrastructure encompasses the network and communication channels that enable data transfer and collaboration. It includes local area networks (LANs), wide area networks (WANs), internet connectivity and other communication protocols. A robust communication infrastructure is vital for seamless data-sharing and real-time collaboration, especially in geographically dispersed forestry operations.

Servers and backend infrastructure

Servers and backend infrastructure are the physical or virtual servers that store and process data, along with the supporting infrastructure like data centres, storage systems and cloud platforms. Reliable servers and backend infrastructure are critical for data storage, processing, and retrieval, ensuring data accessibility and security.

FIGURE 15

A form for SWOT analysis of IT resources

IT resource		Internal		External	
		Strengths	Weaknesses	Opportunities	Threats
1					

Software-as-a-Service solutions at disposal

Software-as-a-Service (SaaS) solutions are cloud-based software applications provided by third-party vendors. They offer flexibility and scalability without the need for extensive on-premises infrastructure. SaaS solutions used in the forestry sector might include data analytics platforms, project management tools and other specialized applications.

Available IT services

Available IT services refer to outsourced or managed services that the forestry sector can leverage, such as IT consulting, cybersecurity services, data analytics services and software development services. These services can supplement internal capabilities and expertise.

Activity 2.3: IT governance and arrangement matrix

Every project starts with an executive order from an appropriately empowered stakeholder. It can be a political decision or a business one, depending on the scope, source of financing, and purpose of the information system to be developed.

Beginning with the initial planning phase, it is crucial to have top management support throughout the whole transformation process. Digital transformation and newly introduced information systems have widespread impact, and their implementation may therefore result in resistance from different areas of the organization. To deal with such resistance, transformation leadership skills are essential and require the active involvement of the different stakeholders affected by the transformation.

Digital transformation is a continuous complex undertaking that can substantially shape an organization or a sector of public administration and their operations. It is therefore important to assign adequate and clear responsibilities for the definition and implementation of a strategy to develop information systems in the forestry sector. If the endeavour is approached half-heartedly, the general scope may be lost, and operational difficulties may appear. It should be ensured that the person who is operationally responsible for the digital transformation strategy and coordination of forest information system development has sufficient experience in transformational projects and their incentives should be directly aligned with the strategy's targets and progress.

At this stage, one should engage relevant stakeholders to discuss the current governance structure of the forest sector and other governance structures influencing the decision-making related to ICT solutions. This should begin with mapping the existing governance structure, paying particular attention to the business objectives that were defined in earlier steps.

Having outlined the current situation, the participants should devise how the strategies proposed in the previous steps will be placed, whether they can be executed and supervised within the existing governance structure and what changes are possibly needed.

An IT Governance Arrangement Matrix is a tool which can be used to map out and define the roles, responsibilities, and relationships between various stakeholders in the governance of IT resources within an organization and/or a large project. This matrix helps to clarify how decisions are made regarding IT and who is responsible for what aspects of IT management. The key components of an IT Governance Arrangement Matrix typically include:

1. **Decision-Making Structures**: This includes boards, committees, and executive roles that are responsible for making strategic decisions about IT.
2. **Roles and Responsibilities**: Clearly defined roles for individuals and groups within the IT governance structure, such as chief information officers (CIOs), IT managers, and other stakeholders.
3. **Processes and Practices**: The procedures and methodologies used to make and implement decisions, such as project management frameworks, IT service management, and risk management practices.
4. **Communication Channels**: Mechanisms for how information is shared and communicated among stakeholders within the IT governance framework.
5. **Performance Measurement**: Metrics and KPIs used to assess the effectiveness of IT governance and its contribution to achieving business objectives.

The matrix typically aligns these components against various IT governance domains such as IT strategy, IT value delivery, IT risk management, IT resource management, and performance measurement. By doing so, it provides a comprehensive overview of how IT governance is structured and operates within the organization, ensuring that IT investments are aligned with business goals, risks are managed appropriately, and IT resources are used efficiently.

The commitment of key decision-makers in a project is crucial for several reasons. Key decision-makers often control or influence the allocation of resources, including funding, personnel, and technology. Their commitment ensures that the project receives the resources necessary for successful progress. They ensure that the project aligns with the organization's strategic objectives. Their commitment helps in steering the project in a direction that is congruent with the broader goals of the organization. Projects often need timely and critical decisions. Committed decision-makers can expedite these processes, reducing delays and increasing the efficiency of project execution. They also play a vital role in identifying, assessing, and mitigating risks. Their commitment to the project means that potential issues are given due attention and are managed effectively. The commitment of key decision-makers often signals to other stakeholders, including project team members, investors, and partners, that the project is valued and supported at a high level. This can boost confidence and morale, leading to better collaboration and support.

Projects often involve change, and decision-makers are crucial in endorsing and managing these changes, especially when they impact multiple parts of the organization. Inevitably, projects encounter conflicts, whether in resource allocation, priorities, or strategic direction. Committed decision-makers are essential in resolving these conflicts in a manner that is beneficial for the project and the organization. Their ongoing support is crucial for not just the immediate success of the project but also for its long-term sustainability and integration into the organization's regular operations.

Furthermore, since the diffusion of digital technologies can change swiftly, there typically is high uncertainty concerning the underlying assumptions of digital transformation strategies. Hence, digital transformation strategies should be subject to continuous reassessment, in which both the underlying assumptions as well as the transformational progress to date are evaluated. To ensure that early actions can be taken if expectations are not met, clear procedures for the reassessment of digital transformation strategies are needed.

Digital transformation strategies and the introduction of new IT systems are cross-functional and must be aligned with other functional and operational strategies. As digital transformation strategies cut across various other strategies at the same time, complex coordination activities may be required both within the entity involved in the implementation and within the wider administrative or governance structure.

Phase 3: **IT strategic planning**

Phase 3 is designed to: (1) define indicators for measuring the goals reached and the efficiency of critical processes, (2) define strategic actions which should cover the elimination or reduce the gaps identified in Phase 2, being ultimately aimed at achieving the objectives of Phase 1, and (3) compose the IT balanced scorecard (IT BSC), contemplating goals related to their actions and metrics. IT BSC consists of the main result of this phase.

Activity 3.1: Identifying indicators

As stated previously, business objectives for building/improving the forest information systems, and the corresponding IT-related objectives have resulted from the analysis of which interventions could improve the efficiency of the forest sector value chain (Phase 1). Tools are needed to assess the results of implementation of these strategies and, if necessary, to take corrective actions.

For each improvement strategy (linked to the business objectives), key performance indicators should be defined, as well as means to assess them.

For example, for the business objective, *have control over illegal logging and deforestation*, and the corresponding IT objective: *create a timber-tracking system*, the KPI could be *the share of timber produced in the country which is tracked by the timber-tracking system*, or: *the number of forest inspectorates which have implemented the timber-tracking system*.

KPIs are essential in a successful project[71]. They provide a quantifiable measure of progress towards achieving the project's objectives. They help in tracking whether the project is on schedule and within budget and whether it is meeting its quality and scope requirements. By providing objective data, KPIs inform decision-making processes. They help project managers and stakeholders identify areas that require attention or adjustment, ensuring that the project remains aligned with its goals. Regular monitoring of KPIs allows for the identification of performance trends. This information can be used to optimize processes, improve efficiency, and enhance the overall performance of the project. KPIs serve as a communication tool that provides stakeholders with a clear understanding of the project's status. This transparency is crucial for maintaining stakeholder trust and support. By monitoring specific KPIs, potential risks and issues can be identified early, allowing for proactive measures to mitigate them before they escalate. At the conclusion of the project, KPIs provide a basis for evaluating its success. They offer measurable outcomes that can be compared against the initial objectives and targets. Post-project analysis of KPIs can yield valuable insights for future projects. Understanding what worked well and what didn't allow organizations to continuously improve their project management practices.

The KPIs must be SMART (specific, measurable, achievable, relevant and time-bound). They must provide the means for measuring the goals reached and the efficiency of critical processes linked to relevant business objectives.

Activity 3.2: Identification of strategic actions

Finally, concrete strategic actions must be defined. They should address strengths, weaknesses, opportunities, and threats (SWOT) in a way that aligns with goals and cover the elimination or reduction of the gaps identified in Phase 2, being ultimately aimed at achieving the objectives of Phase 1.

Turning insights from a high-level SWOT analysis into IT-related strategic actions involves leveraging strengths, addressing weaknesses, capitalizing on opportunities, and mitigating threats. These strategic actions should utilize key strengths (e.g. existing know-how, available human resources, and already existing IT solutions) to achieve business objectives. Building on what works is usually a safe bet that can additionally minimize costs.

71 Cem Sürücü *et al*., Establishing Key Performance Indicators for Measuring Software-Development Processes at a Large Organization, in Proceedings of the 28th ACM Joint Meeting on European Software Engineering Conference and Symposium on the Foundations of Software Engineering (ESEC/FSE 20: 28th ACM Joint European Software Engineering Conference and Symposium on the Foundations of Software Engineering, Virtual Event USA, ACM, November 2020), pp.1331–41, https://doi.org/10.1145/3368089.3417057.

The strategic actions should also attempt to improve or eliminate weak areas to bolster or restructure them.

The feasibility, risks, and potential benefits of each strategic option should be assessed. This evaluation should consider resources, time, and the external environment, to choose strategies that are most likely to succeed.

A SWOT matrix may be used to identify specific strategies like SO (Strengths-Opportunities) strategies that use strengths to capitalize on opportunities, or WT (Weaknesses-Threats) strategies that aim to minimize weaknesses and avoid threats. The SWOT analysis should be regularly updated to reflect changes in the internal and external environment and adjust strategies accordingly.

Turning a SWOT analysis into strategic action requires a deep understanding of a business and its context. It's important to be realistic about strengths and weaknesses, proactive about opportunities, and defensive against threats. Strategic planning is an ongoing process, so the strategies should be continually revisited and refined to ensure they remain aligned with the goals and external environment.

Activity 3.3: Development of IT balanced scorecard

The Balanced Scorecard (BSC)[72] is a management system that clarifies the strategy and vision of an organization, translating them into action that can be tracked. It's a way of understanding the performance of the department or entire organization – an alternate or preferred way to measure successful strategy implementation that goes beyond financials. In addition, a BSC is helpful in the prioritization of measurements that are most meaningful to the organization.

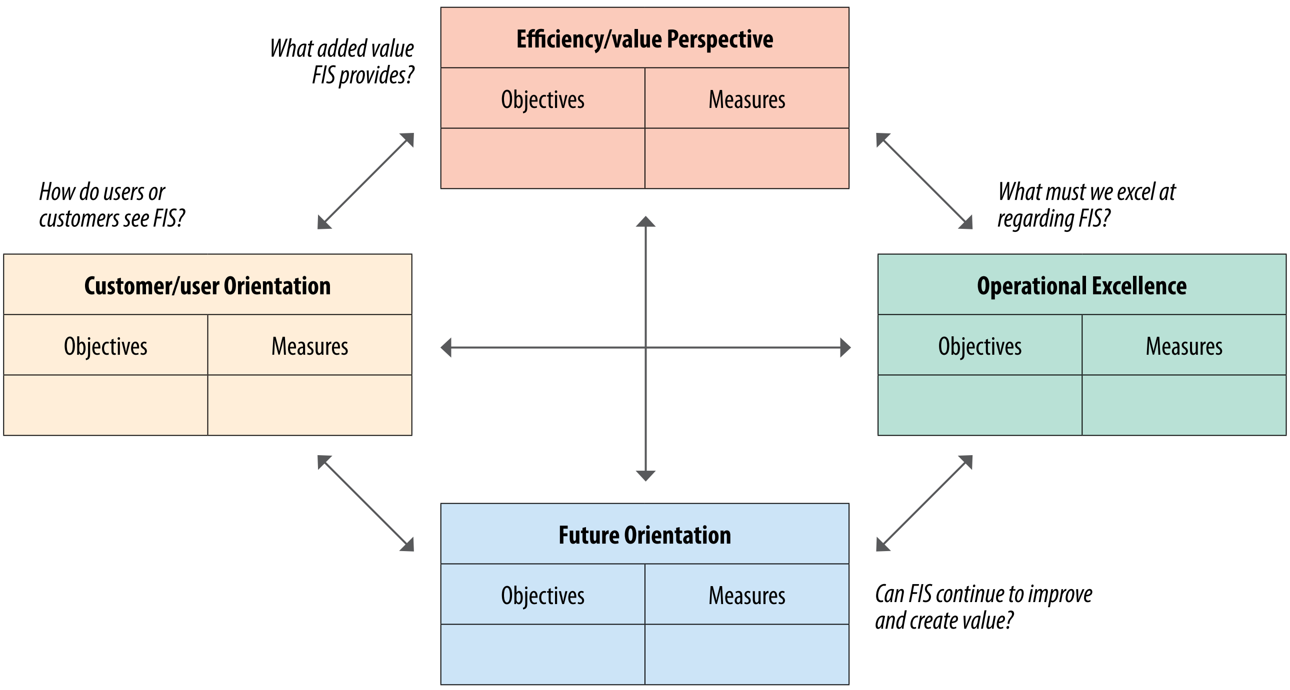
The original Balanced Scorecard defined four perspectives that help managers plan, implement, and achieve the business strategy:

1. **Financial Perspective**: tracking financial requirements and performance.
2. **Internal Business Process Perspective**: measuring critical-to-customer process requirements.
3. **Customer Perspective**: measuring the satisfaction and performance requirements of customers, as it applies to both the organization and what it delivers (products or services).
4. **Knowledge, Education, and Growth Perspective**: measuring how the organization educates employees, gains and captures knowledge, and uses this information to grow and stay competitive.

72 Robert S Kaplan and David P Norton, The Balanced Scorecard: Measures That Drive Performance, Harvard Business Review, vol. 70, no. 1 (January-February 1992), pp.71–79, Available at https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2.

FIGURE 16

IT Balanced Scorecard adapted to FIS

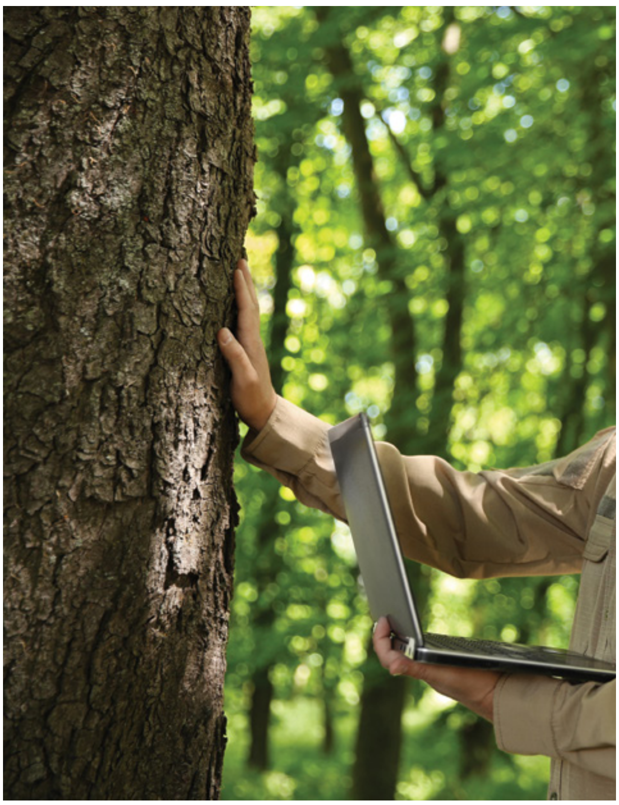


To maintain a BSC, all four areas must be evaluated consistently. Delaying examination or ignoring a metric entirely will lead to an unbalanced business situation with an inevitable and significant negative impact.

The BSC concept has been successfully employed in software engineering and IT projects[73]. The traditional BSC was adopted in several ways to better fit an IT environment. Van Grebergen[74] modified the four perspectives as follows:

1. Corporate Contribution.
2. Customer (User) Orientation.
3. Operational Excellence.
4. Future Orientation.

A more general approach could also be suitable in the public sector – see Figure 16.



73 Lj. Kazi, B. Radulovic, and Z. Kazi, Performance Indicators in Software Project Monitoring: Balanced Scorecard Approach, in 2012 IEEE 10th Jubilee International Symposium on Intelligent Systems and Informatics (2012 IEEE 10th Jubilee International Symposium on Intelligent Systems and Informatics (SISY), Subotica, Serbia, IEEE, September 2012), pp.19–25, https://doi.org/10.1109/SISY.2012.6339539.

74 Win Van Grembergen, The Balanced Scorecard and IT Governance, in Proceedings of the 2000 Information Resources Management Association International Conference on Challenges of Information Technology Management in the 21st Century (Conference: Challenges of Information Technology Management in the 21st Century, 2000 Information Resources Management Association International Conference, Anchorage, Alaska, USA, IT Governance Institute, May 2000), pp.1123–24.

Phase 4: IT tactical planning

In Phase 4, action plans (tactical plans) are formulated to achieve the IT and business strategies. This phase consists of the following activities:

1. Specifying strategic project(s).
2. Specifying necessary outsourcing, acquisition of IT resources and training.
3. Prioritizing projects and strategies.
4. Preparing a tactical plan.

The tactical plan should be regularly revised and confronted with the actual progress.

How the above activities are planned is largely dependent on local circumstances and planning environment. For this reason, only some guidelines are given below.

Guidelines for IT tactical planning

The components of the tactical plan are prioritized according to the current governance structure and to the effect expected. A cost-effectiveness analysis should ensure that the correct project portfolio and scope have been chosen[75].

Choosing the right approach and size for information system implementation is crucial for the success of FIS implementation. The approach should align with the organization's strategic objectives. A mismatch can lead to a system that does not support key business processes or fails to deliver expected benefits.

The scale of the project must be manageable within the organization's resource constraints. Overly ambitious projects can strain financial and human resources, while too small a scale may not adequately address business needs.

The success of an information system largely depends on user adoption. The chosen approach should consider the needs, skills, and acceptance levels of end-users. A system that is too complex or not user-friendly will face resistance, reducing its effectiveness. The approach and size should also reflect the organization's risk tolerance. Larger, more complex implementations are inherently riskier, with higher chances of delays, cost overruns, and failure to meet objectives.

The involvement of stakeholders in the development and implementation of an information system is a key factor for enhancing user adoption. Early stakeholder involvement helps in accurately capturing and understanding the actual needs and requirements of the end-users. This ensures that the software is designed to meet real-world challenges and is more likely to be embraced by its intended audience. When stakeholders are involved from the early stages, they develop a sense of ownership and commitment to the project. This emotional investment can lead to greater enthusiasm and support for the software, promoting its adoption. Stakeholders can act as change agents within their respective domains. Their involvement helps in preparing the ground for the changes that the new software will bring, thereby reducing resistance and facilitating smoother transition and adoption.

Continuous feedback from stakeholders during the development process can lead to improvements and refinements in the system. This iterative process helps in creating a product that is more aligned with user expectations and needs. Stakeholder involvement reduces the likelihood of misunderstandings and misinterpretations regarding the system's functionalities. Clear communication from the outset can ensure that the final product meets expectations, leading to higher satisfaction and adoption rates. By understanding the capabilities and limitations of the end-users, organizations can better plan for necessary training and support systems. Adequate training and support are crucial for encouraging the adoption and effective use of the software.

If not all elements of the FIS are necessary at once, a "supermarket approach" should be used, choosing only those needed for a situation or country. One should avoid the temptation to implement all possible elements of the FIS as seen in Figure 9.

The forest sector in each country certainly possesses its individual features, conditions, and limitations, which should be taken into consideration[76]. In this instance, the "supermarket approach" should be attempted, by choosing only the elements which are needed in a particular situation from the set of all possibilities.

The system should be scalable and flexible to adapt to future business changes. Choosing a system that is too rigid or small may require costly modifications or replacements as the business evolves. The approach should ensure compatibility and efficient integration with existing systems. Poor integration can lead to data silos, inefficiencies, and increased operational risks. Effective change management is critical in information system implementation. The approach should include strategies for managing the change process, training users, and providing support to ensure a smooth transition.

One of the most difficult aspects of FIS development is achieving consistency and effectiveness of the system within

75 EC DG DEVCO Evaluation Unit, Cost-Effectiveness Analysis, Capacity4dev, Available at https://europa.eu/capacity4dev/evaluation_guidelines/wiki/cost-effectiveness-analysis-0 (Accessed 26 October 2020).

76 H. M. Rauscher, D. L. Schmoldt, and H. Vacik, Information and Knowledge Management in Support of Sustainable Forestry: A Review, in Sustainable Forestry: From Monitoring and Modelling to Knowledge Management and Policy Science, K. M. Reynolds *et al.* eds. (Wallingford, CABI, 2007), pp.439–60, https://doi.org/10.1079/9781845931742.0439.

BOX 3
Think of alternatives

A recently developing concept of adaptive management indicate that it may be not feasible nor cost-effective to have complete solutions for problems in a complex multi-dimensional system like the forest sector. It is better to spend less on reaching optimal solutions for a problem and more on inventory and monitoring to detect failures as early as possible and on corrective measures. Such an approach might require creating new elements in an existing FIS to provide data for the new needs and limiting the scope of other elements with large costs and limited benefits.

the financial and organizational constraints of a country's forest sector. Much attention should be paid to thoroughly analysing existing processes and solutions and evaluating which should be kept as they are, which can be changed or modernized and to what extent, and which should be built anew. It is also advisable to carry out an analysis of funds available for building and maintaining FIS components.

Sometimes, a country may already have some functioning FIS, or its components. These should be analysed to determine how well they fit current expectations. If they fit well, they should be improved rather than replaced, as users will be accustomed to them. However, sometimes, for technical efficiency and compatibility with other components, the old system must be completely rebuilt whilst retaining its user interface and process structure.

The total cost of changes should be evaluated against potential gains. A thorough cost-benefit analysis should be conducted to ensure that the benefits of the new system outweigh the costs. This analysis helps in determining the appropriate scale and scope of the implementation. An often-overlooked aspect is the hidden cost of business processes not being fully aligned with how people and organizations see their roles and hove easily they can operate processes for which they are responsible.

Practical aspects of setting up the FIS development process

A gradual process usually works better. If possible, small steps, in the form of pilot and skunk projects should be taken, with investments made in those that prove effective. Management needs to align its roadmap and refine its digital vision in accordance with these smaller projects. Management and staff need clear rewards for making digital transformation a priority.

Even after careful analysis and identification of intervention areas and expected results, all FIS elements should not be implemented simultaneously. Implementation of new ICT tools must be closely aligned with organizational and procedural changes, and these are usually the hardest to achieve as they require modification of human behaviour. It is thus advisable to make use of the iterative development approach[77], which can also allow for the distribution of related costs in time.

It is best to identify the FIS components most needed by stakeholders since these will be more readily accepted. For instance, if there are difficulties in accessing necessary information by the highest-scoring impediment in the current state of affairs, it is recommended to start with building a general-purpose information repository (forest data bank) serving many stakeholders and processes. In another case, a single-purpose system with well-defined boundaries solving one problem can also be the system of choice. For example, if there is major concern about illegal logging, a timber-tracking system could be implemented first.

After successful deployment, those involved in the project will acquire experience, practical knowledge of difficulties, and technical and organizational expertise. These can be shared and applied during the next stages. Satisfied stakeholders will also spread the news about the successful solution, increasing the legitimacy of the FIS and making it easier to convince others in future.

Planning for long-term sustainability

Adjusting the organization to a new or improved information system

FIS development is a cutting-edge innovation, significantly advancing forest information management and bringing many benefits to policymakers, stakeholders, and society. However, to guarantee full functionality, users must construct the right technology and undergo organizational change. Success depends on those involved fully understanding both benefits and related requirements and accommodating them in action. Implementation of technical solutions cannot be separated from changes in, for example, procedures, guidelines and reporting formats. Sometimes, even legislative adjustments may be required. There is a need to invest in key-user training to create awareness of the system's capabilities and enable efficient use. It will only be successful if users are convinced it is a help, not a hindrance.

When implementing a new technical information system, various procedural and organizational changes may be required to ensure that the system effectively supports the business's operations and goals. The introduction of a new system often necessitates changes in existing workflows.

77 Larissa T Moss and Shaku Atre, Business Intelligence Roadmap: The Complete Project Lifecycle for Decision-Support Applications (Addison-Wesley Professional, 2003); Craig Larman, Agile and Iterative Development: A Manager's Guide (Addison-Wesley Professional, 2004).

For example, automating processes that were previously manual can streamline operations and require adjustments in how tasks are performed. Employees' roles may need to be redefined to accommodate the new system.

For instance, staff may take on more analytical roles if routine tasks are automated. Organizational policies, especially those related to data handling, privacy, and IT usage, might need revision to align with the capabilities and requirements of the new system. New systems often come with different security and compliance requirements, necessitating updates to existing protocols and training to ensure adherence.

Changes in communication protocols, such as how information is shared and reported within the organization, might be necessary to leverage the features of the new system effectively. The way data is collected, stored, accessed, and analysed may change significantly, requiring updates to data management procedures.

The availability of real-time data and analytics can lead to changes in how decisions are made and who is responsible for making them. In some cases, the introduction of a new information system may lead to a restructuring of teams or departments, especially if the system automates functions or creates new capabilities. The introduction of new technology can necessitate a shift in organizational culture, particularly in terms of attitudes towards technology, innovation, and change.

The system may introduce new ways of reporting and tracking work, requiring changes in how teams and departments report their activities and performance. The deployment of a new system might eventually lead to changes in how resources are allocated, particularly if the system automates tasks and frees up human resources for other activities.

Planning for system sustainability

The long-term sustainability of an information system is a critical aspect that organizations must consider. It encompasses not only the initial implementation but also ongoing maintenance, updates, and continuous improvement over time. Key factors contributing to this sustainability include stable funding mechanisms and ensuring a return on investment (ROI).

Regular funding is needed for system maintenance, software updates, and hardware upgrades to keep the system current and functioning optimally. Continuous investment in training and support ensures that staff can use the system effectively and that any issues are quickly addressed. Setting aside funds for risk management, such as dealing with cybersecurity threats, data breaches, and unexpected system downtimes, is crucial. Establishing a reserve fund can help the organization quickly address unforeseen issues related to the information system. As the organization grows, the system may need to be scaled up. Allocating funds for scalability ensures the system can handle increased loads and additional features.

It is crucial to ensure the FIS provides a good return on investment made for its development or upgrade. The long-term relevance of the FIS must be ensured. Regularly assessing the system's performance and relevance to current business needs ensures that it continues to provide value. Keeping up with technological advancements and integrating them into the system can prevent it from becoming obsolete. Continuously gathering and integrating user feedback helps to make necessary adjustments and improvements, ensuring the system remains user-friendly and effective.

Phase 5: **Iteration execution**

Finally, in Phase 5 the results of the planning are validated, and a given iteration is executed. This process is, again, largely environment specific.

Activity 5.1: Execute planned projects

Many project management methodologies exit, suitable for various project and product types, governance frameworks and organizational maturity. Advising on choosing them and the actual executing the project is beyond the scope of this publication. General information on design and development methodologies are given in Chapter V. For more detailed aspects the reader is directed to the rich business and management literature.

Activity 5.2: Review and validate project results

Reviewing and validating an information system project results is essential for assessing whether the project objectives, performance metrics, and user requirements have been met. This review often involves a systematic evaluation by project managers, team members, and other stakeholders, who check whether the deliverables align with the project plan and business goals. The review stage includes examining documentation, testing code, analysing system performance, and reviewing any changes made during the development cycle. User feedback may also be collected to measure satisfaction and usability. This stage may include internal reviews, pilot testing, or validation workshops, which help identify any errors, inconsistencies, or areas needing refinement.

Validation is a more rigorous process that confirms the project's outcomes meet organizational standards and function as intended in a real-world environment. For IT projects, validation includes a series of testing phases like unit tests, integration tests, and user acceptance testing (UAT), all of which ensure that individual components work seamlessly within the broader system. Load testing, security audits, and compliance checks may also be conducted to ensure the software meets performance and regulatory requirements. In some cases, pilot rollouts are conducted to test the solution with a subset of users, allowing for real-time feedback and further adjustments. Through validation, the organization confirms that the IT project results are not only technically sound but also ready for deployment and use by end-users.

Alongside each planned activity, every lesson learned is documented, filed and available for reference. Such measures are needed so that those involved can take advantage of past experiences and record the experiences to be used in future initiatives to improve governance.

The review and validation process helps to ensure that the IT project is aligned with the organization's strategic objectives, delivering tangible business value. By engaging stakeholders from different departments—such as IT, operations, and business development—the project team can confirm that the project outcomes are beneficial to all areas involved. This alignment is vital for gaining organizational support and for determining the project's ROI. Successful validation and review ultimately contribute to a smoother implementation, lower maintenance costs, and a higher likelihood of user adoption, ensuring that the project delivers sustainable value to the organization. Through validation, the project team gains confidence that the results are credible, actionable, and ready for broader dissemination.

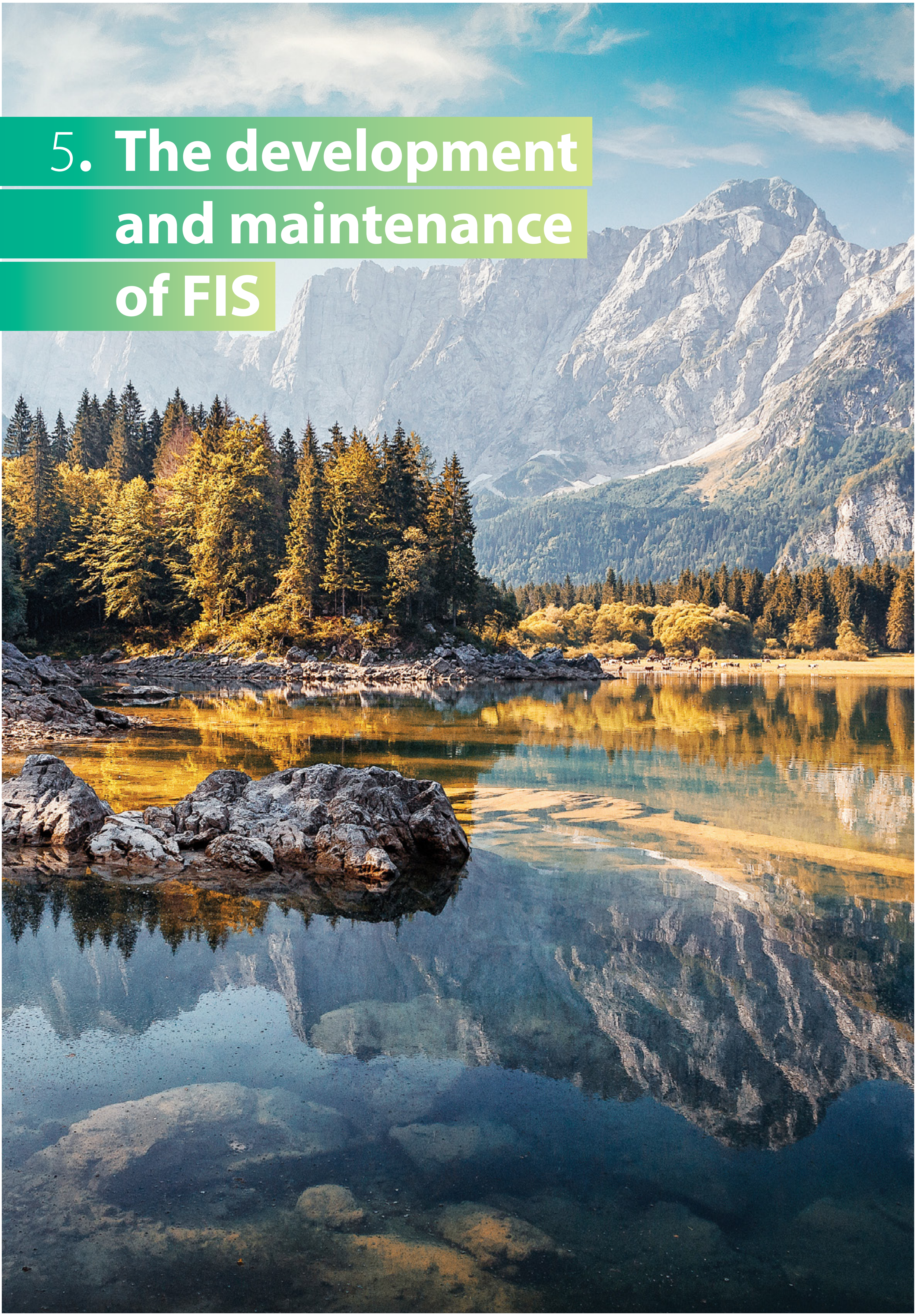
Activity 5.3: Disseminate project results

After a successful project execution, its results are disseminated.

Once an information system project is completed and validated, disseminating the results within the organization is key to maximizing its impact. Internal dissemination typically involves sharing results with relevant departments, such as IT, operations, finance, and senior management, to ensure that all stakeholders understand the system's capabilities and benefits. This can be achieved through presentations, workshops, or demonstrations, where the project team explains how the new system improves processes, enhances data accessibility, or contributes to strategic objectives. Documentation and training materials are also often distributed to support ongoing learning and to help users quickly adapt to the new system.

For the information system to deliver its full potential, broad organizational adoption is crucial. Using newsletters, intranet posts, and video tutorials can help maintain communication about the project's outcomes and demonstrate its practical value in various workflows. By showcasing user success stories or providing examples of efficiencies gained, the project team can encourage more departments to integrate the system into their daily operations. This kind of strategic dissemination fosters a culture of innovation, where employees see the value in leveraging new technology, and ultimately leads to higher productivity and data-driven decision-making across the organization. These activities help obtaining commitment of employees in the activities of project implementation and execution of acquisition strategies, outsourcing, and training.

5. The development and maintenance of FIS



5. The development and maintenance of FIS

This chapter focuses on practical aspects of the FIS development process. It aims to provide the reader from a forestry background with knowledge of the most important general aspects of IT project governance.

5.1. An example process for building FIS in the public sector

As discussed earlier, forest information systems can differ in size, scope, purpose, technological approach and the motivation to develop them. Obviously, there is no single procedural approach to building FIS. Here, an example process for building FIS is outlined, with the purpose of helping the reader to understand how the theoretical framework described in this publication might be applied in real life. It is by no means exhaustive and blindly following it would most likely bring disastrous results. It is a thought experiment to illustrate the practical meaning of some abstract concepts used in project management and software engineering.

5.1.1 An example high-level process to build a national FIS

A high-level decision to build a national forest information system supporting all key business processes taking place in the public forest sector is the first step of the process. The process itself will be quite complex, most likely stretching over many years. Proper control is essential for its success. Looking from a general perspective, the process of developing FIS consists of several stages, outlined below.

I. Governance

1. *Political decision to build FIS.*
2. *Appoint a coordinator* responsible for the whole programme.
3. *Create a steering committee.*

II. Needs assessment and planning

1. *Identify and invite stakeholders* including forest department officials, environmental experts, policymakers, local communities, and IT specialists.
2. *Analyse the current situation, needs, requirements and opportunities*, with the participation of all stakeholders. Conduct workshops and meetings with stakeholders to gather requirements. Focus on what they need from the system, such as tracking forest cover, monitoring wildlife, managing resources, or enforcing regulations.
3. *Perform a cost-benefit analysis* of options, considering resources available to develop and maintain FIS components.
4. *Conduct a high-level feasibility study*. Assess the technical, economic, and operational feasibility of the proposed system. Consider factors like budget constraints, technological infrastructure, and resource availability.
5. *Create a master plan*, defining a minimum viable solution, and options. This should identify desired FIS components, their purposes, their positions in the organizational structure, expected outcomes, and responsibility for operation and maintenance.

III. Strategic planning

1. *Build a roadmap*, choosing what to implement first considering the most urgent needs, available resources, and organizational capacity. The roadmap should include budget, resource allocation and the timeline of the whole endeavour as well as key milestones.
2. *Periodically assess the progress of work and make necessary strategic decisions*.

IV. Iterative project execution

1. *Carry out a single FIS component project*. This must be supervised by the coordinator to ensure compatibility with other FIS components and avoid functional duplication.
2. *Make necessary legislative and organizational changes*. Provide prerogatives and ensure funding for component maintenance.
3. *Evaluate results and modify the master plan as appropriate*.
4. *Repeat steps 1-3* as necessary.

5.1.2 Building a single FIS Component

Each individual project to build a single FIS component requires a controlled process, from requirements analysis, through solution development, and implementation to maintenance and development. Possible phases of such a process are outlined below.

I. Phase 1: Needs Assessment and Planning

1. **Stakeholder Identification:** Identify key stakeholders including forest department officials, environmental experts, policymakers, local communities, and IT specialists.

2. **Requirement Gathering:** Conduct workshops and meetings with stakeholders to gather requirements. Focus on what they need from the system, such as tracking forest cover, monitoring wildlife, managing resources, or enforcing regulations.
3. **Feasibility Study:** Assess the technical, economic, and operational feasibility of the proposed system. Consider factors like budget constraints, technological infrastructure, and resource availability.
4. **Project Plan Development:** Create a detailed project plan, outlining the scope, timeline, budget, resource allocation, and key milestones.

II. Phase 2: System Design and Development

1. **System Architecture Design:** Based on the requirements, design the system architecture. Decide on whether to develop a custom solution or modify existing platforms.
2. **Data Collection and Integration:** Plan for data collection (satellite imagery, on-ground surveys, historical data, etc.) and integration from various sources.
3. **Software Development:** Develop the software components, including user interfaces, databases, and analytical tools. Use agile methodologies for iterative development and testing.
4. **Security Measures:** Implement robust security measures to protect sensitive environmental data.

III. Phase 3: Testing and Validation

1. **System Testing**: Conduct extensive testing including unit testing, system testing, and user acceptance testing (UAT) to ensure the system meets all requirements.
2. **Stakeholder Feedback**: Involve stakeholders in the testing phase for their feedback and make necessary adjustments.
3. **Compliance Checks**: Ensure the system complies with all relevant environmental and data protection regulations.

IV. Phase 4: Implementation and Training

1. **Deployment:** Roll out the system in phases, starting with a pilot program in a selected region before a full-scale implementation.
2. **Training Programs:** Conduct training sessions for government officials, field staff, and other users. Focus on how to use the system effectively and how it integrates with their current work processes.
3. **Documentation:** Provide comprehensive user manuals and technical documentation.

V. Phase 5: Monitoring and Maintenance

1. **Performance Monitoring:** Regularly monitor the system's performance, focusing on system uptime, data accuracy, and user satisfaction.
2. **Feedback and Updates:** Continuously collect user feedback and make periodic updates and improvements to the system.
3. **Maintenance:** Establish a maintenance plan for troubleshooting, technical support, and updates.

VI. Phase 6: Evaluation and Enhancement

1. **Impact Assessment:** Periodically evaluate the system's impact on forest management, conservation efforts, and policy formulation.
2. **Scalability and Upgrades:** Plan for future scalability and incorporate advanced technologies like AI and IoT for enhanced forest monitoring and management.
3. **Stakeholder Engagement:** Keep engaging with stakeholders for their insights and to ensure the system continues to meet evolving needs.

VII. Collaboration and Sustainability

1. **Collaboration with Other Agencies:** Collaborate with environmental agencies, research institutions, and international conservation organizations for knowledge exchange and system enhancement.
2. **Sustainable Practices:** Ensure that the system promotes sustainable forest management practices and contributes to broader environmental goals.

5.2 Key aspects of information system design and development

5.2.1 Strategic system design

System design refers to the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements[78]. It is a broad field that can be applied to any complex system, but it is often used in the context of IT and software engineering. The goal of system design is to create a comprehensive blueprint that guides the development and implementation of a system.

Key aspects of system design include:

1. Understanding and defining what needs the system is supposed to fulfil.
2. Deciding on the high-level structure of the system, including how it will be divided into subsystems or modules and how these will interact with each other.
3. Designing the system's components, including how each component will work internally and how it will interact with other components.
4. Designing the interface in a way that is user-friendly and meets the requirements of the end-users.
5. Structuring the data that the system will use and manage, including database design and data relationships.
6. Designing security-related features, including authentication, authorization, data encryption, and secure communication.
7. Designing the network architecture, including network topology and protocols for systems that require networking.
8. Designing or selecting appropriate hardware configurations.

Additionally, the system should be designed in a way in which it can be scaled effectively with increased load and perform efficiently under expected and peak conditions.

It is imperative that the system design complies with relevant laws, regulations, and industry standards.

Creating an effective strategy is a highly intricate and challenging task that requires well-informed and analytical thinking. Developing a forest information system, especially at an organisational or national level, can be seen as a strategic effort in response to a high-stakes challenge. It should be coherent, coordinated, and adequate to the situation.

78 ISO/IEC/IEEE, ISO/IEC/IEEE 24765:2010, Systems and Software Engineering — Vocabulary (New York, NY, Institute of Electrical and Electronics Engineers, Inc., 15 December 2010).

According to Rumelt, "the core of strategy work is always the same: discovering the critical factors in a situation and designing a way of coordinating and focusing actions to deal with those factors"[79]. Its main elements are a diagnosis, a guiding policy, and a set of coherent actions. The first two have been covered in the previous chapters. Forest information system development is an actual action implementing some elements of the policy.

Strategic system design is a holistic approach to achieving strategic goals. It is the general plan of action to optimally develop a system under particular constraints. It is supported by using the same vocabulary for the entire problem domain, looking at the system from a strategic angle and using specific tools and standards, aligned with the external and internal environment of the system.

5.2.2 Design and development methodologies

Building an IT system is a complex undertaking that requires the cooperation of specialists from different disciplines and the right coordination and control. Good organisation of each stage of the work is needed to operate efficiently and effectively. However, excellent work organisation, which translates into speed and efficiency, requires choosing the right work methodology.

The IT project management methodology is designed to organise work quickly and easily while optimising all development activities. Nowadays, work methodologies, such as well-thought-out systems, organising work based on predetermined rules and guidelines, and tools and channels of communication within the team and with the client, are used on a large scale. The term methodology is very broad, as it largely refers to a certain philosophy or standard of conduct that significantly determines a high level of work order, employee motivation and work-life balance, which is reflected in efficiency.

Many approaches (methodologies) have been developed for creating and designing information systems which should be selected for each individual project:

- **Waterfall Model:** One of the earliest methodologies, it follows a linear and sequential approach where each phase (requirements, design, implementation, verification, maintenance) must be completed before the next begins. It's simple and easy to understand but lacks flexibility for changes.
- **Agile Methodology:** Agile approaches, such as Scrum and Kanban, focus on iterative and incremental development, where requirements and solutions evolve through collaboration between cross-functional teams. Agile approaches are highly flexible and adaptive to change, making them popular for dynamic projects.

79 Richard P Rumelt, Good Strategy/Bad Strategy: The Difference and Why It Matters (New York, Crown Business, July 2011), p.336.

- **Spiral Model:** This model combines the iterative nature of the Agile methodology with the controlled aspects of the Waterfall model. It allows for incremental releases of the product, or iterative refinement through each spiral, with a focus on risk assessment.
- **Rapid Application Development (RAD):** RAD emphasizes quick development and iteration of prototypes, rather than extensive planning and design. It's useful for projects that need to be developed within a short time frame.
- **Prototyping Model:** This approach involves creating quick and rough versions of a system, allowing users to give feedback that informs further development. It's effective in situations where user requirements are not well understood.
- **Structured Systems Analysis and Design Method (SSADM):** This is a waterfall-like method that involves detailed stages of system analysis and design, focusing on data and process modelling.
- **Joint Application Development (JAD):** JAD involves the client or end-user in the design and development process, through a series of collaborative workshops called JAD sessions.
- **Object-Oriented Design (OOD):** OOD is based on the concept of "objects", which are data structures that contain data, in the form of fields and code, in the form of procedures. This methodology is widely used for its modularity, reusability, and scalability.
- **Service-Oriented Architecture (SOA):** This approach designs the system as a collection of services that communicate with each other. The services can be reused and combined to meet various system requirements.
- **DevOps:** Although primarily a set of practices for efficient collaboration between IT operations and software development, DevOps influences system design by emphasizing automation, continuous integration, and quick feedback loops.

Each methodology has its strengths and weaknesses and is chosen based on the specific requirements, complexity, and scale of the project, and the need for flexibility in the development process.

5.2.3 Information system modelling

Information system modelling is an essential process in the development and analysis of information systems. It involves creating abstract representations of the complex structures and processes of an information system, helping to visualize and understand the system's components and their interactions. Different types of models and techniques are used for various aspects of information systems.

Data modelling focuses on how data is stored, accessed, and managed within the system. This process involves identifying the key data entities and their relationships, which is crucial for designing the database structure. Techniques like Entity-Relationship Diagrams (ERD) help in visualizing the data structure, making it easier to understand and modify. Data modelling ensures that data is organized efficiently, maintains integrity, and supports the business processes effectively.

Process modelling aims to understand and delineate the various business processes that the information system will support. It involves mapping out the workflow and the sequence of activities, often using tools like flowcharts or Business Process Model and Notation (BPMN). This form of modelling is essential for aligning the information system's functionality with the organization's operational needs. It helps in identifying potential bottlenecks, inefficiencies, and areas for improvement in business processes.

Object-oriented modelling is another foundational pillar, particularly in the realm of software development for information systems. This approach models systems based on the concept of "objects" – self-contained entities comprising data and behaviour. Object-oriented modelling uses concepts like classes, inheritance, and encapsulation, allowing for more modular and scalable system designs. Tools such as the Unified Modelling Language (UML) provide a standardized way to visualize the design of a system, including its classes, interactions, and internal processes.

Interface modelling defines how users will interact with the information system. It encompasses the design of user interfaces, including the layout, navigation, and accessibility features. This ensures that the system is not only functional but also user-friendly, catering to the needs and preferences of its end-users. In sum, the foundations of information system modelling are about creating a blueprint that guides the development of systems that are efficient, effective, and aligned with the overarching goals of the organization.

System dynamics modelling is used for understanding, designing, and re-designing complex systems. It uses feedback loops and time delays to understand the behaviour of entire systems.

Enterprise architecture modelling involves creating a detailed model of an organization's structure, processes, information systems, personnel, and business. Tools like ArchiMate can be used to model the relationships and dependencies between different aspects of the enterprise.

Each type of model serves a specific purpose and helps stakeholders, from business analysts to developers, to understand different aspects of the system, identify potential issues, and make informed decisions. Effective modelling is crucial for the successful planning, development, and implementation of information systems.

5.2.4 Information system implementation technologies

Information system implementation technologies encompass a broad range of tools, platforms, and methodologies used to bring designed information systems to life. These technologies are critical in translating theoretical models and blueprints into functional, efficient, and effective systems that support organizational operations and decision-making. The selection of appropriate implementation technologies is pivotal, as it directly impacts the system's performance, scalability, user experience, and overall alignment with business objectives.

One of the primary technologies in information system implementation are database management systems (DBMS). DBMS are crucial for storing, retrieving, and managing data efficiently. They support various data models, including relational, document-based, or graph databases, each suitable for different types of applications. Modern DBMS not only ensure data integrity and security, but also provide advanced functionalities like data replication, backup, and recovery. Technologies such as SQL (Structured Query Language) are used to interact with the database, allowing for the manipulation and retrieval of data in line with the system's requirements.

A vital technology area is application development frameworks and programming languages. These tools provide the necessary environment and building blocks for developing the system's software components. Languages such as Python, Java, and C# are widely used for their versatility and robustness, but there are many others, each suited for different purposes and needs. Frameworks like .NET, Django, and Angular offer pre-built components and libraries, speeding up the development process and ensuring consistency in code quality. The choice of language and framework often depends on the system requirements, scalability needs, and the existing technology stack of the organization.

Middleware acts as a bridge between different software applications, databases, and the underlying network infrastructure. Middleware facilitates the smooth interaction of disparate parts of an information system, ensuring seamless data exchange and integration. It includes web servers, application servers, and message-oriented middleware. This technology is particularly crucial in complex systems where various applications and services must communicate and operate in a coordinated manner.

Cloud computing has revolutionized information system implementation by offering scalable, on-demand computing resources. Cloud platforms like AWS (Amazon Web Services), Microsoft Azure, and Google Cloud provide a range of services including computing power, storage, and databases, all accessible over the internet. These platforms enable rapid deployment, scalability, and flexibility, allowing businesses to adjust resources based on their changing needs. Cloud solutions support various deployment models such as public, private, or hybrid clouds, offering choices in terms of cost, control, and security.

Lastly, DevOps tools and practices play a significant role in the efficient and effective implementation of information systems. DevOps brings together software development and IT operations, aiming to shorten the system development life cycle while delivering features, fixes, and updates frequently and reliably. Tools for continuous integration and continuous deployment (CI/CD), such as Jenkins and GitLab, automate aspects of the development process, enhancing efficiency and reducing the likelihood of errors. Infrastructure as code (IaC) tools like Terraform and Ansible allow for the automatic setup and management of the IT infrastructure, making the system implementation process more reproducible and consistent.

Information system implementation technologies are diverse and ever evolving, requiring careful selection and integration to build systems that meet organizational needs effectively.

5.3 Information system maintenance

Information system maintenance is a crucial aspect of the software lifecycle, ensuring that systems continue to function correctly, meet new requirements, and adapt to changing environments. It is, in simple terms, the modification of software after delivery to correct errors to improve the performance or other properties of its systems.

Key software maintenance issues in IT systems include both management and technical issues. Important management issues are alignment with customer priorities, adequate staff to maintain the systems, and cost estimation. The key technical issues are limited understanding, impact analysis, testing, measuring system maintainability, and infrastructure maintenance.

Only about 20 per cent of all maintenance work is spent on correcting errors in the software. The remaining 80 per cent is spent adapting existing systems to changes in their external environment, making enhancements requested by users, and reengineering an application for future use[80].

Information system maintenance encompasses a variety of activities, from routine updates to complex restructuring.

Corrective maintenance involves fixing errors and defects in the software. These issues can range from minor bugs affecting user experience to critical flaws impacting system functionality. Corrective maintenance is reactive; it addresses problems as they arise. Regular monitoring and user feedback are essential for identifying these issues promptly. By resolving these issues, maintenance teams ensure the system remains functional and reliable.

Adaptive maintenance refers to modifying the system to cope with changes in the environment, such as hardware upgrades, changes in data formats, or integration with new systems or software. This type of maintenance is crucial for ensuring the system remains compatible and efficient in a rapidly evolving technological landscape. It requires a proactive approach, anticipating potential environmental changes and preparing the system accordingly.

Preventive maintenance, also known as proactive maintenance, aims to identify and correct potential issues before they cause problems. This could involve refactoring code, optimizing performance, or updating documentation. Preventive maintenance helps in reducing long-term costs and avoiding system downtime. It requires a strategic approach, analysing system performance, and usage patterns to identify areas for improvement.

Perfective maintenance focuses on enhancing the system by adding new features, improving user interfaces, or enhancing system capabilities. It's driven by user feedback and changing business requirements. Perfective maintenance helps to keep the system relevant and aligned with user needs and expectations. This type of maintenance often involves collaboration between the development teams and end-users to understand and implement the desired enhancements effectively.

Proper documentation is critical in maintenance. It ensures that the maintenance team has the necessary information about the system's design, functionality, and history of changes. This is especially important for long-lived systems where communication with original developers may no longer be possible. Knowledge transfer activities, such as training sessions and detailed documentation, are essential for efficient maintenance.

Security maintenance: as cyber threats evolve, maintaining the security of information systems becomes increasingly important. This includes regular updates to address vulnerabilities, monitoring for security breaches, and implementing improved security protocols. Security maintenance is critical for protecting sensitive data and maintaining user trust in the system.

Finally, an often-overlooked aspect of maintenance is cost management. Maintenance activities can become costly, especially for older systems where changes might require significant effort. Balancing the costs of maintenance with its benefits is crucial for decision-making regarding system upgrades, replacements, or retirement. Effective cost management involves regular review and assessment of maintenance activities, prioritizing tasks based on their impact and necessity.

80 Roger S Pressman, Software Engineering: A Practitioner's Approach, 5th ed. (New York, McGraw-Hill, 2001), p.805.

Annexes

Annex 1:
Case Example – Russian Federation

A1-1 Forest Governance and Structure of the Forestry Sector

The responsibility for the protection, preservation, and regeneration of forests has been assigned to the authorized state authorities of the Russian Federation that oversee forest management, as outlined in Articles 81-83 of the Forest Code of the Russian Federation (Figure A1-1).

A1-2 Legislative framework

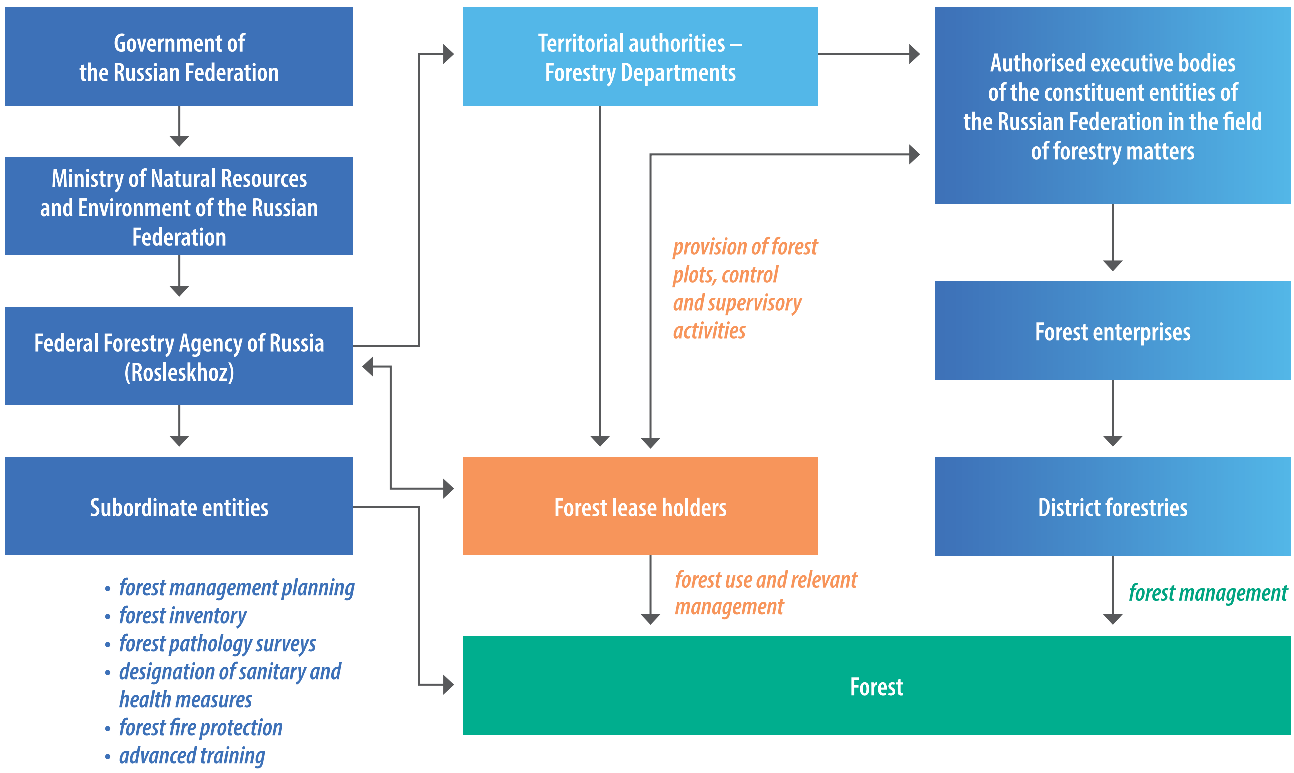
The Forest Code of the Russian Federation (Federal Law No. 200, dated 4 December 2006) represents the principal legislative enactment that delineates the fundamental principles and regulations that govern the management of forests. This includes the use of the Unified State Automated Information System for Timber Accounting and Transactions (ЛесЕГАИС).

The fundamentals of state policy in the field of use, protection, and restoration of forests in the Russian Federation for the period up to 2030 (Order of the Government of the Russian Federation of 26 September 2013 No. 1724) specifies the use of IT when addressing the issues of forest protection against fires, pests and diseases as well as other adverse factors, and combating illegal logging. To achieve these objectives, databases that contain the relevant information regarding the state, usage, protection, and reproduction of forests are used.

Russian Federation Presidential Executive Order No. 1816 (dated November 7, 2020) specifies:

- The creation of the unified Federal State Information System of the Forest Sector (ФГИС ЛК), and also to ensuring the traceability of timber from the place of its harvesting to the production facilities, and in case of their export from the Russian Federation, - to the moment of export.

FIGURE A1-1
Structure of the forest sector in the Russian Federation



- The digitalisation of the State Forest Register.
- The digitalisation of accompanying documents (ЭСД) on timber and products of wood processing that assure compliance with the national law on harvesting and processing.
- Establishing the procedure for interaction of the forest sector information system with other state and municipal information systems, including federal information systems of law enforcement agencies, tax authorities of the Russian Federation and customs authorities of the Russian Federation.
- Ensuring the automatic transfer of information on exported timber and wood products from Forestry Information System (IS) to Customs IS.

Federal Law No. 3, dated February 4, 2021, on Digital Transformation of the Forest Sector, provides for the introduction of a Federal State Information System of the Forest Sector (ФГИС ЛК). The system will contain up-to-date data on the composition and boundaries of forest fund lands, protective forests, forest roads, maps, as well as forest development projects, timber transactions, etc.

"On the Development Goals of the Russian Federation through 2030 and for the Future Until 2036" (Russian Federation Presidential Executive Order dated May 7, 2024) includes, among other national goals and priorities, a comfortable and safe living environment, environmental well-being, digital transformation of state, and municipal administration, economy and social sphere.

A1-3 Development of forestry information systems in The Russian Federation

In the 1960s, automated mapping systems, which were the prototype of the first geographic information systems (GIS), were put into operation.

During the 1970s and to the 1980s, with the advent of the first computers, comprehensive automation of the processes of collection, processing, and analysis of all forest reporting began. Aerial inventory was replaced by multispectral air photo interpretation.

In 1980, the Order of the Ministry of Forestry of the RSFSR established the Main Information and Computing Centre of the Ministry of Forestry of the Russian Soviet Federative Socialist Republic (later renamed Roslesinforg). This was done for the purpose of comprehensive automation of forest reporting processes, including collection, processing, and analysis.

In 2005, the Forest Fires Remote Monitoring Information System (ИСДМ) was launched. The data stored in this system is used by various agencies for rapid response and control of fire situations throughout the country and across all categories of land.

Between 2012 and 2014, organizations from the Federal Forestry Agency of the Russian Federation were connected to the unified System of Interdepartmental Electronic Interaction (СМЭВ). This system ensures the interaction of information systems between government agencies, establishing electronic document flow between federal and regional forestry institutions.

In 2013, the Automated Information System of the State Forest Register (АИС ГЛР / AIS GLR) was launched. The State Forest Register (SFR) is a systematized set of documented information on forests, including their use, protection, reproduction, and forestry units. The AIS GLR system has three levels: federal, regional, and forestry districts.

In 2016, the Unified State Automated Information System of Timber Accounting and Transactions (ЛесЕГАИС / LesEGAIS) was put into operation.

In 2022, electronic accompanying documents (ЭСД) became mandatory for the transportation of timber and wood processing products. These e-documents are one of the data sources for the digital system of timber traceability, which tracks timber from the plot to the forest warehouse and further to timber processing facilities or export. The data from these accompanying e-documents is stored in the LesEGAIS system and is used for inter-agency interaction with customs authorities and law enforcement bodies.

In 2023, the Federal State Information System of the Forest Sector (ФГИС ЛК/ FSIS FS) underwent testing in 30 constituent members of the Russian Federation. The test allowed for checking and improving the system's functionality.

By 2024, all constituent entities of the Russian Federation are connected to the FSIS FS system, which is a digital platform combining state services and data on the forest fund and timber turnover.

A1-4 Examples of federal-level forest information systems

In federal-level forest management processes, information from many sources is used, inter alia:

- State Forest Inventory.
- State Forest Register (ГЛР).
- LesEGAIS (ЛесЕГАИС).
- Territorial Bodies of Federal Forestry Agency of the Russian Federation.
- Forest Tenants.
- Forest Health Monitoring.
- Forest Fires Remote Monitoring Information System.
- Federal State Information System of the Forest Sector.

A1-4.1 The Unified State Automated Information System of Timber Accounting and Transactions (ЛесЕГАИС/ LesEGAIS)

The goal of the system is to ensure control over the turnover of timber and lumber, to combat illegal timber transactions, and to maintain accurate records of timber and timber-related activities. By implementing strict oversight, the system aims to protect the legal timber market and promote transparency in the industry.

The scope of the system covers all processes involved in the turnover of timber within the Russian Federation. This includes everything from logging operations to the sale of processed timber products to the final consumer. The system is designed to monitor each stage of the supply chain, ensuring compliance with regulations and preventing illegal activities.

All participants in the timber and lumber industry are required to register in the LesEGAIS system. This includes producers, forest tenants, importers, exporters, and consumers. Registration ensures that every entity involved in the turnover of timber and lumber is accounted for, enabling better tracking and regulation of timber transactions.

LesEGAIS serves several main functions, including:

- Ensuring the completeness and reliability of data on turnover-related logging operations.
- Improving the accuracy of accounting for imported wood products and sawn timber.
- Analysing the state and prospects of timber production and sales.
- Providing reliable information on producers and forest leaseholders.
- Preventing illegal trade.

The following information is displayed in the LesEGAIS forest system:

- Data of organizations.
- Data of individuals.
- Lease agreements for forest plots, sale and purchase agreements of forest stands.
- Forest declarations.
- Reports on forest use.
- Declarations on transactions.
- Data on the volume of timber received.
- Information on timber marking.

LesEGAIS data is publicly available on the Internet. LesEGAIS interacts with information systems of law enforcement and tax bodies.

A1-4.2 Forest Fires Remote Monitoring Information System (ИСДМ-Рослесхоз)

The Forest Fires Remote Monitoring Information System, developed by the Federal Forestry Agency of the Russian Federation, is designed to monitor and track forest fires, ensuring the accuracy and reliability of fire-related data. The system provides tools for detecting forest fires, assessing their scale, and forecasting fire risks based on current weather conditions. This capability enables timely responses and effective fire management across the Russian Federation's vast forested areas.

The system covers forests on forest fund lands throughout the Russian Federation, as well as other categories of land where forest fires might occur. It serves as a comprehensive monitoring tool, providing essential information to aid in fire prevention and response efforts.

The system displays a range of critical data, including maps of hotspots, information on the area of forest land damaged by fire, the number of active hotspots, and air temperature anomalies. Additionally, it provides information on responses to fires and includes detailed descriptions and classifications of the fires, offering a complete overview of the situation to support effective decision-making.

The information provided by this system is mainly used for:

- Assessment of fire danger on forest lands.
- Monitoring the occurrence and dynamics of forest fires.
- Data support and decision-making.
- Assessing the efficiency of monitoring and firefighting.
- Forecasting of fire danger.
- Control over the consequences of forest fires, including assessment of the areas covered by fire and forest cover damage.
- Preparation and update of the relevant statistics.

The online version of the system is open for registered users of the Federal State Information System "Unified Portal of State and Municipal Services"[81], commonly referred to as "Gosuslugi" (Госуслуги). Citizens can access a map of hot spots, learn about temperature anomalies, and get a report on the area of forests affected by fire.

This Forest Fire IS provides for inter-agency interaction with authorities on emergency situations, space, science, hydrometeorology and environmental monitoring.

81 The platform providing online access to information about state and municipal services in the Russian Federation for individuals and legal entities.

A1-4.3 The Federal State Information System of the Forest Sector of the Russian Federation (FSIS FS)

FSIS FS is currently being developed. It is designed as a unified platform to provide information and analytical support for forest-related activities. It will become a digital platform that brings together dozens of state services, data from the State Forest Register, State Forest Inventory, LesEGAIS, as well as relevant data on the use, forest fire protection, forest pathology monitoring, forest reproduction, afforestation, timber accounting and traceability, accounting for information on timber transactions (more than 500 types of processes).

FSIS FS will be incorporated into the information systems of other state agencies.

A1-4.4 "Unified Portal of State and Municipal Services (Госуслуги)" Federal State Information System

A number of forestry-related services are provided via the "Unified Portal of State and Municipal Services (Госуслуги / Gosuslugi)" Federal state information system. It is a portal providing access for individuals and legal entities to information on state and municipal services in the Russian Federation. Via the Unified Portal, the Federal Forestry Agency of the Russian Federation provides certain services, *inter alia*:

- Approval of documentation on territory planning.
- State expertise in the forest development projects.
- Attestation of specialists who perform works on the allotment and taxation.
- Attestation of specialists who carry out forest management activities.

A1-4.5 Unified State Information System for Recording the Results of Civilian-Usage Research and Technology (R&D IS)

In order to record and manage R&D activities, the Federal Forestry Agency of the Russian Federation is integrated into the Unified State Information System for recording the results of civilian-usage research and technology (R&D IS).

The objectives of R&D IS are:

- Accounting of data on research and development in all fields of knowledge in the Russian Federation.
- Provision of information to all stakeholders on the results of research and development, and technological works.
- Planning, expertise, monitoring and evaluation of scientific research and development.

Annex 2: **Case Example – Kyrgyz Republic**

A2-1 Forests and forest industry in the Kyrgyz Republic

The forests of the Kyrgyz Republic, while covering a relatively small percentage of the country's total land area (1253.8 million ha which is 6,3% of the land area)[82], are nonetheless vital to its ecological balance and cultural heritage. Predominantly located in the mountainous regions, these forests are diverse, ranging from high-altitude coniferous woods to lush, fruit-bearing lowland groves. The Tien Shan and Pamir-Alai mountain ranges, in particular, are home to unique species such as the Tien Shan spruce and the walnut trees of the Jalal-Abad region. These forests not only provide critical habitat for wildlife but also play a significant role in soil conservation, water regulation, and climate moderation. The walnut forests, especially, are globally renowned for their biodiversity and are part of the ancient Silk Road, contributing to the country's historical heritage[83].

The forestry sector in the Kyrgyz Republic, though facing challenges, is a significant part of the rural economy and environmental conservation efforts. The sector is governed by the state, with a focus on sustainable management and conservation practices. However, issues such as illegal logging, limited resources for forest management, and climate change pose threats to the sustainability of these forests. Community-based forestry initiatives have been gaining traction, empowering local communities to participate in forest management actively. These initiatives aim to balance ecological needs with economic benefits, promoting agroforestry and sustainable harvesting practices. Additionally, the sector contributes to the economy through the production of timber, non-timber forest products, and ecotourism, while also serving as an important cultural and recreational resource for the Kyrgyz people[84].

Recently, a great effort to increase the forest cover has been undertaken. After decades of Soviet economy, when the forest cover fell from 6% in 1930 to 3.09% in 1966, this trend has been reversed, with forest cover reaching 6.27% in 2022.[85] The official forest policy aims at further increasing the forest cover up to 6.5% and the share of the forestry sector in the country's Gross domestic product (GDP) to 1% by 2040[86].

All forests in the Kyrgyz Republic are state property. They are governed by the Ministry of Agriculture, which supervises a dedicated agency named the Forest Service. The Forest Service consists of 41 forest management units (forest districts) and a forest protection station.

A2-2 Digitalisation in the Kyrgyz Republic

A2-2.1 Strategic policies related to digitalisation

Digitalisation is the main direction of today's global development. The Kyrgyz Republic is in the process of active digitalisation of its economy, management system, education, social sphere, and other sectors.

Since 2016, the Kyrgyz Republic has been purposefully working on the implementation of e-governance and digitalisation of the country. Based on the provision of the Constitution of the Kyrgyz Republic stating that the development of society and the state is based on scientific research, modern technologies, and innovations, the President and the Supreme Council (parliament) have been consistently implementing the policy of innovative development of the digital economy. In 2017, the Laws of the Kyrgyz Republic "On Electronic Governance" and "On Electronic Signature" were adopted, with amendments made to the Laws of the Kyrgyz Republic "On Personal Information", "On State and Municipal Services", and "On Access to Information Under the Authority of State Bodies and Local Self-Government Bodies". In 2018, the Government of the Kyrgyz Republic decided to launch the "Tunduk" system, which is one of the key elements of e-governance. Several bylaws on the implementation of the Tunduk system were adopted and its operator was appointed.

On October 12 October 2021, the Decree of the President of the Kyrgyz Republic "On the National Development Programme of the Kyrgyz Republic until 2026" was issued. In the area of digitalisation and development of digital infrastructure - it has stipulated that digital technologies will be introduced into all spheres of life. For this purpose, in addition to the formation of basic digital skills and the building of a favourable environment, it is necessary to create appropriate infrastructures and systems. Accessibility of communication services for all categories of citizens, including groups

82 Forest Service of the Kyrgyz Republic, Картографические Материалы и База Данных Лесных Ресурсов Лесная Служба, Available at https://forest.gov.kg/en/lesoustroistvo/map-data.

83 Asyl Undeland, The Development Potential of Forests in the Kyrgyz Republic (Washington, DC, Program on Forests (PROFOR), May 2012).

84 Aidai Zhumasheva, Forest Dependency of Local Communities and Management for Nut and Fuelwood Production in Jalalabad Oblast, Kyrgyzstan, Master's Thesis, Seoul National University, 2022, Available at https://s-space.snu.ac.kr/bitstream/10371/187927/1/000000172796.pdf.

85 Forest Service of the Kyrgyz Republic, Картографические Материалы и База Данных Лесных Ресурсов, Лесная Служба.

86 Government of the Kyrgyz Republic, Concept of Development of the Forest Sector in the Kyrgyz Republic until 2040 [Концепция Развития Лесной Отрасли Кыргызской Республики На Период До 2040 Года], Pub. L. No. 231 (May 2019), Available at https://www.fao.org/faolex/results/details/en/c/LEX-FAOC196023/.

with special needs, based on the principle of "step-by-step accessibility", and overcoming the digital access gap will be fundamental to public policy.

The Ministry of Digital Development of the Kyrgyz Republic is a state executive body that develops and implements the state policy (see AnnexA1-1) in the field of digitalisation, e-governance and e-government.

A2-3 Digitalisation of the Kyrgyz forest sector

A2-3.1 Forest information system of the Kyrgyz Republic

A comprehensive forest information system for the Forest Service is currently under development. The system is centralized, and available to its users via a web interface. It is planned to cover all areas of activity (business processes). Tablets have been purchased for forestry managers to enable them to use the system in the field.

The automation and digitalisation of the forest inventory processes have been planned, with the National Forest Inventory already carried out using tablets. Another area to be digitized is the sales of forest products (e.g. permits for cattle pastures).

The first step of the FIS development was to compile a database of forest lease holders. A forest management planning module is being currently developed. GIS technology is employed to prepare forest maps by forest management planning organizations, with appropriate workflows to exchange data remaining to be organized.

The Kyrgyz Republic has a national information system, called "Tunduk", hosting all state services. The forest information system will be connected to Tunduk.

There are several web portals operated by the Forest Service:

Information web portal on the Kyrgyz forests (forest.gov.kg), containing a map of forest management enterprises, detailed information on every enterprise, and separate sections for each self-managed enterprise.

Internal portal of the Forest Service ISUL, holding and sharing information on the forest enterprises for the purposes of various public administration units, and forest enterprise management system with plans of activities, registering activities, reports etc. ISUL processes field data and generates summarised data for reporting, which allows timely preparation of reports at the republic level and monitoring. Additionally, ISUL, designed to automate information exchange between the Forest Service and other government agencies within the framework of the Tunduk system, provides access to information on the state of forests and the activities of the Forest Service for all interested organisations and the public.

Afforestation portal "Green Heritage" (planting.forest.gov.kg), providing planning and progress monitoring of afforestation activities. It helps coordinate afforestation projects and activities. It contains information on forest areas of the Kyrgyz Republic and their seedling planting needs, so that interested individuals and legal entities can provide assistance in the form of financial aid for forest restoration in the Kyrgyz Republic, or directly participate in tree planting. The platform enables targeted restoration works and makes a significant contribution to the restoration of the Kyrgyz Republic's forests.

A2-3.2 Forest Atlas

The Forest Atlas was an effort to create a complete digital map of forests in the Kyrgyz Republic. The first step was to identify and gather all available spatial and non-spatial forest, and land-use data available within the government entities. From there, the team was able to assess what additional information was needed and dedicate time and resources to filling data gaps and improving the quality of the data.

The resulting product has become the base of other forest information systems in the country. Ministries contributing data, and other ministries such as the Ministry of Economy, Planning and Regional Development (MINEPAT), as well as non-government organizations, civil society groups, universities and research institutions, have also requested Forest Atlas products.

A2-3.3 Challenges in the digitalisation of the forest sector

The state still faces several challenges in improving digitalisation in the forest sector.

The instrumental and methodological aspects of the existing digitalisation policy should be updated and enhanced. The process of introducing of digital technologies and digital platforms in the management of different areas in the forest sector is difficult and requires changes in workflow and the processing of information. A development of a system of digital identification of tree species is needed. Data management standards must be improved, ensuring the availability of information necessary for administration. Automated timber volume calculation algorithms should be developed and introduced to practice.

A2-4 Information systems in nature protection

Forests belong to the following land use categories: 1) forest fund, 2) protected areas, 3) pastures, 4) hunting grounds. There are 50 hunting grounds, supervised by the ministry. They are leased commercially by private persons.

The following databases exist or are planned:

- Data on protected areas (exists).
- Data on the occurrence of wild animals (exists).
- Data on the occurrence of plants (planned).

These datasets are inventoried once a year. Two websites will be developed with the help of the Kyrgyz University to provide decision-makers and other state institutions with appropriate reports, including statistics.

A process of transformation of the land use cadastre is under way, aiming to establish land use forms for all grounds.

A2-5 Common IT and data infrastructure

A state-owned commercial company under the name of AgroSmart is responsible for the IT support of the Ministry of Agriculture. It is currently carrying out several projects: building a CRM/ERP system, improving the networking infrastructure, building a single web portal for all public services for Kyrgyz citizens, and creating a digital marketplace for selling goods and ecosystem services by farmers and forest lease holders. While Geospatial data is created and managed in subordinate agencies, it will be kept in the main GIS portal covering all agricultural lands. Agriculture data is a priority due to the issue of food security and the need to monitor exports and imports, with data on forests and pastures due to be included at a later stage.

Land cadastre and land-use registry are held by a state-owned company "Kyrgyzgiprozem" (Land Management Institute/ Enterprise). Its main area of activity is land-use inventorying and geobotanical analyses. An important asset is a large archive of land use which has been collected for 80 years. The company has field offices in every oblast, usually employing 10-15 people (15-20 in the south). There are also specialized units:

- For soil inventory, performing soil analyses, soil laboratory assessments, and establishing soil productivity indices.
- For monitoring of pastures, methodology included traditional methods for assessing pasture condition (a remnant from soviet times), and modern methods, such as remote sensing.

In the last 3 years, low-productivity pastures have been identified and mapped.

There are 7 land-use categories in the Kyrgyz Republic:

1. Agricultural (including in-field trees).
2. Forest.
3. Water.
4. Transportation.
5. Industrial.
6. Urbanized.
7. Reserve (mountains, rocks).

When establishing boundaries between land types Kyrgyzgiprozem collaborates with the Forest Service. After they are agreed upon, the data on borders are stored both in Kyrgyzgiprozem and the Forest Service. There is no digital database of land use borders. Different map formats are used (e.g. by the Forest Service, municipalities etc.). Efforts have been made to unify maps, introducing the national Kyrgyz coordinate system. The land cadastre does use this coordinate system; however, the Forest Service has its own coordinate system, with efforts made to gradually switch to the national system since 2010. A country-wide orthophoto map has been prepared in the national system. Comprehensive standards are currently under development to ensure consistency and quality across all processes. A working group has been created, with the participation of 22 ministries and other agencies, on the development of the national spatial data infrastructure.

Two map portals have been created: KyrgyzMap.KG hosting background maps, and nsgi.kg hosting thematic maps and Web Feature Services (WFS) and the Web Map Services (WMS). The regulation on building a national spatial data infrastructure was adopted in December 2022.

Annex A2-1

Current legislation related to digitalisation in the Kyrgyz Republic

The principal elements of the current legislation related to digitalisation and e-governance include:

1. Law of the Kyrgyz Republic "On e-Governance" dated 19 July 2017 No. 127.

2. Law of the Kyrgyz Republic "On Electronic Signature" dated July 19, 2017 No. 128.

3. Law of the Kyrgyz Republic "On Innovative Activity" dated 26 November 1999 (later amended on 1 April 2020).

4. Law of the Kyrgyz Republic "On Virtual Assets" dated 21 January 2022 No. 12.

5. Law of the Kyrgyz Republic "On Electronic Commerce" dated 22 December 2021 No. 154.

6. Law of the Kyrgyz Republic "On Electric and Postal Communications" dated 2 April 1998 No. 31.

7. Law of the Kyrgyz Republic "On Access to Information under the jurisdiction of State Bodies and Local Self-Governance Bodies of the Kyrgyz Republic" dated 28 December 2006 No. 213.

8. Law of the Kyrgyz Republic "On Public Procurement" dated 3 April 2015 No. 72.

9. Law of the Kyrgyz Republic "On Information of Personal Nature" dated 14 April 2008 No. 58.

10. Law of the Kyrgyz Republic "On Biometric Registration of Citizens of the Kyrgyz Republic" dated 14 July 2014 No. 136.

11. Law of the Kyrgyz Republic "On National Security Bodies of the Kyrgyz Republic" of 2022 No. 57.

12. Decree of the President of the Kyrgyz Republic "On the National Development Programme of the Kyrgyz Republic until 2026" of 12 October 2021 UP No. 435.

13. Decree of the President of the Kyrgyz Republic "On Further Measures of Digital Transformation of the Kyrgyz Republic" dated 21 July 2021 No. 305.

14. Decree of the President of the Kyrgyz Republic "On Urgent Measures to Enhance the Introduction of Digital Technologies in Public Administration of the Kyrgyz Republic" dated 17 December 2020 UP No. 64.

15. Decree of the Cabinet of Ministers of the Kyrgyz Republic "On Approval of the Action Plan of the Cabinet of Ministers of the Kyrgyz Republic for the Implementation of the National Development Programme of the Kyrgyz Republic until 2026" dated 25 December 2021 No. 352.

16. Resolution of the Cabinet of Ministers of the Kyrgyz Republic "On Establishment of the State Institution "Project Office" dated 16 August 2021 No. 137.

17. Resolution of the Government of the Kyrgyz Republic "On Approval of the Rules of Use of the State Portal of Electronic Services" dated 7 October 2019 No. 525.

18. Resolution of the Government of the Kyrgyz Republic "On Approval of Requirements for the Protection of Information Contained in the Databases of State Information Systems" dated 21 November 2017 No. 762.

19. Resolution of the Government of the Kyrgyz Republic "On Approval of the Regulations on the State Electronic Payment System" dated 28 October 2017 No. 709.

20. Resolution of the Government of the Kyrgyz Republic "On Approval of the Requirements for the interaction of information systems in the system of interdepartmental electronic interaction "Tyndyk" dated 11 April 2018 No. 200.

21. Resolution of the Government of the Kyrgyz Republic "On the implementation of the pilot project "State as a platform" to introduce innovative ways 28 of providing State and municipal services and services" dated 25 February 2020 No. 113.

22. Resolution of the Government of the Kyrgyz Republic "On some issues related to the use of electronic signature" dated 31 December 2019 No. 742.

23. Resolution of the Government of the Kyrgyz Republic "On Approval of the Regulations on the State Electronic Messaging System and Rules for its Use" dated 31 December 2019 No. 745.

24. Resolution of the Government of the Kyrgyz Republic "On Approval of the Regulations on the automated information system "State Electronic Document Management System" dated 30 October 2020 No. 526.

25. Resolution of the Government of the Kyrgyz Republic "On the Model Instruction on Office Management in the Kyrgyz Republic" dated 3 March 2020 No. 120.

26. Resolution of the Government of the Kyrgyz Republic "On Some Issues Related to State Information Systems" dated 31 December 2019 No. 744.

27. Resolution of the Government of the Kyrgyz Republic "On Approval of Requirements for State Data Processing Centres and Connecting Communication Channels" dated 31 December 2019 No. 747.

28. Resolution of the Government of the Kyrgyz Republic "On certain issues of implementation of e-governance in the Kyrgyz Republic" dated 31 December 2019 No. 748.

29. Resolution of the Government of the Kyrgyz Republic "On some issues related to the State infrastructure of e-governance" dated 5 December 2019 No. 661.

30. Resolution of the Government of the Kyrgyz Republic "On Certain Issues Related to Basic State Information Resources" dated 6 February 2020 No. 66.

31. Order of the Cabinet of Ministers of the Kyrgyz Republic No. 74 dated 2 July 2021.

32. Order of the Cabinet of Ministers of the Kyrgyz Republic No. 2 dated 12 January 2022.

33. Digital Transformation Concept Digital Kyrgyz Republic 2019-2023.

Annex 3:
Case Example – Uzbekistan

A3-1 Forests of Uzbekistan

Forests cover less than 8 per cent of Uzbekistan's area. The total forest area in Uzbekistan has increased in recent years, reaching 3.69 million hectares in 2020.

During the last six years, the surface of the forest cover has expanded by 1 million hectares. In 2023, the Forestry Agency carried out afforestation and restoration on 235,000 hectares[87].

In Uzbekistan, forest policy and production activities related to forests are under the jurisdiction of the State Committee on Forestry of the Republic of Uzbekistan (Goskomles) (see Figure A3-2).

By Decree of the President of the Republic of Uzbekistan dated May 11, 2017, the Main Directorate of Forestry under the Ministry of Agriculture and Water Resources was transformed into the State Committee on Forestry. During the introduction of the Goskomles, forestry and forest areas included in various departments were transferred; as a result, the forest fund area increased by 2.575 million hectares.

In addition, Goskomles is responsible for the preservation and improvement of existing forests, as well as for the increase of forest land through forest restoration, afforestation, creation of forest, and pasture protection belts and forest cultures. A place of significant afforestation efforts is the former area of the Aral Sea.

A3.2 State of the Information and Communications Technology sector in Uzbekistan

Looking at the scale of Uzbekistan's service sector, the total service industry output in 2020 was 218.9 trillion UZS (17.4 billion USD), of which the information and communication industry was 12.9 UZS trillion (1.0 billion USD). This accounted for 5.9% of the total service industry.

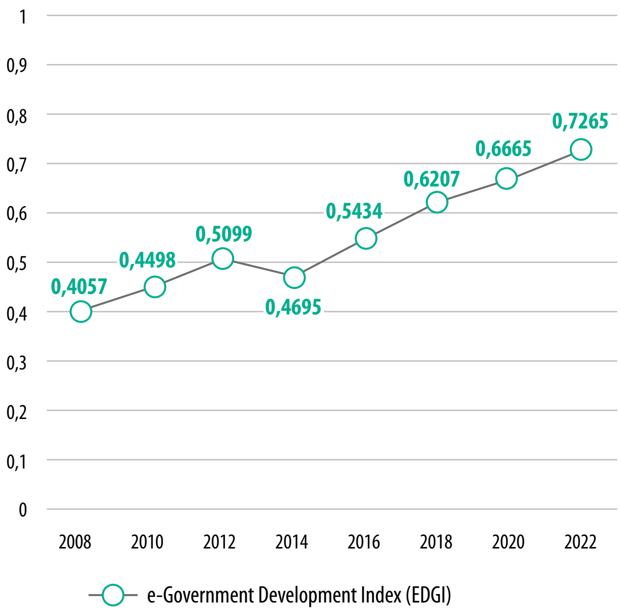
Although the information and communications industry accounted for a small percentage of the total industry, it showed a growth rate of 15.3% between 2019 and 2020, the second-highest non-contact service due to COVID-19.

According to the ICT Development Index (IDI) announced in 2018 by the International Telecommunication Union (ITU),

87 The Tashkent Times, Uzbekistan's Forest Cover Increases in 2023 - Officials, 6 February 2024, Available at http://tashkenttimes.uz/national/12450-uzbekistan-s-forest-cover-increases-in-2023-officials.

FIGURE A3-1

e-Government Development Index of Uzbekistan



Uzbekistan's ICT competitiveness is low and was ranked 95th out of 176 countries. This is however remarkable growth compared to 2013, when it was 115th.

According to the 2022 e-Government Development Index (EDGI) of the United Nations Department of Economic and Social Affairs (UN DESA), Uzbekistan ranked 69th out of 193rd United Nations Member States and it was classified among the top-performing countries in Asia. Considering the recent steep rise in the index, a substantial effort is being put into ICT development.

A3-3 Major Government Agencies related to ICT in Uzbekistan

A3-3.1 Ministry of Finance of Uzbekistan

The Ministry of Finance of Uzbekistan manages and supervises taxes and budgets. The ICT-related roles of the Ministry of Finance are as follows:

- Invest in large-scale investment projects, establish and strengthen national policies.

- Improve the tax system.
- Modernize and diversify State budget work.
- Concentrate resources according to economic development priorities.
- Strengthen tariff-setting procedures and payment rules.
- Strengthen national fiscal control to rationalize the use of funds.

Key projects include the National Tax Service's ICT development strategy, the national fiscal strategy for 2021-2023, and changes to the tax system.

A3-3.2 Ministry for Development of Information Technologies and Communications of Uzbekistan

The Ministry of Information and Communication Technology Development of Uzbekistan is responsible for national policies in the fields of information technology (IT) and telecommunications.

The ICT-related roles of the Ministry for Development of Information Technologies and Communications are as follows:

- Develop an integrated program for the introduction and development of the national information and communication system.
- Actualize e-Government.
- Develop and modernize communication infrastructure.
- Provide coordination and support for the realization of ICT in the real economy.
- Foster talent in information security and R&D.
- Promote international cooperation in technology and telecommunications and attract foreign capital.

Key projects include Digital Uzbekistan Strategy 2030, e-Government, Digital CASA-Uzbekistan, IT Park Creation Project, and the Personal Information Protection Act.

The "Digital CASA-Uzbekistan" project is funded by the World Bank.

A3-3.3 Ministry of Innovational Development of Uzbekistan

The Ministry of Innovation and Development of Uzbekistan is responsible for implementing a unified national policy in the field of innovation and scientific and technological development.

The ICT-related roles of the Ministry of Innovational Development are as follows:

- Innovate for the modernization and intensive growth of agriculture.
- Innovate social development including medical and educational systems.
- Innovate the environmental protection and management system.
- Determine the priorities of the national science and technology innovation policy and confirm the science and technology program of basic, applied, and innovative research according to available subsidies.

Key projects include Smart City, Concept for Healthcare System Development 2019-2025, Uzbekistan National Innovation System Project (UNIS), and remote monitoring service.

A3-3.4 State Unitary Enterprise e-Government and Digital Economy Project Management Center

The centre was established in 2017 to create an environment for effective project implementation as an organization under the direct control of the President of Uzbekistan.

The ICT-related roles of the State Unitary Enterprise e-Government and Digital Economy Project Management Centre are as follows:

- Suggest strategies and directions for ICT project implementation.
- Manage ICT-related government organizations and identify industry trends.
- Suggest the regulatory and developmental directions for the ICT industry.

A3-4 Major ICT Policies in Uzbekistan

On July 2, 2019, the government of Uzbekistan government enacted the "Act On Personal Data" to regulate the relationships affecting personal information. The Act extends to relationships that arise during the processing and protection of personal data, regardless of the applied means of processing, including IT.

Additionally, on October 5, 2020, the President of Uzbekistan approved "Digital Uzbekistan 2030", which aims to promote more than 580 projects including e-Government, digital agriculture, online industry expansion, and startup nurturing by Presidential Decree to build a sustainable economic foundation through the establishment of digital infrastructure (Table A3-1).

TABLE A3-1 Selected ICT projects of "Digital Uzbekistan 2030"

Project	Description
Digital Tashkent	"Digital Tashkent" was introduced on March 17, 2020. It aims to digitize public infrastructure in Tashkent from 2020-2022.
My Home	A system for online payment of public utility bills (tentatively called "My Home"), public transportation fare collection, construction licensing and monitoring, and public health information were included.
Agricultural Digitization	The digital system was introduced in agriculture and agriculture-related industrial facilities on December 17, 2020 (On measures to develop the digitalization system in the agro-industrial complex and agriculture of the Republic of Uzbekistan"). It aims to build a smart agriculture infrastructure in major regions by 2021-2023. Primary targets are divided into general cultivated land, farms, gardens, greenhouses, livestock houses, etc. It includes not only the introduction of digital technology, but also the strengthening of capabilities to identify geographical information and produce, manage, and utilize agricultural data and statistics.
Digital Healthcare	The Ministry of Health (MoH) announced public projects in the field of digital healthcare to be promoted by 2023. Integration and computerization of medical examination records (EHR, Electronic Health Record): Project to establish a medical record system for each patient that can be entered, managed, and queried by all public and private hospitals by designating Tashkent City as a pilot area (targeted to be completed by 2022). Electronic Public Medical Center System (Electronic Polyclinic): Pilot operation of a reservation system for visits to public medical centres at the end of 2021 through an online site13 (currently under construction), with a target to expand nationwide. Introduction of a compulsory public medical insurance system: From July 2021- December 2022, a fund of 7.7 billion UZS (about 846 million KRW) was created and is being implemented temporarily in Syr Darya.
e-Government	Raised the national rating in the "United Nations e-Government Assessment" by improving the e-Government Development Index. e-Government Development Index aims to increase from 0.70 in 2022 to 0.86 in 2030.

A3-5 Digitalisation of the forest sector in Uzbekistan

The institutional landscape of the forest sector in Uzbekistan is shown in Figure A3-2.

There have been some efforts to build a forest information system in Uzbekistan.

The Food and Agriculture Organization of the United Nations (FAO) has funded the project called "Technical note on the implementation of the National Forest and Landscape Monitoring System in Uzbekistan". This project report is aimed at selecting a pilot area to promote the National Forest Inventory (NFI) in Uzbekistan and studying the system for promoting NFI using Collect Earth. It includes tasks to be performed and budgeting for overall NFI performance, regarding the establishment of organizations and institutions to promote NFI, the methodological aspects of NFI, and the technical aspects of the software to be used in NFI.

For system development, this report includes a schema of the major technical parts of the NFI/NFMS information system and the Open Foris Collect Earth and Collect applications.

The main schema of the NFI/NFMS information system presented in the report is shown in Figure A3-3.

FIGURE A3-2

The institutional landscape of the forest sector in Uzbekistan

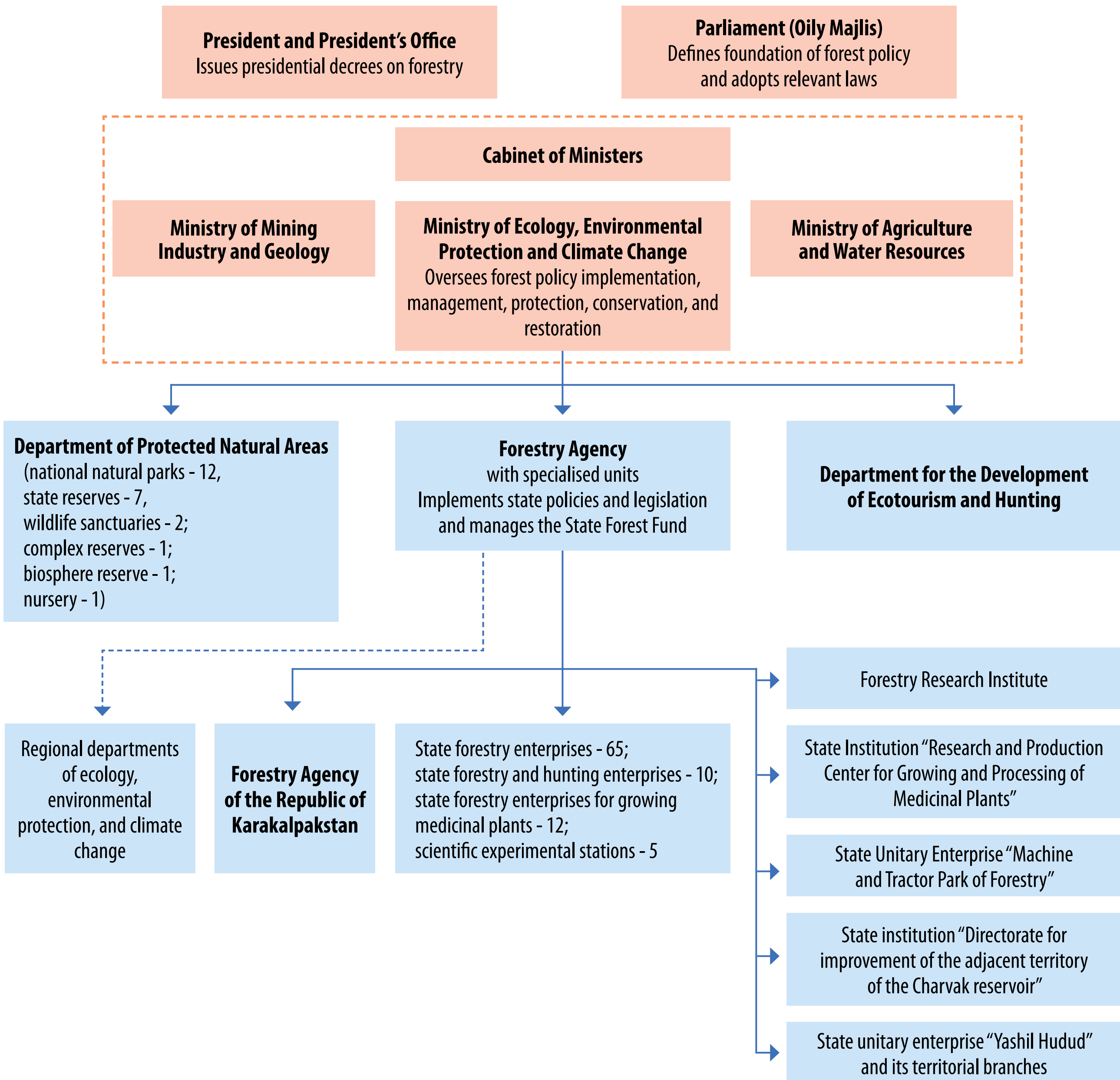
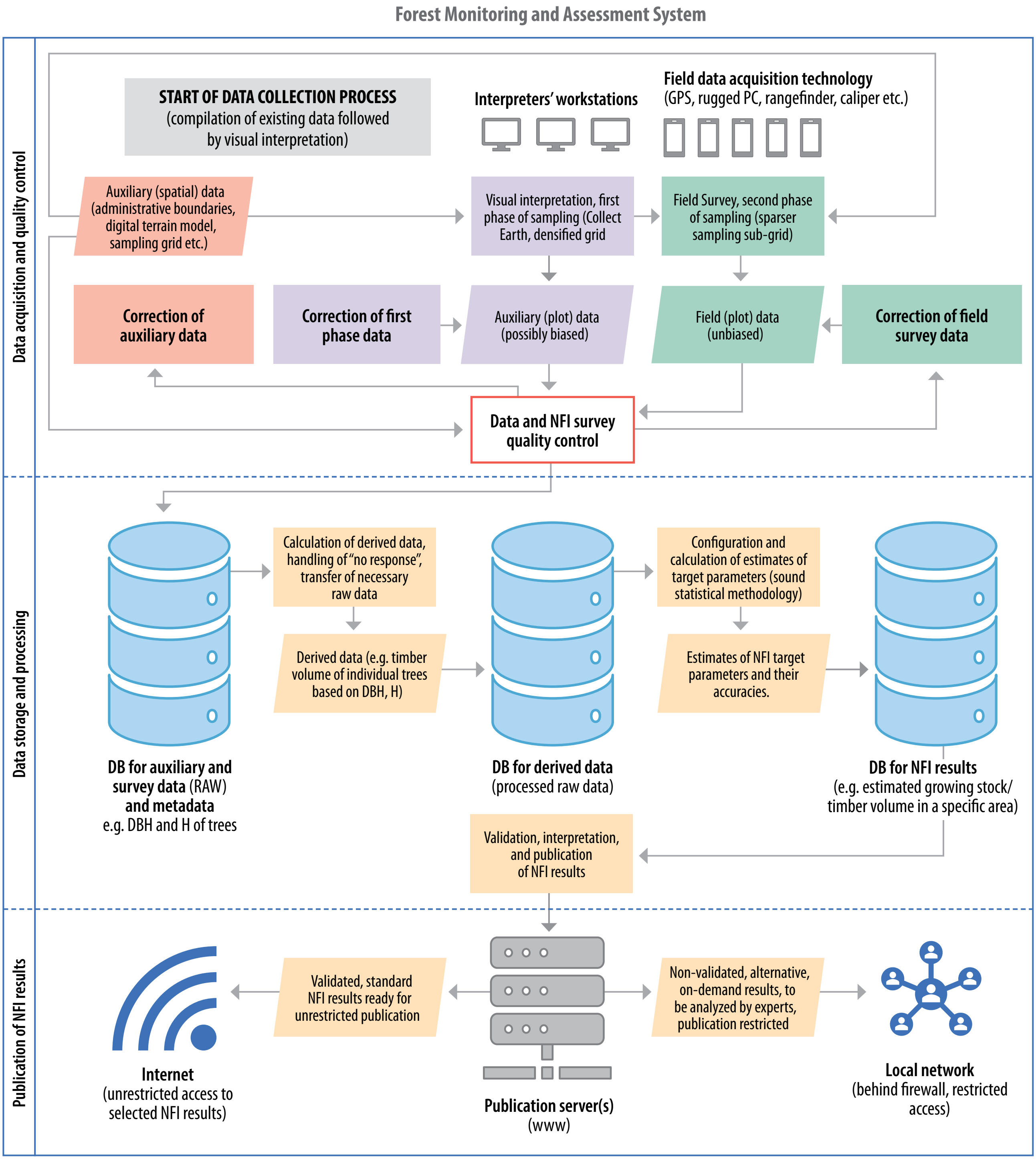


FIGURE A3-3

The main schema of the NFI/NFMS information system proposed for Uzbekistan



The National GIS of the Cadastral Agency includes 20 thematic cadastres. Among them, the State Forest Cadastre will be primarily used on the forest ICT platform. It is expected that the State Cadastre of Cultural Heritage Objects, State Cadastre of Flora Objects, State Cadastre of Wildlife Objects, State Cadastre of Protected Natural Territories, and State Cartographic and Geodetic Cadastre will be also used (Table A3-2).

TABLE A3-2 Six Major Thematic Cadastres to be used in the proposed Forest Information System of Uzbekistan

Category	Use for Forest ICT
State Forest Cadastre	To check the boundary and location of the national forest area
State Cadastre of Cultural Heritage Objects	To provide cultural heritage information for forest ecotourism
State Cadastre of Flora Objects	To provide local plant information for forest ecotourism
State Cadastre of Wildlife Objects	To provide local wildlife information for forest ecotourism
State Cadastre of Protected Natural Territories	To identify the boundary, location, and scope of protected territories for forest management
State Cartographic and Geodetic Cadastre	To find locations of activities including forest surveys using functions to search location information, etc.

As described in Table A3-2, six thematic cadastres will be applied to systems to be developed in the future. If additional user requirements are reflected, the necessary cadastres can be further increased.

The geographic coordinate systems must be consistent for the use of the National GIS cadastres and geospatial data in the forest management system. On December 26, 2017, the Uzbekistan cabinet adopted a resolution on the application and public use of the international geodetic coordinate system for the territory. Accordingly, the geospatial data to be used in the establishment of the forest ICT platform will use the WGS84 coordinate system and will also be used in the development of geospatial information-related systems.

Annex 4: **Case Example – Poland**

A4-1 Forests and forest industry in Poland

A4-1.1 Forests

Poland's forests, covering a substantial area of the country, are a hallmark of its natural landscape and an essential resource. Poland's forest cover experienced a decline until 1945, reaching a low of 20.8%. This process was reversed in the post-war years, particularly between 1945 and 1970, when, as a result of the afforestation of 933,500 hectares, Poland's forest cover increased to 27.0%. The area covered by forests has been increasing steadily over the past few decades, thanks to concerted reforestation efforts and sustainable forestry practices. Today approximately one-third of Poland's land area, which equates to 9.3 million hectares, is forested[88]. This expansive coverage makes Poland one of the more forest-rich countries in Europe. These forests are not only crucial for the environment and biodiversity but also play a significant role in the country's economy, contributing to various industries such as timber, paper, and tourism.

In terms of forest types, Poland's forests are diverse and rich, comprising of mainly coniferous (2/3 of the area), mixed, and deciduous forests. The most common tree species include pine, accounting for nearly 60% of the forest area, followed by other species such as spruce, beech, and oak. The high proportion of coniferous species is due to their preference by the timber industry since the 19th century. This diversity is a result of Poland's varied climate and terrain, which ranges from the mountainous regions in the south to the low-lying plains in the north. Each type of forest supports a different ecosystem, contributing to the country's rich biodiversity. The Białowieża Forest, straddling the border between Poland and Belarus, is a prime example of this diversity. It is one of the last and largest remaining parts of the immense primaeval forest that once stretched across the European Plain and is home to the European bison, among other species.

Forest ownership in Poland varies, with the State Treasury owning the majority, managed for the most part by the State Forests National Forest Holding. This organization is responsible for the management of about 77% of Poland's forests, ensuring sustainable use and conservation of these vital natural resources. About 2% of forests fall within national parks. The remaining forest areas are owned by private individuals (over 18%), local governments, and other entities. Regardless of ownership, forest management in Poland is governed by national policies and legislation that emphasize sustainable development, biodiversity conservation, and the balancing of economic and environmental interests. This approach ensures that Poland's forests are not only preserved for future generations but also continue to contribute to the nation's economic development and ecological balance[89].

Forests in Poland fulfil, either naturally or through human action, a variety of functions, the most important of which are:

- Natural (protective) functions, which include the beneficial influence of forests on the global and local climate and regulation of the water cycle in nature, prevention of floods, avalanches and landslides, protection of soils against erosion and the landscape against steppe formation, as well as CO_2 absorption.
- Social functions, which include creating favourable health and recreational conditions in forests as they are a place of work and environmental education in society.
- Production (economic) functions, primarily timber and non-timber products, and in-game management.

The statutory obligation of forest owners is to carry out sustainable forest management aimed at preserving the sustainability of forests, the continuity of their multifunctional use and the expansion of forest resources.

A4-1.2 Timber industry

In recent years, about 40 billion m^3 of timber was produced annually in Poland.

Poland's wood-processing sector of the economy employs as many as 330,000 people, accounting for 2.5 per cent of employment in the overall economy. The timber industry generates 2.3 per cent of the country's GDP and around 11 per cent of the value added in manufacturing in Poland[90]. The combined sold production of the wood, paper, and furniture industries in 2020 reached 9.5% of the total sold production of Polish industry[91]. Poland is among the world's leading producers of chipboard (4th place) and fibreboard (6th place). It is also the third largest exporter of fibreboard[92].

The Polish timber industry is based almost entirely on domestic timber resources, harvested from Polish forests. Poland has

88 GUS, Rocznik Statystyczny Leśnictwa 2020 (Warszawa, Główny Urząd Statystyczny, 2020).

89 PGL LP, Raport o stanie lasów w Polsce 2021 (Warszawa, Państwowe Gospodarstwo Leśne Lasy Państwowe, 2022).

90 Bogdan Czemko, Polski przemysł drzewny, Poradnik biznesu, 16 July 2019, Available at https://www.poradnikbiznesu.info/przemysl-4-0/polski-przemysl-drzewny/.

91 GUS, Rocznik Statystyczny Leśnictwa 2020.

92 PKO BP, Strategia Leśna UE 2030 a przetwórstwo drewna w Polsce (PKO BP, 11 October 2021), Available at https://www.pkobp.pl/centrum-analiz/analizy-sektorowe/branzowe-raporty-przekrojowe/strategia-lesna-ue-2030-a-przetworstwo-drewna-w-polsce/.

a strong furniture industry and an equally strong group of producers of wood panels - chipboard, fibreboard, and others. Large cellulose and paper manufacturing conglomerates exist, as well as a vast sector made up of producers of lumber, pallets, wooden floors, garden architecture, wooden structures, wooden houses and dozens of other home and garden products.

In 2023, 2464 Polish entities held valid Forest Stewardship Council (FSC) Chain of Custody (CoC) certificates preceded only by China (17.2 thousand) and Italy (3.3 thousand)[93].

A4-2 Construction of the IT System in the State Forests

A4-2.1 Use of computers in the forest administration in the 1970s and 1980s

In Polish forestry, the first computing machines were used as early as the 1970s. The first period of development of forest information systems took place until 1989, which was not centrally controlled. Various devices were in use, from simple accounting machines, through 8- and 16-bit microcomputers, to mainframes (e.g. the Polish-made ODRA computer, installed in the Centre of Information Technology for Agriculture and Forestry, ROLKOM).

In terms of software, a few original small employee-made applications were used in various units within the State Forests, as well as some commercial-made applications – used mainly for accounting, payroll and human resources services, as well as for timber trading.

Independently, in the unit responsible for the preparation of forest management plans (Bureau for Forest Management and Geodesy, BULiGL), since the beginning of the 1980s, a supporting information system was implemented, based on the Polish-made microcomputers MERA (operated in BULiGL) and the mainframe ODRA (in ROLKOM). That system supported calculations as part of the statistical method of forest inventory and collected forest stand descriptions in digital form, uniform for the entire Polish public forest estate.

In the 1990s, BULiGL began efforts to create digital forest maps with the use of GIS software, which laid the foundations for their future use in the State Forests.

Several shortcomings emerged during this period:

1. Lack of uniform computer hardware and software in individual organizational units (most units at the time did not use computer systems at all).
2. Lack of uniform software at different management levels (a set of inconsistent programs, without proper documentation).
3. Lack of a uniform set of database identifiers and a consistent dictionary of object types to be stored in databases, which severely limited interoperability and data exchange.
4. Presence of different document templates and different workflows.

A4-2.2 Strategy for the Construction of a State Forestry Information System

In 1989, the General Directorate of the State Forests began to develop a strategy for the construction and implementation of a uniform IT system for the entire organization under the name of the State Forests Information System (SILP).

The strategy provisioned the following stages:

1. Equipping the SF organizational units with modern computer equipment of high reliability, with the expected operation of 5-8 years.
2. Developing integrated software to support the needs of a forest district – using the 4th generation programming languages and relational database technology.
3. Establishing a national hardware and software support service with a short reaction time.
4. Training IT professionals in the State Forests structure so that they would be able to use the new tools, and to maintain and further develop the system in the future.
5. Developing and implementing the system first at the forest district level (2 years) and then at the lowest forest management level, and later at the level of regional directorates.

In December 1990, the Council of the State Forests adopted a resolution on the construction of the State Forests Information System.

A4-2.3 Project implementation stages

In 1991, nationally operating major IT companies were invited to participate in the tender procedure for SILP. A basic working document containing preliminary organisational and technical premises of the system was prepared. After thorough discussions, three out of the twelve companies were selected. Separate negotiations were held with the selected companies. A contract for the SILP implementation was signed with the selected contractors. The total amount was approximately 15 million USD, with 90% of the value being hardware.

93 Powermeetings.eu, Działając wspólnie stajemy się silniejsi – dalsze wnioski z Forum Przemysłu Drzewnego 2023, 26 July 2023, Available at https://powermeetings.eu/dzialajac-wspolnie-stajemy-sie-silniejsi-wnioski-z-forum-przemyslu-drzewnego-2023/.

In 1992, five analysis and design teams were established to develop a detailed concept of the system from the user perspective in the forest district:

1. Forest management team.
2. Commodity management team.
3. Finance and accounting team.
4. Payroll and HR team.
5. Infrastructure team.

The teams consisted of practitioners employed by the State Forests, specialists from the Forest Research Institute, BULiGL and the Faculty of Forestry at the Warsaw University of Life Sciences.

Corresponding teams were established on the software contractor's side. They consisted of professional analysts (1 in each team) and programmers. (3-4 in a team).

Over the following years **(1992–1995)**, the first version of the system was developed. The teams from the State Forests and the system contractor met once every 2-3 months for 1-week sessions at one of the State Forests training centres. Between sessions, the contractors' teams created new system functionalities and the State Forests teams tested the delivered modules.

In 1995, testing of the SILP system prototype began in selected forest districts (8 districts were selected). Identified errors and suggestions for changes were analysed and approved by the State Forests teams and forwarded to the software development company for correction. The State Forests teams developed manuals for the applications. The implementation of a training regime was also started. A hierarchical structure was adopted, due to the large number of people requiring training. In the first round, participants of the State Forests teams trained several dozen people - selected State Forests employees, who were assigned the status of regional SILP trainers.

In 1996, training of end users from forest districts by regional SILP teachers continued - several thousand people were trained. More forest districts were equipped with hardware. and the software was installed and configured.

In 1997, a decision was taken to fully implement the SILP system in all the forest districts. Commissioning of further modules of the system in the forest districts started.

This was an extremely challenging year of a major crisis in the development of the project. The contract with the software development company was terminated. The State Forests were left without the system source code and its documentation, and the system software provider company was dissolved. To control the damage, a contract was signed with a Polish company for the reconstruction of the system's analytical documentation, mainly by reverse engineering the existing databases and software. Unfortunately, the software was too complex and access to it was limited, which prevented a wider group of the State Forests professionals from working on it. Consequently, after a year of work, the State Forests cancelled the contract and abandoned the work in this direction. However, two key analytical documents were produced - the DFD flow diagram and the ERD entity relationship diagram, which served as a source of information about the system during the later stages of the work.

In 1998, the source code of the system was purchased from the owners of the former contractor company. The IT unit operating within the General Directorate of the State Forests was enlarged. The first batch of field handheld terminals for foresters was purchased.

In 1999, the hardware installed in forest districts was upgraded due to its underperformance and the Year 2000 problem.

In 2000, all field forestry specialists were equipped with handheld terminals which had the capacity to exchange data with SILP. All the forest district systems were linked together within a single WAN.

In 2001, the Forest Digital Map Standard was introduced and officially adopted for use in the State Forests. This was a major step towards creating the spatial information system of the organization.

In 2004, a separate organizational unit was established within the State Forests to provide IT services. A portal for online timber auctioning was launched.

In 2008, full coverage of the Forest Digital Map was completed. This allowed for the ubiquitous use of GIS in daily operations, in addition to the main text terminal SILP software.

In the years 2010–2012, the use of servers in the headquarters of the forest districts was discontinued. A dedicated computer facility was built in DGLP and ZILP, to which the district databases were moved. In forest districts, only terminals for working in SILP via WAN remained.

Since 2012, the original version of the SILP software is still being maintained and used. Efforts have been undertaken to develop a next-generation system software in web technology.

In 2011–2013, BULiGL built the Forest Data Bank – a multi-module data warehouse and publishing system for collecting, processing, and sharing data on all forests in Poland. The best-known part of it is the website allowing for public access to detailed information on forests and forestry operations. The website is now widely used by foresters, public servants, researchers, environmental activists, and members of the general public. In the following years, a freely available mobile app was developed. The Forest Data Bank has been continuously improved and updated.

In 2018, the development of a new app for handheld devices used by the State Forests field specialists began.

A4-2.4 Hardware and software configurations

Initially, the system operated independently in each forest district. Its main component was an HP 9000/A180C workstation running the HP-UX Unix operating system. Several (4-5) character terminals were connected to the workstation. Most often, two of them were equipped with a terminal printer. Over time, expensive and inconvenient to use terminals began to be taken over by personal computers (PCs), on which terminal functionality was emulated. PCs could also use a network printer.

An Informix database was installed on each server, along with software written in a language dedicated to handling this database - Informix 4GL.

An important step in the development of the system was the use of ODBC drivers, allowing desktop applications developed for Windows PCs to connect to the database server. This resulted in the capability to develop and use data analysis and reporting tools. This was initially InfoMaker and then BusinessObject. GIS tools for forestry were also developed in this way.

At the centralisation stage, the databases of all forest districts were moved to central servers located at the General Directorate of State Forests. Four IBM servers were purchased. Over the years, the whole server environment has been virtualized. A separate backup data centre has been built.

The SILP system was modernized to be able to work in the new configuration - an independent application server and many (about 400) district databases on RDBMS servers. The functionality of the system from the district level point of view remained unchanged, maintained by the same technology: Informix database and Informix 4GL application.

The SILP system is under constant development. All new functionalities are now created in web technology using Java/JavaScript. The main ones include:

- A central GIS application for handling the digital maps of all forest districts with the possibility of editing of geometry and related attributes in the database with many specialised tools created for forestry.
- Forester's portal - an application containing a set of functionalities and materials supporting the work of a forester.
- Forest district road network management system – linked to the Infrastructure module.

Some functionalities of the current basic SILP application have also been transferred to the web-based platform.

A4-2.5 Functional scope of SILP

The basic functional scope of SILP is comprised of five subsystems:

1. Forest management including the planning module

The key element of the module is the forest stand description. Every ten years it is renewed, based on the results of an inventory performed during the forest management planning process. After that, the stand descriptions are updated annually via an automated process, considering management activities (fellings and silviculture).

During the update process, forest stand divisions are split if final felling is performed, descriptions of newly established forest renewal plots are created, and the current standing volume is corrected by adding the calculated increment and subtracting the harvested volume.

An integral part of the subsystem is the planning module, which allows for the preparation of annual economic plans in the full scope of activity of the forest district, with detailed planning of income and costs, followed by ongoing recording of execution.

2. Commodity management

This subsystem supports business processes related to timber production and trade, marketing of non-wood forest products, management of timber storage and invoicing.

3. Payroll and HR

This is the subsystem to support activities related to managing workforce. It contains employee data, work time records, and activity records, allowing for the calculation of wages.

4. Finance and accounting

Most documents in this area are automatically generated based on data from other subsystems, including internal invoices, depreciation, salaries and surcharges, and consumption of warehouse materials.

Some documents still need to be still manually entered such as bank statements, cash receipts, and external invoices.

5. Infrastructure

The purpose of this subsystem is to support the management of the organization's infrastructure, including real estate, roads, vehicles, machinery, and other equipment. It contains inventory data, records of day-to-day operations, maintenance records, and calculation of depreciation. There is also a dedicated part for road network maintenance.

A4-2.6 Lessons learned

A4-2.6.1 Successes and good practices

1. A unified system for the whole of the State Forests was created. This was possible thanks to continuous and committed support from the executive management, and appropriate and timely regulations enabling the necessary organisational changes and implementation of the system.
2. Appropriate structures for implementation were established within the State Forests: task forces, coordinators, system trainers, and the State Forests IT Division.
3. The system covered the entire scope of the State Forests' operations from the start. This was a great advantage especially at the beginning of its operation, when there were not many proven and accessible solutions on the market for even typical business activities, e.g. in the area of accounting or payroll and human resources. As the situation today changes it would be worth revisiting this approach, perhaps making more use of standard solutions available on the market.
4. The system has been implemented with considerable participation of the State Forests employees of different specialisations and management levels, especially at the stage of defining requirements and functionalities, and the initial phase of system development. A well and efficiently conducted training campaign involving all employees of the State Forests was a success. This has resulted in a large group of employees within the organisation with expert knowledge of the system's architecture and functions, with the knowledge remaining within the organisation.
5. Development of the system involved the use of the latest available IT technologies. In the 1990s, professional, large and secure systems were still built on the Unix operating system. The State Forests used hardware and an operating system integrated with it, supplied by HP, one of the world leaders in this type of solutions.
6. The integrated system allows for the automation of many cross-cutting processes and reduction of the document circulation. For example, when a timber receipt is executed by the forester, the timber stock is updated and, in addition, information on the execution of the annual plan items, activities performed and products harvested is automatically recorded; the forest division's stand descriptions are also updated, and appropriate notes on the costs of the work performed are sent to the accounting system.
7. The system has been revised and extended in line with the changing technological landscape and the growing needs of users, keeping its optimal alignment with the business needs and external environment.
8. The development and implementation of the State Forest Information System should be considered as an example of a successful IT implementation on a large scale, executed in satisfactory time, without disruption by basic business processes in the organisation and in a very cost-effective way.

A4-2.6.2 Mistakes and problems

1. No comprehensive analysis of the information system under construction was carried out at the beginning of the work. The analytical work focused on the digitisation of the existing data sets and information flows. Consequently, the system collects huge amounts of data, which is primarily used for reporting.
2. No uniform format and methodology for creating analytical documentation was established from the start. Consequently, residual and unstructured notes were produced, resulting in additional costs from recreating the necessary knowledge of the system.
3. The work focused on building a system for the forest district level. There was no system concept for management levels higher than the forest division (regional directorates and the General Directorate of State Forests). As a result, these units received the same software as the forest districts, which was not adequate for their needs.
4. No efficient analytical team has been built within the SF structure with knowledge of the system dispersed. The IT Division handles single development tracks (the timber auctioning portal, the handheld device app, etc.), while there is no single analysis and decision-making centre, overseeing the coherence of the architecture and guiding the development of the system.

A4-3 Information systems in other forests

A4-3.1 Private forests

Private forests in Poland are a neglected area in terms of IT services. This is due to the much smaller share of these forests in the country and their high fragmentation. An additional problem arises from the unclear division of responsibilities and competencies for forest owners in forest management. The management of private forests is carried out by the county governors, and it is their responsibility to plan management and protection measures and to supervise their implementation. The county administrative authority is therefore the body that manages private forests throughout the county, and this is where the development of IT solutions began. In 2012, a regulation was introduced that made it compulsory to produce forest management plans for private forests exclusively in digital format. This was a sign for county offices to start equipping themselves with IT tools to manage their forest data.

A4-3.2 National Parks

The Nature Conservation Act requires the national parks in Poland to properly manage the park's land and natural resources, maintain the infrastructure in proper condition, conduct scientific research to determine methods and means of nature conservation, the effectiveness of conservation measures, and the recognition of biodiversity. Other responsibilities of the national parks include providing access to the park area, conducting educational activities, as well as providing information and promotion in the field of nature conservation. Effective management and supervision of the national parks require the creation of a unified system to support the performance of the tasks imposed on the national parks, ensuring uniform reporting, and performing analyses and assessments that could be tools to assist the minister responsible for supervising the national parks. The law imposes numerous obligations on the national parks as public institutions to store and make public data available.

The great diversity and specificity of individual NSAs, both in terms of nature and individual conditions, mean that management support systems must be adapted to the local needs of the park in question. At the same time, however, an appropriate level of integration is necessary for uniform reporting and performance of park oversight.

Currently, the national parks use a collection of different tools for their work, many of which are outdated. Individual departments, even within a single national park, use separate databases for their day-to-day operations. This causes difficulties with data integration, establishing timeliness, report generation, data sharing, and accessibility.

A4-4 Forest Data Bank

In recent years, the Forest Data Bank (FDB) has become one of the most important places for collecting and sharing forest information in Poland. It aims to collect key forest information relevant to forest management, forest policy-making and public communication.

The largest dataset consists of data from stand inventories carried out during the preparation of forest management plans and protection plans for national parks, supplemented by up-to-date data on forests under the State Forests Holding management, coming from SILP. This data is subject to unification, and aggregation, and is presented in various systems and cross-sections.

Another large set of data comes from habitat studies carried out for the State Forests districts, as well as (although to a lesser extent, only in selected forest areas) from phytosociological studies.

A unique set of data is information on game management for districts leased by hunting associations (data made available by the Polish Hunting Association) and for districts constituting game breeding centres managed by the Polish Hunting Association, State Forests Holding, and scientific institutions.

The FDB also collects and makes available forest information from other sources: (1) NFI results, (2) data from public statistics, (3) results of forest monitoring, (4) data on fires and current information on fire danger from the forest fire monitoring system at the Forest Research Institute, (5) information on epidemiological threat (African swine fever, ASF) obtained from the Chief Veterinary Inspector, (6) information on tourist and educational infrastructure in the State Forests, (7) as well as a range of complementary information (e.g. climatic, geological, hydrological, nature protection data, forest seed regionalization, etc.).

All data collected in the FDB is made available through a web portal equipped with an interactive map viewer and a dataset download module.

A4-5 Information infrastructure of the Polish forest sector

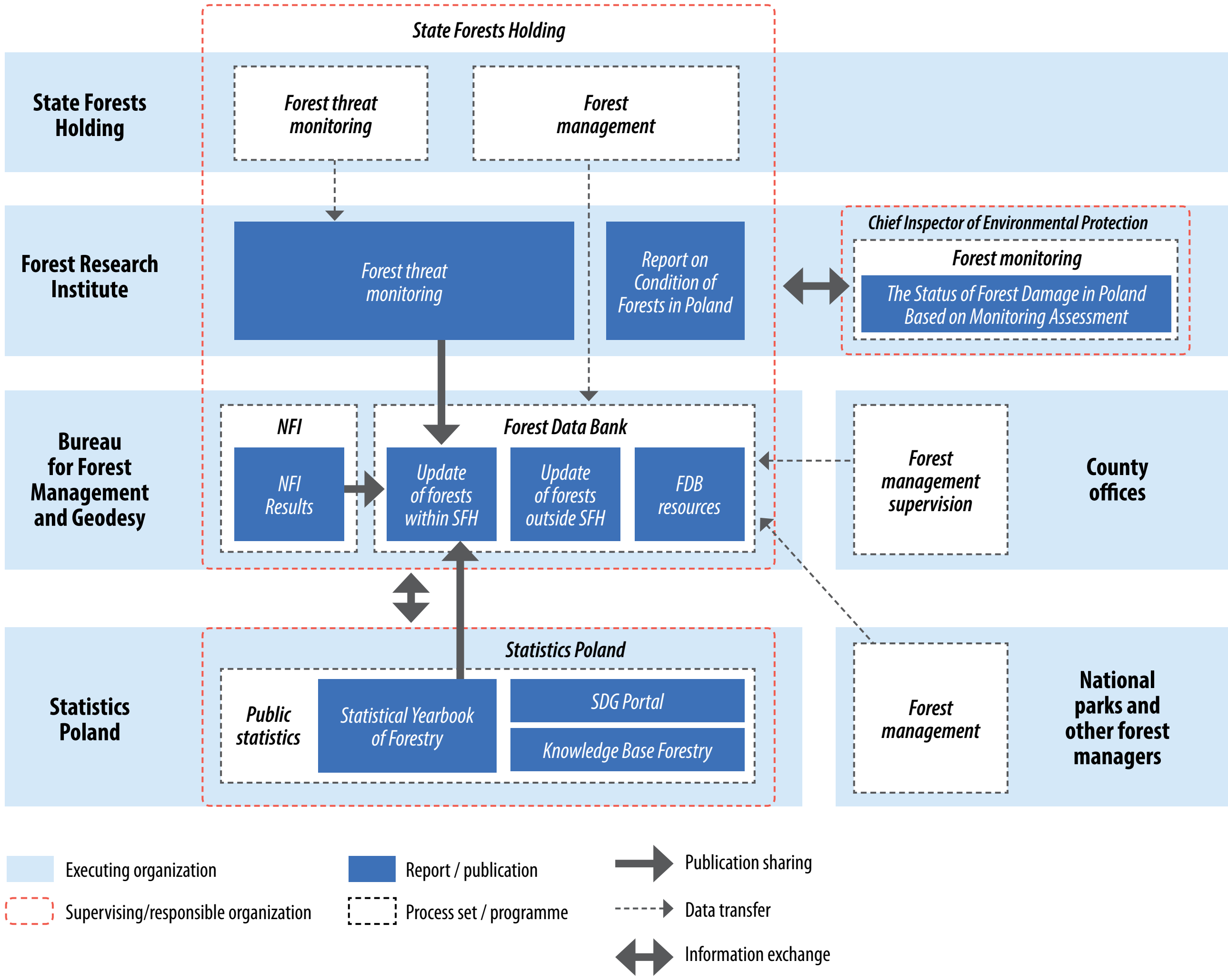
Data on the state of forest and forest management in Poland are collected through several local, regional and national efforts, supervised and implemented by various entities. They are then published in studies for the needs of government institutions, national statistics, environmental monitoring services, forestry and the public (Figure A4-1)[94]. This extensive data collection system allows changes in forests and the forest and wood sector to be tracked. The range of data is large, although given the objectives and focus of the monitoring, it still needs to be expanded.

In recent decades, significant progress has been made in the digitisation of forest management and the collection and integration of forest information. The Digital Forest Map has been successfully implemented in all forests under the supervision of the State Forests Holding, and forest management is carried out using the State Forests Information System.

94 Andrzej Talarczyk *et al*., Podstawowe Krajowe Systemy Monitorowania Stanu Lasów i Udostępniania Informacji o Lasach w Polsce w Kontekście Opracowania Kryteriów i Wskaźników Trwale Zrównoważonej Gospodarki Leśnej, Sylwan, vol. 165, no. 4 (2021), pp.267–78, https://doi.org/10.26202/sylwan.2021025.

FIGURE A4-1

The forest sector data collection and publication system in Poland



Source: after Talarczyk *et al.*, 2021

Since 2005, the National Forest Inventory has been carried out as a permanent programme, providing up-to-date and reliable information on the state of the country's forest resources[95].

In 2011, the Forest Data Bank became operational, playing an extremely important role in driving progress in the integration of existing data and new initiatives to expand forest information resources. Thanks to initiatives undertaken in connection with the FDB, data on game management or tourism infrastructure in forests have become available. The existing systems are well-established institutionally, ensuring their sustainability. A factor contributing to this evolution is the ownership structure of forests in Poland, where most of them are owned by the State Treasury and managed by one strong organisational entity.

However, Poland still lacks an integrated decision-support system at the national level, which would provide the factual background for the government and the minister of climate and environment to make strategic decisions on national forest and environmental policy. There is a need for greater development of strategic instruments, such as a system for long-term forecasting of changes in forest resources and forest condition, or tools for modelling the spread of infectious diseases and risk analyses of stand damage.

Despite the areas for improvement described above, the forestry sector in Poland has been comprehensively digitised and information on it is among the most complete and detailed in Europe.

95 Andrzej Talarczyk, National Forest Inventory in Poland, Baltic Forestry, vol. 20, no. 2 (2014), pp.333–40.

Annex 5:
Glossary of terms

It will be helpful to define some of the terms used frequently in this guide before describing the details involved in the analysis.

Forest Information

Forest information refers to the comprehensive collection of data and knowledge on spatial, ecological, social, and economic insights about forest resources, and their ecosystems, used to inform decision-making and sustainable forest management.

Forest information is gathered from various sources, including aerial imagery, remote sensing, on-ground surveys and data collected from forest management activities. Information and data are subsequently processed, analysed and organised into a structured database or system to facilitate the decision-making of stakeholders and support sustainable forest management.

Forest information management

Information management is the practice of identifying, collecting, storing, and maintaining data and other types of information which are needed in the context of a particular organization or objective. It involves the gathering, dissemination, archiving and permanent removal of information in all its forms. Information management covers the procedures and guidelines organizations adopt to manage and communicate information among different individuals, departments, and stakeholders.

Forest information management covers all stages of processing forest-related information, like data collection, aggregation, analysis and storage, related national and international reporting, dissemination, and communication. Purpose and types of data include e.g., state and trends of forests ecosystems and resources, health conditions of forests, forest products and services, their management, trade and use, related policy-making, etc.

Forest information system

Information systems are integrated sets of components (technology, networking communication, people and processes) that allow users to collect, process, store, organize and distribute data for providing information, knowledge and digital products, as well as provide a feedback mechanism to meet an objective. They are work tools that enable users to perform certain periodic repeatable tasks.

Forest information system (FIS) is a generic term for information systems used in forest, wildlife, and environmental management as well as policymaking. FIS is a system that provides forest managers, owners, decision-makers or other stakeholders with accurate and up-to-date information about the forest resources and forest-related activities to support effective decision-making.

FIS plays a critical role in the collection, management, and dissemination of forest-related information, and thereby supports sound management decisions in the forest sector, including its public and private forests, the timber industry, forest policy and other stakeholders.

FIS provides essential data and information on forest resources, including their extent, distribution, and conditions, as well as the social and economic benefits they provide. This information can include data on forest cover, tree species, ecological processes, timber trade and other human activities, as well as maps, reports and other forms of visual representation.

FIS can be understood in two ways:

a. The overall processes, subjects and stakeholders related to the collection, analysis, management, circulation, use, and dissemination of forest-related information. FIS exists whether they are as such identified and described or not. FIS can be a set of different tools, methods and databases used to collect, process, store, analyse and disseminate information related to forests.

b. Information technology systems to aid in gathering information to support informed choices, monitoring results and refining policies. It can include hardware, software, and network components, as well as institutional and human resources to support them.

An integrated FIS is a structured approach of system design that manages, and processes different types and sources of forest information and data made accessible and usable for a wide range of stakeholders within a single environment.

IT capacities (assets and skills) in the context of forest information systems

In the context of FIS, IT capacities are the assets and skills that are needed to enable and sufficiently carry out the collection, digitization, storage, processing and dissemination of forest-related data and information.

The assets typically include hardware and software components (such as servers, computers, databases, networking devices, and applications), physical facilities (such as data centres, communication networks and power supply systems), broadband Internet supply as well as trained human resources with sufficient expertise to manage and maintain the IT systems.

The skills are knowledge of individual human resource assets (employees and contractors), institutional memory (the stored knowledge within the organization) and organizational capabilities to perform tasks related to building, maintaining and operating FIS.

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Developing Forest Information Systems

A Guide to creating effective Forest Information Systems

An effective forest policy requires appropriate decisions regarding the management and use of forest resources. Forest policy and management, however, are areas which are not well structured despite their high complexity. Recent advances in information processing technologies, as well as an unprecedented ease of information exchange, provide new abilities for better management of forest ecosystems and the services they provide. Forest information systems (FIS) aim to facilitate this issue by providing tools to assist in gathering forest information, making them accessible for informed decisions, monitoring their results, and correcting existing policies.

A FIS can increase operational efficiencies, bring cost reductions, supply better information for decision-makers, and through this contribute to the improvement of forest ecosystem services and state governance. They can also be a strategic tool for economic development and a solution for increased transparency and participation expected by modern societies. This capacity-building guidance outlines how these technological advances can be used to improve modern forest policymaking and natural resources management.

The study provides an overview of forest information systems in the context of their application in forest policy and management. It outlines the FIS types and functions and analyses their application in the forest sector. It outlines how these technological advances can improve modern forest policy-making and natural resource management. It provides examples of FIS solutions and their implementation in selected countries. The study is complemented by the separate practical guide (Developing National Forest Information Systems. A Practical Guide - ECE/TIM/SP/56), which details the needs, opportunities and constraints for developing/improving forest information systems for the forest sector.

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