Medium-term Plan 2026–2029

Geological Survey of the Netherlands



TNO | Geologische Dienst Nederland

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Woord vooraf

Onze maatschappij is niet alleen letterlijk maar ook figuurlijk gevestigd op de ondergrond. Zijn eigenschappen bepalen wat we waar en hoe kunnen bouwen. Hij levert ons energie, water en grondstoffen. Hij biedt onze energievoorziening buffercapaciteit en bergingsruimte, om de grootschalige inzet van vernieuwbare bronnen mogelijk te maken, voor een betere leveringszekerheid en voor meer strategische autonomie.

Ondergrondse bestaansbronnen zijn aan het oog onttrokken en kunnen alleen met kostbare gegevens en specialistische kennis worden geïdentificeerd en beheerd. Hetzelfde geldt voor de identificatie en beheersing van risico's gekoppeld aan bodemdaling en aardbevingen, al dan niet door de mens veroorzaakt. Als nationaal verzamelpunt van ondergrondgegevens en huis voor ondergrondspecialisten vervult de Geologische Dienst Nederland hierin een spilfunctie en is het een onmisbaar onderdeel van de publieke informatie- en kennisinfrastructuur.

Voor u ligt ons **Middellangetermijnplan 2026-2029** (Engelstalig, met een voorwoord en samenvatting in het Nederlands): het strategische plan waarin de Geologische Dienst Nederland voor de komende vier jaar haar koers uitzet. Onze omgeving verandert sterk. We hebben te maken met een combinatie van niet aflatende uitdagingen op het gebied van water, energie, klimaat en schaarse ruimte, een technologische revolutie met een grote impact op alle facetten van ons werk en de economische en strategische consequenties van de huidige geopolitieke instabiliteit. Onze omgeving verandert ook snel. Tijd is een factor – aanpassingsvermogen is cruciaal.

Deze uitdagingen en mogelijkheden kunnen we tegemoet treden terwijl we voortbouwen op grote recente successen. De Geologische Dienst Nederland is de afgelopen jaren flink gegroeid. Er zijn nieuwe taken op het gebied van duurzaam beheer van de diepe ondergrond en kritieke grondstoffen. Er zijn extra middelen beschikbaar gemaakt voor het beheer van de basisregistratie ondergrond. Er is een groeiende vraag naar advies. Het beheer van onze gegevens en IT worden compleet vernieuwd. Er zijn grote stappen gezet in onderzoek, want kennis blijft alleen relevant als die vermeerderd wordt.

Deze groei kwam niet vanzelf. De onzichtbaarheid van de ondergrond vertaalt zich naar een onbekendheid van ons vakgebied en domein, wat betekent dat wij ons altijd bovengemiddeld moeten inspannen om de relevantie van investeringen over het voetlicht te brengen. Wij zijn daarom extra trots op de successen die hierin zijn geboekt, alhoewel een aantal daarvan nog bestendigd zullen moeten worden om blijvend te renderen.

In het vertrouwen dat we verder zullen kunnen bouwen aan de Geologische Dienst Nederland, zetten wij alles op alles om onze rol met verve te vervullen, in het belang van de samenleving en de wetenschap, samen met onze partners en opdrachtgevers in de overheid en het bedrijfsleven!

Wij bedanken onze Strategische Adviesraad, Geowetenschappelijke Kenniscommissie en onze eigen staf voor hun waardevolle adviezen en bijdragen, en wensen u veel leesplezier.

MT Geologische Dienst Nederland

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Management-samenvatting

Geologische Dienst Nederland (GDN)
In Nederland is de nationale geologische dienst GDN ondergebracht bij onderzoeks- en technologieorganisatie TNO. De missie van de GDN is het bevorderen en mogelijk maken van veilig en duurzaam gebruik van de ondergrond door middel van betrouwbare geowetenschappelijke kennis. Hieraan wordt invulling gegeven door middel van gegevens- en informatiediensten, formele adviesrollen en onderzoek.

De sturing en verantwoordelijkheden van de GDN zijn vastgelegd in een overeenkomst tussen TNO en de Staat, waarin is bepaald dat elke vier jaar een Middellangetermijnplan (MTP) wordt opgesteld. Het huidige plan (MTP29) bestrijkt 2026 t/m 2029 en sluit aan bij de TNO-strategie voor dezelfde periode.

Strategische ontwikkelingen
De strategie van de GDN speelt in op een reeks sociaal-maatschappelijke, geopolitieke en technologische ontwikkelingen, in het bijzonder een grotere strategische autonomie, de energie- en grondstoffentransitie, klimaatadaptatie, ruimtedruk en de huidige, door AI gedreven versnelling van de digitale revolutie. Geopolitieke instabiliteit heeft geleid tot een nadrukkelijker streven naar meer energie- en grondstoffenautonomie binnen de EU, en een grotere focus van de GDN op duurzaamheid en digitale soevereiniteit. Klimaatgerelateerde uitdagingen omvatten het verminderen van de afhankelijkheid van fossiele brandstoffen, het beheersen van bodemdalingsrisico's en het aanpassen aan extreme weersomstandigheden. De snelle ontwikkelingen in de informatietechnologie vereisen een herbezinning op de gehele organisatie en haar continue digitale transformatie.

Strategische prioriteiten
De GDN geeft invulling aan haar strategische agenda via vier prioriteiten:

- **Toekomstbestendig landgebruik** richt zich op de relatie tussen de gebouwde omgeving en de ondergrond, waaronder



bodemgesteldheid, bodemdaling, ruimtelijke ordening en de effecten van mijnbouwactiviteiten. De strategie is toekomstgericht en richt zich op de langetermijngevolgen van het gebruik van de bovengrond en ondergrond, gebaseerd op kennis van ondergrondeigenschappen en relevante geologische processen.

- **Rentmeesterschap grondwater** speelt in op de toenemende onbalans in grondwatersystemen, veroorzaakt door klimaatverandering, verstedelijking, de energietransitie en de groeiende watervraag. De belangrijkste activiteiten van GDN zijn gericht op het herstellen van deze balans door middel van systeembegrip, het delen van data en samenwerking tussen verschillende sectoren en actoren.
- **Geo-energie** ondersteunt de energietransitie en omvat geothermie, duurzame warmtenetten en geologische opslag van CO_2 en waterstof. Ondanks de decarbonisatieopgave blijven investeringen in productieoptimalisatie noodzakelijk, aangezien koolwaterstoffen voorlopig een belangrijk onderdeel van de Nederlandse energiemix blijven.
- **Grondstoffen** vormen een nieuwe strategische prioriteit, die momenteel vooral gekoppeld is aan het Netherlands Materials Observatory (NMO). De GDN zal haar grondstoffenportfolio verbreden, voorbij de kritieke grondstoffen (Critical Raw Materials, CRM's), en daarbij nieuwe klanten en stakeholders betrekken.

Digitale strategie

Gezien het hoge huidige tempo van de digitale transformatie hanteert de GDN een principegedreven digitale strategie om de organisatie voor te bereiden op de toekomst. Deze strategie wordt geleid door de principes van **datacentriciteit**, **wendbaarheid** en **connectiviteit** en is gebaseerd op twee kernconcepten: **waardeketens** en **dataspaces**.

Langs waardeketens worden ruwe data vertaald naar bruikbare inzichten, waarbij de GDN het volledige proces faciliteert, van dataverzameling tot de levering van eindproducten. Dataspaces zijn netwerken van organisaties die binnen een gereguleerd kader samenwerken, waarbij datakwaliteit, gemeenschappelijke uitwisselingsstandaarden en helder gedefinieerde waardeketens worden gewaarborgd. De GDN digitale strategie kent de volgende implementatierichtlijnen:

- **Ontwikkeling binnen enterprise architecture** – Het afstemmen van bedrijfsprocessen, informatiesystemen en technologische infrastructuur binnen een strategisch kader om samenhang, interoperabiliteit en optimalisatie te waarborgen.
- **Pilotgedreven transformatie voor grote veranderingen** – Grote veranderingen worden eerst getest in pilots om verstoring van bestaande werkprocessen te minimaliseren.
- **Live transformatie voor incrementele veranderingen** – Het integreren van AI binnen bestaande werkprocessen om kleinere taken te versnellen, met minimale verstoring van de dagelijkse operatie.
- **Voortbouwen op lopende transformaties** – Het integreren van nieuwe technologieën naast bestaande initiatieven, zoals de migratie van DINO naar GDNR.

De uitvoering van de digitale strategie kent ook belangrijke personele en ethische dimensies. Naar verwachting zal de toepassing van AI werkprocessen ingrijpend veranderen en verstoren. Daarom investeert de GDN in de co-evolutie van menselijke expertise en machine learning-systemen, waarbij rekening wordt gehouden met het welzijn en de duurzame inzetbaarheid van medewerkers.

Implementatie

De strategie van de GDN wordt uitgevoerd via de management- en governancestructuren van de organisatie, programma's en een strategische agenda die regelmatig wordt gemonitord en geactualiseerd. Onderliggende plannen richten zich op de herziening van de governance van de GDN, uitvoering van de digitale strategie, wetenschap, geomodellering, communicatie en internationale positionering.

Samenwerking vormt een kernonderdeel van de werkwijze van de GDN. De organisatie werkt nauw samen met overheidsorganisaties, sectorpartners en universiteiten op het gebied van onderzoek, data en innovatie. Internationaal is de GDN actief binnen EuroGeoSurveys (de organisatie van Europese geologische diensten) en draagt zij bij aan Europese projecten, samenwerkingsverbanden, standaardisatie en harmonisatie. Daarnaast ondersteunt de GDN de Nederlandse inzet rond Europese beleidsontwikkelingen, zoals de Critical Raw Materials Act en de Net-Zero Industry Act. Door dergelijke samenwerkingen versterkt de GDN haar positie als gezaghebbende bron van geowetenschappelijke kennis.



Foreword

Our society is founded on the subsurface, not only literally but also figuratively. Its properties determine what we can build, where and how. It provides us with energy, water and mineral resources. It offers our energy system storage capacity and space for the large-scale deployment of renewable sources, helping to improve security of supply and strengthen strategic autonomy.

Subsurface resources are hidden from view and can only be identified and managed using costly data and specialist knowledge. The same applies to identifying and managing risks associated with subsidence and earthquakes, whether natural or human-induced. As the national hub for subsurface data and home to subsurface specialists, the Geological Survey of the Netherlands plays a pivotal role in this respect, making it an indispensable part of the public information and knowledge infrastructure.

Before you is our **Medium-Term Plan 2026–2029**, the strategic plan in which the Geological Survey of the Netherlands sets out its direction for the next four years. Our environment is changing rapidly. We face a combination of persistent challenges relating to water, energy, climate and scarce space, a technological revolution with a major impact on every aspect of our work, and the economic and strategic consequences of the current geopolitical instability. Our environment is also changing rapidly. Time is a factor, and adaptability is crucial.

We can meet these challenges and seize these opportunities while building on a number of major recent successes. In recent years, the Geological Survey of the Netherlands has grown considerably. New responsibilities have been added in the field of sustainable management of the deep subsurface and critical raw materials. Additional resources have been made available for managing the Key Registry of the Subsurface. Demand for our advisory services is growing. Our data management and IT systems are undergoing a complete overhaul. Substantial steps have been taken in research, because knowledge remains relevant only if it is advanced.

This growth did not happen by itself. The invisibility of the subsurface translates into a lack of familiarity with our field and domain, which means that we must always make an above-average effort to demonstrate the relevance of investment in this area. We are therefore particularly proud of the successes achieved in this respect, although some of them will still need to be consolidated in order to deliver lasting benefits.

Confident that we can continue to build on the Geological Survey of the Netherlands, we are doing everything in our power to fulfil our role with distinction, in the interests of society and science, together with our partners and commissioning bodies in government and industry.

We would like to thank our Strategic Advisory Council, Geoscientific Knowledge Committee and our own staff for their valuable advice and contributions, and wish you an enjoyable read.

Management Team, Geological Survey of the Netherlands

Tirza van Daalen, Michiel van der Meulen, Maurice Hanegraaf, Denise Maljers, Nico Zornig, Patrick Brooijmans, Marc Langelaar, Yvonne Schavemaker, Annemiek Asschert, Sanne Huveneers



Executive summary

The Geological Survey of the Netherlands

The Geological Survey of the Netherlands (GDN) is operated by research and technology organisation TNO. Its mission is to promote and enable safe and sustainable use of the subsurface through trusted geoscientific knowledge, delivered through data and information services, formal advisory roles, and research.

The GDN's governance and responsibilities are defined in a contract between TNO and the Dutch State, which requires a four-year Medium-Term Plan (MTP). The current plan (MTP29) covers 2026–2029 and aligns with TNO's strategy for the same period.

Strategic drivers

The GDN's strategy responds to a set of socio-environmental, geopolitical, and technological drivers, particularly the pursuit of strategic autonomy, the energy and materials transitions, climate adaptation, land-use pressures, and the current AI-driven acceleration of the digital revolution. Geopolitical instability has highlighted the need for greater energy and raw material self-sufficiency within the EU, influencing the GDN's focus on sustainability and digital sovereignty. Climate-related challenges include reducing dependence on fossil fuels, managing subsidence risks, and adapting to extreme weather events. Rapid developments in information technology require a rethinking of the entire organisation and its ongoing digital transformation.

Strategic priorities

The GDN advances its strategic agenda through four priority areas:

- **Future-proof land use** focuses on the relationships between the built environment and the subsurface, including ground conditions, subsidence, spatial planning, and mining effects. The focus is on the long-term consequences of land and subsurface use, based on an understanding of subsurface properties and relevant geological processes.
- **Groundwater stewardship** addresses the growing imbalance in groundwater systems, caused by climate change, urban growth, the energy transition, and rising water demand. The GDN focuses on restoring this balance with system understanding, shared data, and cooperation across sectors and stakeholders.
- **Geo-energy** focuses on the energy transition, including geothermal energy, sustainable heat networks, and geological storage of CO_2 and hydrogen. Despite decarbonisation, investment in production optimisation continues as hydrocarbons remain key to the Dutch energy mix.
- **Raw materials** is a new strategic priority, currently focused on the Netherlands Materials Observatory (NMO). The GDN will diversify its raw materials portfolio beyond critical raw materials (CRMs), engaging with new customers and stakeholders.

Digital strategy

Given the current pace of digital transformation, the GDN has adopted a principle-based digital strategy to prepare the organisation for the future. The strategy is guided by the principles of **data centricity**, **agility**, and **connectivity**, and is built around two key concepts: **value chains** and **data spaces**. Value chains transform raw data into actionable insights, with the GDN facilitating the process from data acquisition through to the delivery of value-added products. Data spaces refer to networks of organisations that interact within a regulated governance framework, ensuring data quality, common exchange standards, and clearly defined value chains. The GDN Digital Strategy is implemented through the following guidelines:

- **Development under enterprise architecture** – aligning business processes, information systems, and technology infrastructure through a strategic framework to ensure coherence and optimisation.
- **Pilot-driven transformation for large changes** – large changes will be tested in pilots to minimise disruption to existing workflows.
- **Live transformation for small changes** – accelerating small tasks with AI integration within existing workflows, with minimal disruption.
- **Piggybacking on ongoing transformations** – incorporating new technologies alongside current initiatives like the migration from the legacy information system DINO to the new GDNR.

Delivery of the digital strategy also has important human resources and ethical dimensions. AI adoption is expected to reshape and disrupt workflows, and the GDN is investing in the co-evolution of human expertise and machine learning systems while taking staff well-being and employability into account.

Execution

The GDN strategy is implemented through the organisation's management and governance structures, programmes, and a strategic agenda that is monitored and updated on a regular basis. Subordinate plans focus on a revision of the organisation's governance, implementation of the digital strategy, science, geomodelling, communication, and international engagement.

Collaboration is central to the GDN's approach. The organisation works closely with public agencies, sector partners, and universities on shared research, data, and innovation agendas. Internationally, the GDN is active in EuroGeoSurveys (the organisation of European geological survey organisations) and contributes to European projects, cooperations, standardisation, and harmonisation. It supports the Dutch response to EU policy developments, such as the Critical Raw Materials Act and the Net-Zero Industry Act. Through such collaborations, the GDN strengthens its position as an authoritative source of geoscientific knowledge.



1 Introduction

1.1 Background

The Dutch national geological survey organisation GDN (*Geologische Dienst Nederland*) is operated by the Netherlands Organisation for Applied Scientific Research (TNO). The GDN's governance and responsibilities are defined in a contract between TNO and the Dutch State, which, among other things, requires the organisation to prepare a four-year Medium-Term Plan in consultation with key governmental and societal stakeholders. This plan outlines relevant challenges, developments, and the GDN's strategic goals for the coming four years. The current plan, MTP29, covers the period 2026–2029, replaces the previous MTP25, and integrates the new TNO strategy for the same period.

MTP29 was drafted in an era of profound change. The global supply chain crisis that occurred in the aftermath of the COVID-19 pandemic was exacerbated by both the intensification of the Russo-Ukrainian war and, domestically, the closure of the giant Groningen Gas Field. As a result, the Netherlands and the EU began to critically reassess their dependencies on global supply chains in a rapidly changing world order and push for greater strategic autonomy.

This, in turn, influenced the rationale, pace, and priorities of the energy and materials transitions that the GDN supports. Additionally, autonomy carries a security dimension, which may challenge some of the core principles underpinning the GDN and other public information services. Should data, for example, be open by default? Moreover, the launch and rapid adoption of ChatGPT and other AI chatbots have made generative artificial intelligence widely accessible almost overnight, marking the beginning of a disruptive shift in how information and knowledge are created, delivered, discovered, and used.

Meanwhile, the existing drivers of the GDN's work remain: the organisation continues to support the management of land, sea, geological resources, and the impacts of land and subsurface use, geohazards, and climate change – all for the public good and grounded in a solid, ever-growing understanding of the geology of the Netherlands. The GDN's long-standing application domains are the **built environment**, **groundwater**, **geo-energy**, and **raw materials**. MTP29 sets strategic priorities for each domain and prepares the organisation to deliver them.

1.2 The GDN at a glance

1.2.1 Mission and identity

The mission of the GDN is **to promote and enable safe and sustainable subsurface use through independent geoscientific and related technological knowledge.** The organisation's core functions are:

- Delivering **data and information services**.
- Delivering **advisory services**.
- Conducting **research**.

The GDN's tasks are underpinned by the abovementioned State contract as well as two laws. Research activities are undertaken both to support society at large, in line with TNO's general mission, and to develop the statutory tasks. Geological surveying is inherently conservative – requiring the consistent development of databases and the mapping of large areas over extended periods of time. Being part of the research and technology organisation TNO provides the advantage of a continuous drive to innovate. It also gives the GDN access to researchers in other relevant disciplines within the organisation.

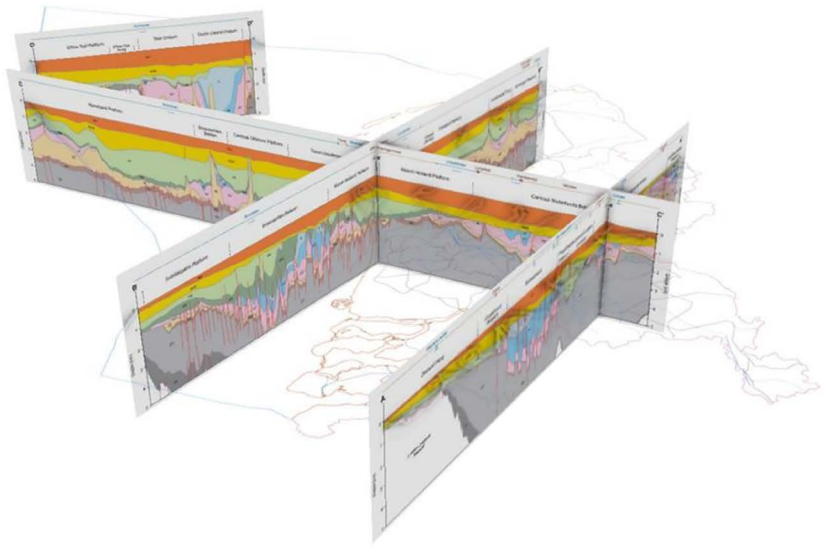


1.2.2 Contributing to the mission of TNO

The mission of TNO is **to create impactful innovations for the sustainable well-being and prosperity of society**. Established by law in 1932 as a national research organisation positioned between academia, industry, and government, TNO conducts contract research, engages in public-private partnerships, creates spin-off companies, supports start-ups, scale-ups, and SMEs, and carries out public tasks. Overall, TNO provides its constituent units and divisions with a purpose, a way of working, an extensive network, and a strong reputation.

In its Strategic Plan 2026–2029, TNO has adopted a leading innovator approach by concentrating on domains in which it excels and leads, supported by dynamic portfolio management. The way and the extent to which the GDN sets priorities align with TNO's intention to maintain focus. The strategy also aims to shorten time to market and enhance customer and market centricity. In this respect, it is relevant that, in its public tasks, the GDN acts as a client of its own research and development activities, ensuring strong alignment. Faster development cycles will be primarily delivered through the GDN's Digital Strategy, which forms part of MTP29 (Chapter 7).

As one of six TNO units, the GDN's parent TNO unit Energy and Materials Transition (EMT) innovates primarily towards a sustainable and safe society. Placement of the GDN within this unit sets the reduction of carbon emissions as one of the major overarching goals of its work. It also enables a system-oriented, holistic approach to the energy and materials transitions, bringing together relevant scientific disciplines, actors, and sectors.

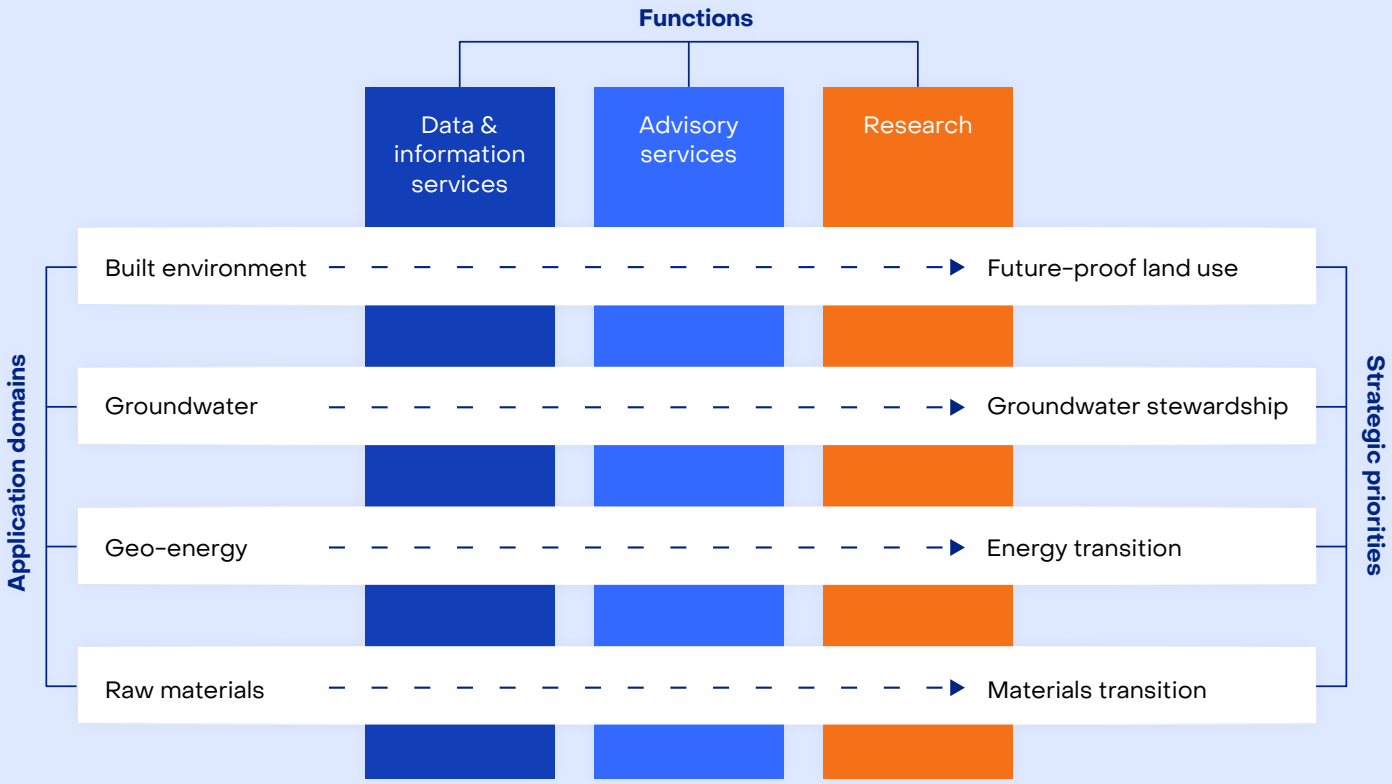


The GDN contributes to these transitions through geoscientific research, as well as information and advisory services. Examples include incorporating geothermal heat into EMT's renewable energy portfolio, assessing the subsurface for energy and carbon storage potential, exploring critical minerals as key enablers of electrification, and developing production optimisation tools to improve energy efficiency.

However, as a fully-fledged geological survey organisation, GDN also supports activities and policies that are unrelated, or only indirectly related, to the energy and materials transitions. These include land use planning, groundwater management, civil engineering, and non-energy minerals planning (such as rock salt, aggregates, and clay). In the context of climate change, much of this work broadens EMT's focus from primarily mitigation to also include adaptation (see Chapter 3).

What is a geological survey?

The core activity of geological survey organisations is to systematically investigate the geology of their territory to identify natural resources and hazards. There are several reasons why geological surveying must be institutionalised. Most importantly, it directly supports economic, environmental, and other public policies that depend on the availability of independent geological knowledge. On a practical level, geological surveying requires multi-year to decadal programmes, which can only be executed by a stable organisation. Core products and services such as databases, maps, and models cannot be created on demand; they must be readily available when needed. In this sense, geological survey organisations function as a public utility and are organised accordingly.



1.3 Strategic priorities

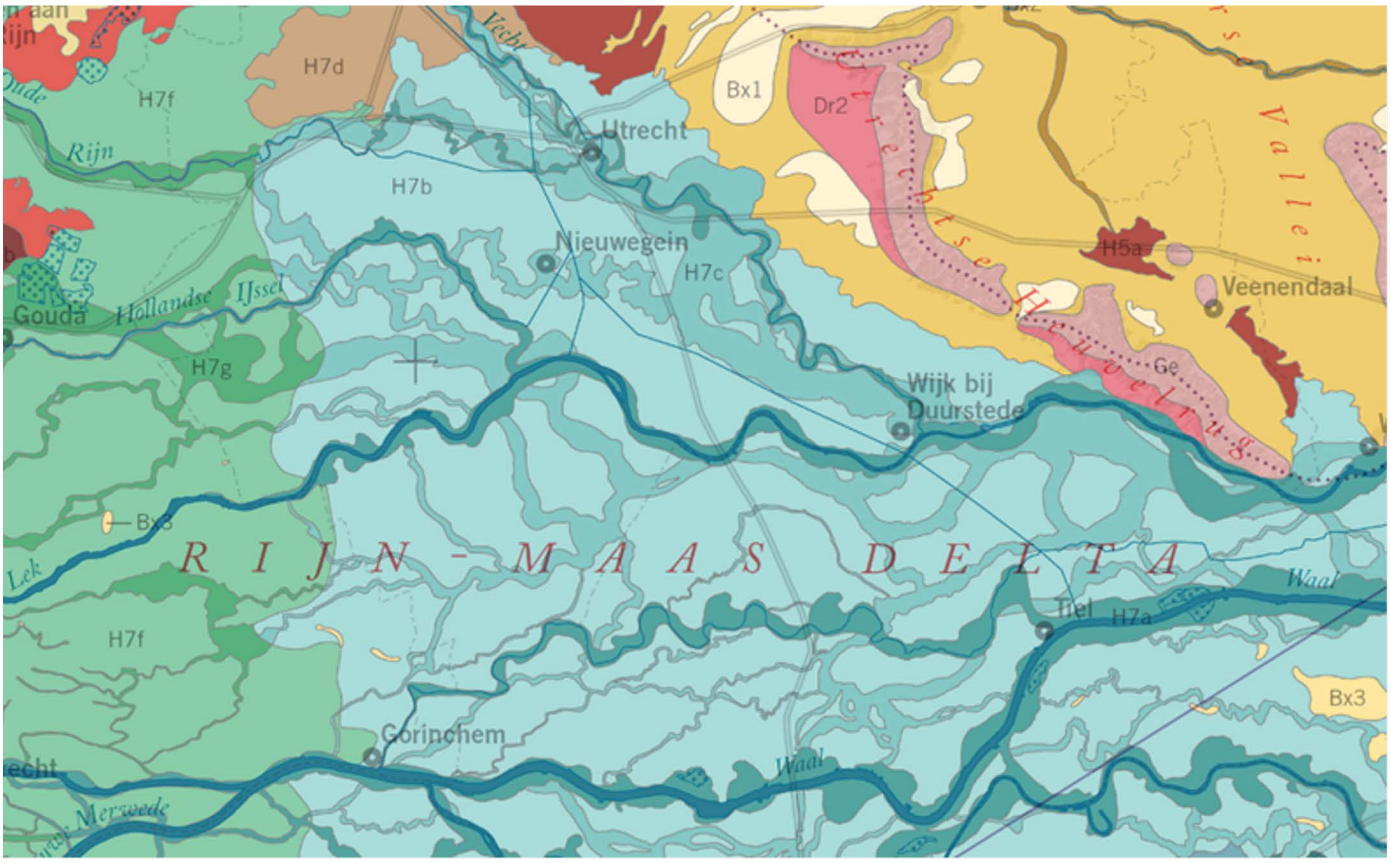
The main application domains of the GDN are the built environment, groundwater, geo-energy, and raw materials. Each of these application domains is characterised by its own combination of public and private stakeholders, challenges, information needs, and geoscience disciplines, and the GDN product portfolio reflects those. MTP29 has four strategic priorities that focus and connect the goals and activities for each application domain: **Future-proof land use**, **Groundwater stewardship**, **Geo-energy** (dedicated to the energy transition), and **Raw materials** (dedicated to the materials transition). Each of the priorities is further outlined in a dedicated chapter, and Figure 1 shows their relationships with the GDN's core functions.

Future-proof land use covers the relationships between the built environment and the subsurface. Key topics include ground conditions, subsidence susceptibility, spatial planning, and the superficial effects of mining. The main activities and accomplishments in this priority area include data and information services, policy support for the Ministry of Economic Affairs and Climate under Advisory services, consultancy and contract research projects, and the successful completion of a TNO exploratory research programme (ERP[1]) on subsidence. The strategic choice is to be future-oriented, which implies a long-term perspective on land and subsurface use, rooted in an understanding of subsurface properties and behaviour, as well as relevant geological and environmental processes and conditions.

Figure 1.
The GDN's core functions, application domains, and strategic priorities (see text for explanation).

Groundwater stewardship addresses the traditional pillars of groundwater resource management – quality and quantity – and, in particular, the resilience of groundwater quality and quantity to climate change. It also considers multipurpose use potential in view of the emerging competition among different uses of groundwater. An example of this is groundwater abstraction for drinking water production and its use for geothermal energy extraction or heat storage. The main activities within this strategic priority are the delivery of data and information services and contract and co-funded research. The strategic focus is on safeguarding resilient groundwater systems for the future.

1 ERPs (Exploratory Research Programmes) are TNO programmes for cross-theme, early-stage/low-TRL research.



Geo-energy: the energy transition is the central strategic focus of GDN's geo-energy activities, which comprise a balanced mix of data and information services, advisory services, and research. The organisation concentrates on geothermal energy, sustainable heat networks, and the geological storage of CO_2 and hydrogen. Dutch hydrocarbon production has passed its peak but will continue to contribute to energy supplies in the foreseeable future. The GDN therefore invests in the safe decommissioning of hydrocarbon infrastructure as well as in optimising production. TNO's Well Technology Centre provides the GDN with the opportunity to conduct experimental geo-energy research in an internationally unique facility that also has applications in the groundwater and raw materials domains.

Raw materials is a new strategic priority that is for the time being almost exclusively tied to the Netherlands Materials Observatory (NMO), a newly established programme set up by the Ministry of Economic Affairs and Climate to collect, manage, and provide data, information, and knowledge about critical raw materials and supply chains. Alongside the NMO, the GDN will diversify its raw materials portfolio to include other raw materials, as well as additional customers and stakeholders.

1.4 Operational context

1.4.1 Geology of the Netherlands

The expertise and ways of working of individual geological surveys reflect the geology of their territories. The GDN is primarily set up to work in an environment that can be summarised as a flat-topped stack of mostly undeformed to mildly deformed sedimentary deposits. Deeper geological structures and resources are largely concealed beneath Quaternary fluvial, coastal, periglacial, and glacial sediments that cover much of the country (Fig. 2)[2].

Under these circumstances, the GDN became the first, and so far the only, geological survey in the world to systematically map its subsurface geology in 3D. Subsurface surveying is expensive. In mountainous and structurally complex regions, exposed geological features

2 The Kingdom of the Netherlands includes six islands in the Caribbean, three of which are independent coun-tries (Aruba, Curacao, and St. Maarten), the other three being special municipalities of the Netherlands proper (Bonaire, Saba, and St. Eustatius). However, unless stated otherwise, 'the Netherlands' refers to the European part of the Kingdom. The GDN does aspire to serve the Caribbean parts as well and has initiated a new round of geological mapping, but this is not yet part of its official remit.

←



Figure 2.
Fragment of the Geological Map of the Kingdom of the Netherlands at a scale of 1:600,000. Main features include the channel-belt network of the Rhine-Meuse delta (shades of blue), its downstream marine-influenced equivalent (shades of green), occurrences of peat (shades of brown), periglacial windblown deposits (yellow), and push moraines of Utrechtse Heuvelrug and the Veluwe (shades of pink).

allow for initial subsurface interpretations using relatively low-cost field and remote sensed data. In contrast, surveying and exploring less deformed sedimentary basins relies entirely on drilling and geophysical methods.

Fortunately, mechanisms have been put in place that provide the GDN with large volumes of third-party subsurface data, which constitute an indispensable foundation for all our activities. The Dutch **Mining Act** stipulates that data acquired under an exploration license must be submitted to the GDN and be made publicly available after a five-year confidentiality period. In addition, the **BRO Act** – a law governing geological data, described in more detail below – requires that geological data collected by public bodies be deposited in the **BRO 'Key Registry of the Subsurface'** operated by the GDN. As a result, the GDN manages a vast collection of subsurface data, representing an estimated replacement value in the order of one hundred billion euros. This includes the fruits of over a century of **geological surveying**, decades of **hydrogeological mapping** and licensed subsurface **exploration**, as well as a plethora of **third-party data** contributions.

1.4.2 Subsurface use driving innovation

In addition to being part of a research and technology organisation, there are three related reasons why the GDN needs to be innovative to operate successfully in the Netherlands:

- **Working on the subsurface** – While traditional geological surveying used to be a relatively low-tech, largely stand-alone, and mainly geology-driven operation, mapping and exploring the subsurface is technically challenging and multidisciplinary by nature, relying on geological, geophysical, geochemical, geomechanical, geohydrological, engineering, and/or IT inputs (depending on context and application).
- **Data intensity** – Managing, handling, and getting the most out of the large volumes available to the organisation necessitates keeping up with rapid developments in IT and data science.
- **Industry collaboration** – The GDN needs to keep pace with rapid developments in technically advanced energy and geospatial sectors.





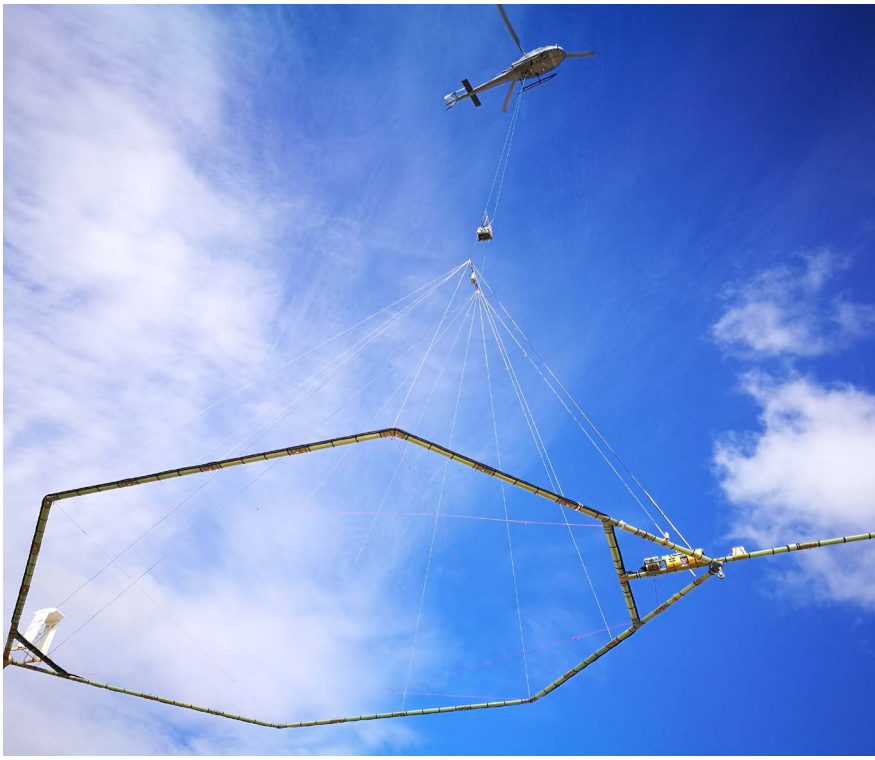
Finally, due to the Netherlands' high population density, the GDN benefits from a large taxpayer base. This makes it a medium-sized geological survey in a small country, with the advantage of not having to spread its resources as thinly as many of its international peers. Compared to most other geological surveys worldwide, the GDN is well resourced – in terms of both data and financial support – is innovative, and was rated accordingly in recent Knowledge Audits (2020, 2025).

1.5 Organisation and capabilities

1.5.1 Functions and structure

The organisational structure of the GDN is based on its three core functions, which are carried out by six operational groups:

- **Data and information services** are primarily delivered by three groups: Geodata and Information Management (GDIM), Geo-Information Technology (GIT), and Subsurface Modelling (SSM). Their activities are funded from the dedicated Geo-information Programme (GIP), which has been running for decades. On behalf of the state government and with a legal mandate, these departments jointly operate and provide public access to national geological databases, which contain subsurface data along with the results of the GDN's systematic subsurface mapping efforts. In 2024, the GDN was tasked with establishing the **Netherlands Materials Observatory (NMO)**, in order to support the Dutch raw materials strategy and the EU Critical Raw Materials Act (see below). The NMO's minerals intelligence and exploration components bring a new domain to the GDN's data and information portfolio.
- **Advisory Services** – The GDN's Advisory Group for Economic Affairs (AGE) is tasked with supporting the Ministry of Economic Affairs and Climate (EZK) and the State Supervision of Mines (SodM) with advice on geological aspects of mining policy and licensing. The advisory services are delivered from dedicated work programmes. The NMO introduces a new policy domain to TNO's advisory services, from within the GDN and elsewhere in TNO.
- **Research** – Two GDN groups have research as their core activity: Geoscience and Technology (GST) and Hydrology and Reservoir Engineering (HRE). The GDN conducts research on geo-energy (GST and HRE) and groundwater (HRE), creating innovations for and with the public and private sectors, as well as for the development of the GDN's other functions. They are primarily funded from three TNO research programmes (on geo-energy, groundwater, and subsidence), contract research projects (for industry and government clients), and co-funded research (e.g. EU and national subsidies). A business development team is tasked with acquiring and contracting co-funded partnerships (EU, joint industry projects) and contract research for private or public organisations, both nationally and internationally. The objective is to bring innovations to the market, including – but not limited to – deployment in the public tasks.



1.5.2 Projects and processes

In research and in the delivery of advisory services, GDN operates as a project-based organisation, in line with TNO as a whole. The focus is on the delivery and management of temporary, one-off initiatives with defined start and end points, aimed at achieving specific outcomes. TNO's management system and job architecture are designed accordingly.

By contrast, the delivery of data and information services requires GDN to operate as a process-based organisation, structured around ongoing, repeatable workflows.

Effective synchronisation and handovers between processes and projects require continuous attention from GDN's management, awareness and mutual understanding across groups and teams, as well as clear communication with stakeholders regarding governance and expectations for products and services. The development of such tasks – in terms of strategic direction and funding – is taken up by a dedicated team.

1.5.3 Facilities

The GDN has five main facilities, whose operational expenses are covered by equipment and hourly rates. Large facilities typically require additional external investments.

- The GDN stores industry core samples of licensed exploration efforts and other valuable samples in the **National Core Store** in Zeist (operated by GDIM). After approximately 25 years of operation, this facility is close to full capacity. Funding has been secured to build a new core store.
- The **Well Technology Centre** in Rijswijk (managed by GST) is an open innovation lab for improving technologies to accelerate the energy transition, with a focus on geothermal energy and the subsurface storage of heat, hydrogen, and CO_2. Capabilities include full-scale testing and demonstration of new drilling techniques, flow, and materials under high pressure and temperature.
- GST's rock mechanics lab **iM4RockLab** supports geomechanical studies with measured parameters.
- SSM's **core sample description laboratory** supports the parametrisation of subsurface models.
- SSM's **hydrolab** supports the hydraulic parametrisation of subsurface models.

1.5.4 Measurement and monitoring

Alongside its on-premises analytical capabilities, the GDN maintains a wide range of field-based measurement and monitoring activities:

- **Sercel digital wireless 3-component geophones** ('Smurfs'), for all-round high-resolution active seismic surveys, passive seismic interferometry, and (induced) seismicity monitoring.
- **Fibre-optic DAS cables and interrogators**:
  - Active seismic surveys, passive seismic interferometry, VSPs, and (induced) seismicity monitoring in boreholes, urban environments, offshore settings, etc.
  - Temperature monitoring in boreholes, urban environments, offshore settings, etc.
  - Strain, deformation, and subsidence monitoring in boreholes, urban environments, onshore and offshore settings, etc.
- **Passive seismic monitoring** of aquifer pore pressure and S-wave velocity to depths of up to 250 m at both local high-resolution and regional scales. This is done with either Sercel geophones or fibre-optic cables along the surface with spacing according to the desired resolution.
- Electromagnetic surveying:
  - **tTEM electromagnetic resistivity imaging**, for mapping subsurface lithological profiles to depths of approximately 50 m, salinity mapping, and calibration of airborne EM surveys.
  - **Vertical Electrical Sounding (VES)**, for 1D electrical resistivity profile mapping and calibration of airborne EM and tTEM surveys.
  - **Mobile EM and satellite-based soil moisture monitoring** – for monitoring soil moisture content within the upper metre below ground level at both local high-resolution and regional scales.
- **InSAR radar ground-level measurements**, for measuring ground-level movement using satellite data with millimetre-scale precision.
- **Field geology**: sampling, making observations, and mapping in a variety of settings.
- Design, implementation, and operation of **hydrogeochemical monitoring networks**.
- **Field hydrogeology**, including groundwater and soil sampling:
  - Major and trace elements, gas composition, alkalinity, dissolved organic carbon (DOC), microbiological analyses, and isotope analyses.
  - **Groundwater age dating** based on tritium-helium ($^3H/^3He$) methods.
  - **Temperature measurements** using divers or fibre optics (distributed temperature sensing, DTS) in piezometers and wells.
  - **Groundwater table measurements** using divers in piezometers and wells.
  - Advanced equipment for **groundwater gas sampling**, in which in-situ hydrostatic pressures are preserved to prevent the degassing of sensitive dissolved gases such as ^3He and ^{85}Kr.



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2 Drivers

2.1 Introduction

The GDN's work encompasses all subsurface usage and associated risks in the Netherlands. It would be impossible to provide an exhaustive overview of all relevant policy, societal, scientific, and business developments currently shaping the evolution of the GDN's products and services. Instead, this chapter focuses on the major socio-environmental, geopolitical, and technological drivers, i.e. those that go beyond business-as-usual and define our strategic priorities. These include the geopolitically motivated pursuit of greater strategic autonomy, the related energy and materials transitions, climate change, land-use pressure, and the AI revolution.

2.2 Geopolitics

Public and political awareness of global warming gained momentum in the mid-2010s. Since then, the primary motivation for mitigating climate change has been the existential threats posed by sea level rise, increasing temperatures, and the growing frequency of meteorological and hydrological extremes. These come in addition to the environmental degradation and loss of biodiversity already occurring as a result of global economic growth. This shift in awareness is reflected in key frameworks such as the UN 2030 Agenda for Sustainable Development (2015), the Paris Agreement (2015), major policy initiatives including the European Green Deal (2020), and their implementation at the national level.

However, recent global political instability has led to a shift in perspective on sustainability. The European Union has recognised the need to become more self-reliant in several key areas, including energy and raw materials. Green growth ambitions are now being supplemented by a focus on strategic autonomy. While this evolving perspective may not necessarily change the technical and scientific content of our work, it does influence the expectations and priorities our government sets for our data, information, and advisory services. Furthermore, where strategic autonomy translates into digital sovereignty, it is expected to have a direct impact on our open data policies and the confidentiality of our work in general.

2.3 Climate

2.3.1 Mitigation

Decarbonising our economies requires a fundamental transformation of the existing energy system, a large part of which will take place in the subsurface. This will involve industrial-scale expansion of geothermal energy production and storage, large-scale buffering of sustainably produced energy carriers, the safe permanent storage of CO_2, and, in the longer term, the storage of other residual materials such as nuclear waste.

Within the energy and climate policies of the Netherlands and Europe, two major societal challenges are central:

- **Strategic autonomy** – How can we reverse the rapidly increasing dependence on imported energy and, through alternative forms of energy production from domestic resources, maintain a secure and affordable energy supply?
- **Climate targets** – How can we ensure that climate targets remain within reach and prevent the persistently high demand for energy in the Netherlands from undermining a healthy and safe living environment?

For decades, the availability of low-cost, domestically produced natural gas has contributed to the country's favourable business climate, particularly for energy-intensive industries. Most buildings are heated with natural gas distributed through a dense network. All of the above means that decarbonising the Dutch economy will be particularly challenging.

Within the complex, multifaceted, and often controversial energy transition, the **earth sciences contribute** to the exploration, siting, and monitoring of emission reduction solutions, including geothermal, solar, wind, and nuclear energy; energy storage; electrification; carbon storage; and the safe decommissioning

of existing hydrocarbon production and associated infrastructure.

However, **public trust** in subsurface operations – as well as in government oversight, scientific expertise, and the companies and institutions involved – has been profoundly undermined by the handling of induced seismicity in Groningen. For the energy transition to succeed, the science underpinning decision-making must be not only rigorous but also clearly communicated and accessible to the broader public. Beyond the subsurface itself, it should address the trade-offs and consequences associated with competing uses, potential environmental impacts, and the further integration of above-ground infrastructure and land use more generally.

2.3.2 Adaptation

Climate change presents particular challenges to Dutch society, several of which relate to geology or subsurface use.

Sea-level rise and subsidence present a growing risk to the low-lying economic heartland of the Netherlands. Relative sea-level rise – land subsidence – already began many centuries ago as the unforeseen but inevitable by-product of land use and water management in the extensive Dutch fluvial and coastal plains. Additional subsidence has occurred since the late 19th, early 20th, and late 20th centuries as a result of coal mining, salt mining, and hydrocarbon extraction, respectively. Where subsidence is caused by compaction and/or peat degradation at or near the surface, it is expected to accelerate under global warming, as droughts increase both compaction and degradation rates. Regardless of the cause, subsidence poses a significant challenge to climate adaptation strategies.

Meteorological extremes – Until recently, Dutch flood protection focused primarily on the fluvial and coastal lowlands, which are particularly vulnerable to peak river discharges, storm surges, and the combination of both, especially during the winter and early spring. However, the most recent major flooding event in the Netherlands was caused by extreme summer rainfall in the Dutch-German-Belgian border region. Such meteorological extremes are expected to become more frequent, increasing the risk of both off-season flooding and droughts of a severity not previously experienced in the Netherlands, posing challenges for irrigation and navigation.





Water shortages – The effects of drought on groundwater recharge, overexploitation, and competing demands from the drinking water and thermal energy storage sectors have brought groundwater management back onto the national policy agenda after some 15 years of relative neglect. Current priorities include balancing groundwater use under climate change, managing contaminant pressures from urban, agricultural, and industrial sources, and accommodating subsurface demands related to the energy transition.

Caribbean Netherlands – A court case brought by Greenpeace and residents of Bonaire found that the Dutch government has failed to adequately protect the island from the impacts of climate change, including rising sea levels and heat stress, in violation of human rights obligations. The court ruled that Bonaire has been treated less favourably than the European Netherlands and ordered the government to strengthen both climate adaptation measures and emissions reduction targets. The case forms part of a broader debate about the Dutch government's duty of care towards the BES islands (Bonaire, Saba, and Sint Eustatius) concerning, amongst other things, environmental protection and water management.

2.4 Land-use pressure

Land-use pressure is a defining feature of spatial planning in the Netherlands, which is densely populated and faces overlapping demands from housing, energy, agriculture, nature, and infrastructure. The draft *Nota Ruimte* (National Spatial Strategy) characterises the country as facing a 'battle for space', in which structural land shortages require more explicit prioritisation and long-term choices up to 2050. It links major national transitions – such as climate adaptation, the energy transition, and housing – to concrete spatial allocations.

In addition to adapting to global change, Dutch land-use planning must also address severe housing shortages. Approximately one million homes need to be delivered between 2024 and 2033. In addition to economic considerations, site selection must take into account the physical environment, including subsurface-related conditions and processes such as ground conditions, susceptibility to subsidence, flood risk, drought, and the effects of mining – some of which are subject to change and require predictive scenarios. Furthermore, the construction effort will require raw materials, particularly aggregates.

2.5 AI revolution

The current phase of the digital revolution is characterised by the convergence of permanent, ubiquitous connectivity, increasingly powerful computing infrastructure, and advanced analytics. Together, these technologies are transforming the way information is produced, shared, and used, reshaping economic activity, public services, scientific research, and everyday life.

While earlier phases of digitalisation focused primarily on data, modelling, and automation, the latest wave of innovation increasingly affects knowledge-intensive activities that were considered uniquely human until now. In this respect, AI stands out as a particularly disruptive technology. Recent advances in machine learning and generative AI have enabled systems to recognise patterns, generate text and images, support decision-making, and perform complex analytical tasks at an unprecedented speed and scale. This affects not only the nature and business of geological survey organisations, but also the entire information and knowledge infrastructure of which they are part.

Public debate on AI is often shaped by hype, framing it as either a cure-all or a threat. In reality, successful adoption depends on organisational readiness, governance, data quality, and clear problem definition. Beyond that, it requires a clear ethical framework that takes into account the full spectrum of potential issues, from staff well-being and employability to data ownership, provenance, legality, fundamental rights, and public values.



3 Future-proof land use

3.1 Recent developments and strategic direction

The Future-proof land use priority addresses the relationships between the subsurface and the built environment. It encompasses and integrates key topics such as ground conditions, land subsidence, induced seismicity, and land-use planning.

Recent major accomplishments and milestones include:

- Securing funding for the maintenance and further development of the BRO, reinforcing its role within the geospatial key registries and as a tool for infrastructure planning.
- Being commissioned to establish seismic monitoring for the Portos CCS site.
- Completing a TNO Exploratory Research Programme (ERP) on subsidence and building damage, laying the groundwork for a national subsidence information system.
- Contributing to the initial development of the national foundation register.

There are two major challenges for this priority in the next strategic period. The first is to consolidate and stabilise the organisation following a period of rapid growth. This includes the implementation of new workflows, particularly in relation to the transition to a new corporate database system and the adoption of new technologies in modelling and research practices. Much of this will depend on the successful implementation of the Digital Strategy (Chapter 7). The second challenge is to diversify the portfolio, customer base, and funding streams in a priority area currently dominated by data and information services.

3.2 Scope and ambition

Operating the Key Register of the Subsurface (BRO) positions the GDN as one of the designated enablers of land-use planning in the Netherlands. However, while the organisation supports land-use planning and decision-making through information services delivered via the BRO, its active involvement in policy and decision-making processes remains limited. The overall ambition for Future-proof land use is to achieve a balanced role within this domain, in which information services, advisory services, and the research function act as mutually reinforcing elements of the GDN's work, with Geo-energy serving as a reference. The term 'future-proof' expresses the ambition to contribute to sustainable land use, supporting plans that can adapt to a changing environment.

Adapting to change requires a focus on the ability to model and predict the outcomes of human interaction with the subsurface, such as construction, groundwater abstraction, and mining. External factors, such as anticipated prolonged periods of summer drought, intense precipitation, and saltwater intrusion present additional challenges for subsurface use, affecting ground stability, pluvial or flash flooding, and crop conditions, respectively, for example. For optimal land-use planning, and to prevent future damage caused by these processes, it is essential to understand the underlying physics. In addition, the availability of reliable data and validated 3D geological models populated with relevant ground parameters is required to ensure stability and sustainable subsurface use.

3.3 Solutions

3.3.1 Ground conditions

To contribute to the onshore and offshore spatial planning challenges of the coming decades, understanding and anticipating varying and changing ground conditions is essential. In the built environment, the anthropogenic – or anthropogenically modified – top layer is poorly characterised and mapped. For optimal use of the shallow subsurface, it is important to reduce risks associated with anticipated climate change, foundation problems, and the future development of expanding urban areas. The GDN's data and knowledge position regarding the characteristics of the shallow subsurface provides a strong basis for enriching current models and information.

An intensification of research and mapping activities in the anthropogenic domain is needed to enhance the value and applicability of GDN's 3D subsurface models and information. Enriching and integrating current geological models with underused geotechnical, geochemical, geophysical, and environmental data will improve the characterisation and parametrisation of both natural and anthropogenic deposits underlying urban areas, as well as onshore and offshore infrastructure. By 2029, the GDN will have developed and demonstrated a 3D subsurface modelling workflow capable of incorporating currently underused datasets and generating results for the shallow subsurface at both local and regional scales. To support this goal, preparations are underway to deliver a sovereign AI foundation model and digital twin for geotechnical subsurface interpretation, utilising the national subsurface register BRO as the training corpus.

The report *Goed Gefundeerd* ('Well-Founded') by the Council for the Environment and Infrastructure (RLI) describes a stalemate in which foundation repairs lagged behind and property owners, market players, and governments were unable or unwilling to address the issue until recently. As a result, the condition of foundations has played only a limited role in property transactions. Moreover, foundation repairs require cooperation between households, which often proves difficult. Finally, the legal question of responsibility for foundation damage is highly complex. In addition to providing geological information, the GDN will contribute to the establishment of a much-needed foundation register. As currently envisaged, this register will not only provide basic information to prospective homeowners, but also offer risk assessments to support asset portfolio management by banks and housing associations.

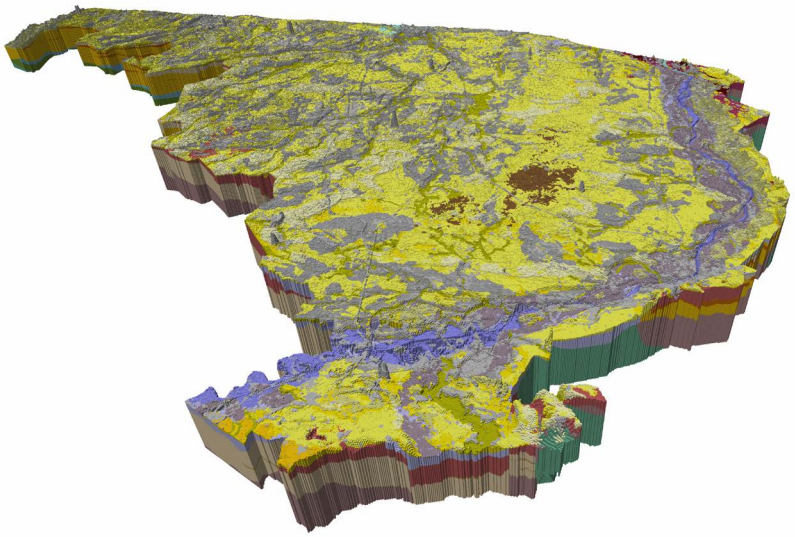
3.3.2 Land subsidence

In the Netherlands, land subsidence is a major cause of large-scale damage to buildings and infrastructure and exacerbates flood risk. The associated costs are substantial and are projected to increase in the future. Disentangling deep subsidence drivers, such as mining and energy storage, from shallow drivers, such as water table management, is becoming increasingly important for both government and industry. Addressing this growing societal challenge requires the ability to measure and understand the underlying subsurface processes, and to forecast future developments resulting from both natural processes and anthropogenic influences. The GDN holds extensive knowledge and data on subsidence and is well positioned to connect with materials and building experts elsewhere within TNO, covering the full chain from drivers to economic impacts.

Towards 2029, the GDN will expand its advisory capacity on this topic for government and industry and provide freely accessible, regularly updated data based on in-house InSAR processing capabilities. It will enhance proprietary models to incorporate the ability to forecast the consequences of decisions and policies in terms of both subsidence and its economic impacts. This evidence-based insight will support robust and transparent decision-making.

3.3.3 Induced seismicity

The success of the energy transition depends on the ability to safely utilise the subsurface for sustainable energy production and storage. In response to the problems caused by – and public outrage over – the induced seismicity associated with gas production in the Groningen Field, the permitting procedure under Dutch mining law places particular emphasis on seismic risk assessment. At present, decisions on licence applications for sustainable subsurface use are often significantly delayed due to challenges associated with seismic risk and its assessment. The





seismic risk assessment process needs to be improved to enable robust and reliable evaluation of risks associated with new projects, allowing applications to be granted or refused without ambiguity. In addition, management and understanding of induced seismicity are essential for maintaining the industry's social licence to operate and for providing a diagnostic tool for subsurface behaviour.

The GDN aspires to a leading role in assessing the effects of subsurface operations. By 2029, the approach to seismic risk assessment across all subsurface applications will be harmonised. Geomechanical datasets will be secured, refined, and disseminated, providing a shared basis for harmonised risk assessment and for advanced geomechanical modelling of earthquake source mechanisms. At the same time, both baseline and operation-specific seismic monitoring will be expanded to validate and calibrate models used to forecast earthquake generation and monitor conformance, with fibre optics and machine learning playing an increasingly important role. Advanced monitoring-data processing workflows will be implemented and integrated according to the value-chain principle discussed in Chapter 7.

3.4 Implementation

Amid an ever-growing scarcity of space, informed decision-making relies on connections between all relevant stakeholders, such as spatial planners, economists, developers, policymakers, and a range of subject-matter experts. The GDN's expertise enables the provision of subsurface information and the effective integration of surface and subsurface domains, thereby supporting informed decision-making and identifying potential opportunities. Information products are provided to multiple stakeholders at appropriate scales.

Looking ahead to 2029, the implementation of the solutions within the Future-proof land use priority area is expected to result in an expansion of data and information services, as well as an increase in research and advisory services, particularly in the spatial planning domain. Successful implementation requires a solid foundation: strong and flexible support from data and information services, particularly with regard to newly acquired and currently underutilised data types.

Land-use planning is inherently multi- and interdisciplinary. Beyond delivering geoscientific information, TNO is particularly well positioned to support spatial planning at the intersection of geological expertise and economic analysis. The aim is to establish a programme within TNO on this basis that addresses pressing societal challenges in the Netherlands, including housing, the energy and materials transitions, water management, soil quality, climate adaptation, and the use of subsurface resources. Across these themes, such programme would emphasise a broad well-being approach and distributional effects, assessing who benefits, who bears the costs, and the implications for fairness and policy choices.



4 Groundwater stewardship

4.1 Recent developments and strategic direction

Groundwater stewardship concerns the socially just, sustainable, and economically sound management of groundwater, for which public, private, and civil society actors share responsibility. The GDN supports society in making decisions on climate-resilient, sustainable, and economically responsible groundwater use through world-class knowledge, tools, and facilities.

Climate change, environmental pressures, emerging contaminants such as PFAS and pharmaceuticals, and competing demands on subsurface space – particularly from the energy transition – have brought groundwater management back to the forefront of national policy. Issues such as prolonged droughts, excessive rainfall, and the PFAS pollution crisis are having significant impacts, including altered recharge rates and land subsidence.

The Dutch government has responded with two key policy initiatives:

- ***Water en Bodem Sturend*** (water and soil/subsurface as guiding principles), which mandates the integration of groundwater and subsurface considerations into land-use planning.
- **Sustainable use of the subsurface**, which aims to identify and subsequently manage conflicts in subsurface use, such as those between drinking water protection and thermal energy storage. This is a joint effort by the Ministries of I&W and EZK, with scientific support from the GDN and Deltares.

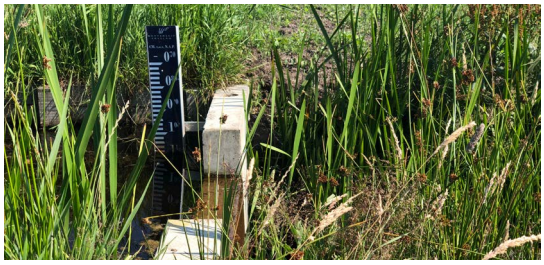
The GDN's groundwater research discipline is at a strategic crossroads. It needs to scale up and broaden its scope to address emerging societal and environmental challenges. During the upcoming strategy period, TNO will increase the research investment budget by approximately a factor of two. This increase, together with existing groundwater-related information services in the BRO, will enable the GDN to meet the growing demand for high-quality groundwater data and intelligence.

4.2 Scope and ambition

Groundwater stewardship increases transparency of the subsurface, supports sustainable governance, and connects stakeholders to ensure a resilient groundwater system for future generations. This is achieved through a progressive national groundwater intelligence platform, innovative services, and building a leading role in the groundwater domain.

The GDN has been collecting, storing, and disseminating groundwater data for decades. These data are used to generate information and knowledge that inform advice to public and private institutions on societal challenges. In recent years, groundwater resources have come under increasing pressure, resulting in an increasing demand for data, information, and applied knowledge. At the same time, responsibilities for different aspects of groundwater management are dispersed across various governing bodies, which often hinders an integrated approach to groundwater issues.

There are clear opportunities to expand the portfolio in response to emerging needs. This is being addressed by building on the GDN's data and information services, which also cover groundwater. In combination with science and socio-economic expertise available across TNO, this enables an integrated approach to addressing groundwater-related challenges.



4.3 Solutions

4.3.1 System understanding

Groundwater is used for drinking water supplies, irrigation, industry, and to support the energy transition, in particular for heat extraction and thermal storage. Pressures on the quality and quantity of groundwater resources are driven by population growth, pollution, and climate change.

Solutions currently being explored include water purification, water storage, and the use of alternative sources (e.g. seawater or brackish-to-saline groundwater). To properly assess the environmental impacts of subsurface activities, the economic feasibility of resource extraction, and the effects of policy on groundwater resources, a clear understanding of the groundwater system is essential. This requires insight into the natural baseline and the current state of groundwater resources, as well as an understanding of past trends and well-founded expectations for the future.

The GDN's ambition is to make the entire Dutch groundwater system visible and predictable in real time and in four dimensions. This will be achieved through a suite of advanced, reliable, and accessible information products. Although many steps have already been taken, achieving this ambition by 2029 remains challenging. Acceleration will require close alignment with user needs and the GDN's Digital Strategy (Chapter 7), clear prioritisation of activities and/or areas, exploration of applications of machine learning and artificial intelligence, and transparency regarding the reliability of data and models in use.

The GDN aims to expand its capabilities in assessing groundwater resources through an enhanced REGIS model, featuring extended depth coverage and additional parameters (such as thermal properties). To provide a comprehensive understanding of hydrogeological characteristics and the dynamic behaviour of groundwater quantity and quality, the GDN also aims to develop a national groundwater age database. This will require the implementation of age-dating methods in national and provincial monitoring networks and offers potential for international technology transfer.

4.3.2 Multipurpose use

Groundwater serves multiple purposes. As the availability of fresh and clean groundwater becomes increasingly limited, competing interests arise regarding its use. A clear example is the risk of penetrating clay layers for geothermal energy extraction while simultaneously seeking to protect drinking water resources located beneath these layers. Under the motto 'From conflicting interests to value creation – towards a unified four-dimensional framework for smart and sustainable groundwater use,' the GDN focuses on two aspects:

- **4D planning** – Subsurface use planning is an inherently four-dimensional undertaking, aimed at identifying interferences and synergies between different applications in space and time. The GDN's ambition is to support clients with a clear decision-making framework that indicates what can and cannot take place where, and whether this entails risks or opportunities, using advanced decision-support tools. Potential maps for different uses can support initial strategic considerations.
- **Technology for minimising environmental impacts** – Activities in the subsurface involve risks that may affect groundwater dynamics and composition. The GDN therefore contributes to improved drilling, extraction, and storage techniques in collaboration with industry partners to mitigate or minimise impacts such as leakage or thermal effects. This is achieved through the development of existing and new innovations towards higher technology readiness levels, amongst other things in the Well Technology Centre (5.4.3). The GDN's work aims to reduce risks and optimise business cases for industry, thereby stimulating innovation in the sustainable use of the subsurface and groundwater.



4.3.3 Climate Resilience

Building on systems understanding and data and information tools, the GDN researches adaptation and mitigation measures for the impacts of extreme weather driven by climate change, with the ultimate goal of translating knowledge of climate impacts on soil and groundwater into actionable solutions for a safe and sustainable living environment.

Drought and extreme rainfall can alter subsurface conditions, including lower groundwater levels, higher subsurface temperatures, flow and contaminant transport pathways, and soil shrink-swell behaviour. Research focuses on:

- **Key surface–subsurface interactions** – flow paths, unsaturated-zone transport, evaporation, groundwater-table dynamics.
- Using weather and climate drivers in historical and **predictive groundwater models**.
- **Downscaling** results from regional to local (urban) scale.

Outputs include short and long-term forecasts; decision support for risk assessments; assessments of the effects of climate change on groundwater and soil policies; and feasibility assessments of safe, cost-effective measures, such as managed aquifer recharge. This work translates the impacts of climate change on the subsurface and groundwater into practical recommendations that support a safe and sustainable living environment.



4.4 Implementation

Implementing the solutions within the Groundwater stewardship priority area is expected to increase the share of contract research relative to the current proportion of data and information work, which has already reached a higher level of maturity. In addition, the GDN aspires to develop an advisory role in the groundwater domain, analogous to those in geo-energy and critical raw materials.

To realise these ambitions, the GDN requires stronger positioning as an expert organisation in the groundwater domain. Demonstrating the impact of multidisciplinary projects through compelling examples will support this effort. Closer engagement with users will improve understanding of their challenges, needs, and the conditions under which tools and technologies can be applied. Through this strategy, the GDN will contribute to the objective of climate-resilient, sustainable, and economically responsible groundwater use.





5 Geo-energy

5.1 Recent developments and strategic direction

The Geo-energy strategic priority supports the energy transition, with a particular focus on the heat transition (geothermal energy and aquifer thermal energy storage); the subsurface storage of hydrogen, CO_2, and radioactive waste; and the responsible phase-out of fossil fuels.

Recent major advances in the Geo-energy domain include:

- Securing budget increases and investments in energy-transition-related information services, the Well Technology Centre, and a new core store.
- Fostering substantial growth of the research portfolio.

The major challenge for this priority area in the next strategic period will be consolidation. Organisationally, this will depend on:

- Successfully delivering the PIO programme and securing continued funding for energy-related data and information services beyond 2028.
- Developing the CO_2-storage and transport application domain, in conjunction with the Dutch implementation of the EU Net-Zero Industry Act.

5.2 Scope and ambitions

The GDN focuses on the development of innovative technologies, model-ready data, scientific knowledge, and decision-making frameworks that support the feasible, cost-efficient, and socially responsible development and scaling up of new industrial uses of the subsurface associated with the energy transition. Additional areas of focus include responsible and efficient multipurpose use of the subsurface, closer integration with above-ground demand and infrastructure, and the provision of transparent information to citizens and regional authorities (alongside the GDN's well-established advisory role to the central government).



5.3 Solutions

5.3.1 Geothermal energy and heat storage

The development of geothermal energy production is in a phase of steady growth, and high-temperature heat storage is moving towards commercial application. However, the current pace of development is insufficient for the acceleration required in the heat transition in the built environment and is hindered by the delayed rollout of district heating networks, insufficient coordination between municipalities, heat companies, and investors, high exploration risks, and the complex linkage between supply and variable heat demand. The GDN is working on solutions that market parties cannot address independently, including reducing exploration risks, system optimisation, and developing robust frameworks for the spatial integration of geothermal projects. Together with the heat sector and the relevant authorities, TNO is committed to accelerating geothermal heat production and associated seasonal heat storage capacity to a level of 15 PJ/year by 2030.

5.3.2 CO_2 capture, transport, and storage (CCS)

CO_2 capture, transport, and storage (CCS) comprises a chain of technologies that is



essential to achieving Dutch and European climate targets. The Netherlands has committed to the Net-Zero Industry Act (NZIA) and must be ready, by 2030 at the latest, to facilitate the commercial-scale deployment of CO_2 injection and storage at a rate of 22 Mt per year. Together with other geological institutes across Europe, TNO is working on a dynamic storage portfolio that provides insight into the feasibility and delivery of medium to long-term CO_2 storage targets in the Netherlands and Europe.

The GDN and other TNO departments are jointly developing a central knowledge base for the entire CCS value chain, including the integration of storage and transport. Under the Future-proof land use priority area, which encompasses the effects of mining, the GDN is laying the foundation for a national platform to secure monitoring and injection data, provide insight into the controllability of technical storage risks, and establish a robust advisory and information programme capable of anticipating the challenges associated with large-scale deployment.

5.3.3 Hydrogen and radioactive waste

National energy scenarios rely heavily on the timely scaling up of the production, transport, and storage of emission-free hydrogen. Continued technological development and cost reduction across all parts of the hydrogen value chain are essential to this. In recent years, TNO has taken on an internationally leading role in the development of the hydrogen value chain. In the coming years, the GDN will steer the further consolidation of international cooperation, linking R&D, industry, and policy, and use this to support the realisation of demonstration projects and the first commercial hydrogen storage facilities in the Netherlands. In the past period, TNO has developed innovative concepts for the safe storage of radioactive waste. In the coming years, these will be further developed with a view to delivering the first pilot projects. The outcomes will be applicable across Europe and thereby offer prospects for a responsible future expansion of nuclear energy.

5.3.4 Oil and gas in transition

Domestic natural gas production is steadily declining, although there may still be a brief resurgence as a result of the recent gas acceleration policy and sector agreement. Accordingly, the GDN focuses on innovative solutions for the responsible decommissioning or reuse of wells and infrastructure. Furthermore, the knowledge and data acquired by the oil and gas industry over the past 70–80 years must be prevented from being lost. The GDN therefore focuses on securing and accelerating the availability of these data.

5.4 Implementation

5.4.1 Information services innovation

In the coming years, through its information services, the GDN will focus on the further development of existing information systems into a fully integrated national digital subsurface knowledge and information system, in which all relevant subsurface data, industrial interpretations, and the latest geological and technical insights are continuously updated. In line with the GDN's Digital Strategy (Chapter 7), the capacity and functionality of existing information systems and modelling processes will be scaled up to accommodate the accelerated release of exploration and production data driven by national and European regulations. By expanding and refining domain-specific information value chains and dynamic models, the foundation will be laid for the affordable, safe, and sustainable scaling up of geo-energy applications in support of energy and climate policy. The implementation of innovative AI solutions and the further development of computationally intensive process models and integrated modelling chains will form the crucial backbone enabling large-scale geological information processing.

5.4.2 Digital models for resource development

By 2029, the GDN aims to have laid the groundwork for the implementation of fully integrated, AI-supported and real-time data-driven digital

modelling environments aimed at the robust scaling of innovations in the design, operation, monitoring, regulation, and decommissioning of geo-energy applications. Through this, TNO will support governments and regulators in faster and better substantiated permitting processes, while helping market parties accelerate the implementation of innovations and make investment decisions covering the entire life cycle of projects. In line with the Digital Strategy, the GDN will transform existing – but currently stand-alone – reference tools for permitting, seismic hazard analysis models (SDRA), and optimisation tools into a new generation of integrated workflows and modelling instruments applied across the sector and within specific domains.

5.4.3 Well Technology Centre

Through the **TNO Well Technology Centre**, the GDN aims to provide the national industry reference point for large-scale testing of innovative drilling and well technologies by 2029, with the ambition of evolving into an international research infrastructure through close collaboration with academic laboratories. The focus will be on the development of breakthrough subsurface technologies for the energy transition. The Well Technology Centre already has proven capacity for large-scale testing up to Technology Readiness Level (TRL) 6–7 and offers a unique integration of physical facilities with advanced digital models and AI. TNO's independent position enables open innovation between government, industry, and knowledge partners.

5.4.4 Future-proof energy systems

In the coming years, the GDN also aims to position TNO as a system authority for future-proof energy systems, in line with the desired role of government in steering energy infrastructure, addressing grid congestion, and informing spatial planning decisions. The GDN contributes to reducing portfolio risks and achieving robust optimisation within an incrementally scaling and evolving energy system. TNO is developing a framework for advanced system and optimisation models for energy systems. The GDN combines national subsurface data and domain knowledge of subsurface technology, modelling, and optimisation with a public role. This enables integrated decision-making for the subsurface that market parties and research institutions cannot achieve independently.





6 Raw materials

6.1 Recent developments and strategic direction

The Raw materials strategic priority addresses the materials transition by identifying resources and supply options needed to enable the energy transition and strengthen the strategic autonomy of the Netherlands and the EU.

The most significant recent advance in the raw materials domain has been the establishment of the Netherlands Materials Observatory (NMO), a joint initiative led by the GDN but implemented across TNO. TNO now faces a substantial new responsibility that currently relies on the Dutch government as a single client. The challenge in the next strategic period will be to consolidate and further develop the NMO and to diversify the GDN's raw materials portfolio in terms of funding and subject matter. This will include:

- Expanding the scope to all relevant mineral resources, particularly construction raw materials such as aggregates and clay. This will involve both consolidating and strengthening existing GDN activities in this field and developing a contract research portfolio.
- Further aligning raw materials research within TNO, particularly in the defence and high-tech domains.
- Aligning the tasks within the NMO with the GDN's core functions, distinguishing between information and advisory services within the NMO, and expanding raw materials research to support the development of the programme.

6.2 Scope and ambition

6.2.1 EU Critical Raw Materials Act

Europe's economic resilience, technological leadership, and the energy transition depend on secure, sustainable, and affordable access to raw materials. The Netherlands, like all EU Member States, relies heavily on imports of metals, minerals, and other essential resources. Among these, an increasingly large subset is classified as critical raw materials (CRMs): resources that are both economically indispensable and exposed to significant supply chain risks.



The 2024 EU Critical Raw Materials Act (CRMA) aims to secure the EU's supply of critical raw materials by increasing domestic capacities for the extraction, processing, and recycling of raw materials. The European Commission updates the list of CRMs every three years and requires Member States to develop robust monitoring systems, improve supply chain transparency, and address vulnerabilities that could threaten the EU's energy transition and economic resilience. The CRMA also requires Member States to assess their geological potential for CRMs through the implementation of national exploration programmes.

At the same time, the extraction of raw materials faces mounting societal pressure. Local communities are increasingly concerned about mining activities, their environmental impacts, and their long-term risks. This makes innovation indispensable. Demand is growing for sustainable, cost-effective, and transparent extraction technologies, while mining practices must meet increasingly stringent environmental and social expectations. Equally important is the ability to engage communities early and meaningfully, embedding local perspectives at the heart of mining-related decision-making.





6.2.2 Netherlands Materials Observatory

The Ministry of Economic Affairs tasked TNO with establishing the NMO to meet the objectives and requirements of the National Raw Materials Strategy and the EU Critical Raw Materials Act relating to research and information services. The Ministry of Foreign Affairs subsequently joined this initiative and asked the NMO to support the development and facilitation of knowledge partnerships with resource-rich countries outside the EU. The NMO acts as:

- A single, authoritative provider of data and insights for government and industry.
- A catalyst for greater supply chain transparency.
- A knowledge hub supporting risk assessment, policy development, and strategic action.
- A platform for national and international collaboration.
- A trusted custodian of sensitive data shared by companies and sectors.

In addition to critical raw materials, the Netherlands requires large volumes of non-critical but essential materials – such as salt, clay, sand, and gravel – that underpin construction, infrastructure, shoreline protection, and the chemical and manufacturing industries. Understanding the occurrence and availability of these materials is essential to developing a coherent, fully fledged national materials strategy.

Although hosted within the GDN and closely aligned with this strategic priority, the NMO's remit extends beyond the GDN's raw materials priority alone. Some responsibilities – most notably supply chain analysis and international policy intelligence – fall largely outside the GDN's current areas of expertise. At the same time, the NMO's scope is narrower than the GDN's, as it is limited to critical raw materials and currently excludes other raw materials. This strategic priority therefore focuses on the GDN's core functions of research, information provision, and advisory services, structured around five types of solutions.



6.3 Solutions

6.3.1 Minerals potential

Regarding minerals potential, TNO's ambition is to serve as the strategic partner to the Ministry of Economic Affairs and Climate (EZK), enabling informed decisions on which minerals could be responsibly extracted in the Netherlands (including overseas territories) to meet national needs. This requires a clear understanding of where minerals occur, what constitutes a reasonable prospect for extraction, what would be required to extract them, and the factors driving future demand for these materials.

The GDN is uniquely positioned to build this understanding. Its extensive geological knowledge of the Dutch subsurface, its role in the NMO, and its robust data infrastructure – supported through platforms such as the BRO and NLOG – provide a comprehensive basis for understanding subsurface characteristics and communicating these insights to policymakers, industry, and society. The ambition for 2029 is to establish two major products:

National Exploration Programme (NEP) – a systematic, ongoing effort designed to determine:

- The mineralogical and geochemical composition of the Dutch subsurface.
- The potential and demand for critical and non-critical minerals.
- Opportunities for safe and sustainable production.

The NEP responds to the requirements of the Critical Raw Materials Act for strengthened monitoring and knowledge bases among EU Member States. By 2029, the NEP will facilitate seamless access to data, ensure data quality, and support policy-relevant decision-making. Analogous to the geo-energy information services, the NEP aims to stimulate mineral exploration in the Netherlands, which will require the development of a framework for accessing privately held minerals exploration data. The NEP would also serve as the Dutch vehicle for participation in European public exploration investments.

Minerals Potential Map (MPM) – a platform presenting the results of the National Exploration Programme through a clear and accessible overview of the occurrence of minerals in the Netherlands, including the Caribbean Netherlands. The platform will be underpinned by studies demonstrating the potential for identifying previously undiscovered resources, while respecting confidentiality requirements where necessary. In addition to critical raw materials, the MPM will also include non-critical mineral resources. The existing *Delfstoffen Online* platform, which contains information on near-surface occurrences of aggregates and clay, will be incorporated into the MPM. With the exception of the non-critical minerals and Caribbean Netherlands components, the MPM is largely being developed within the NMO.

6.3.2 Minerals intelligence

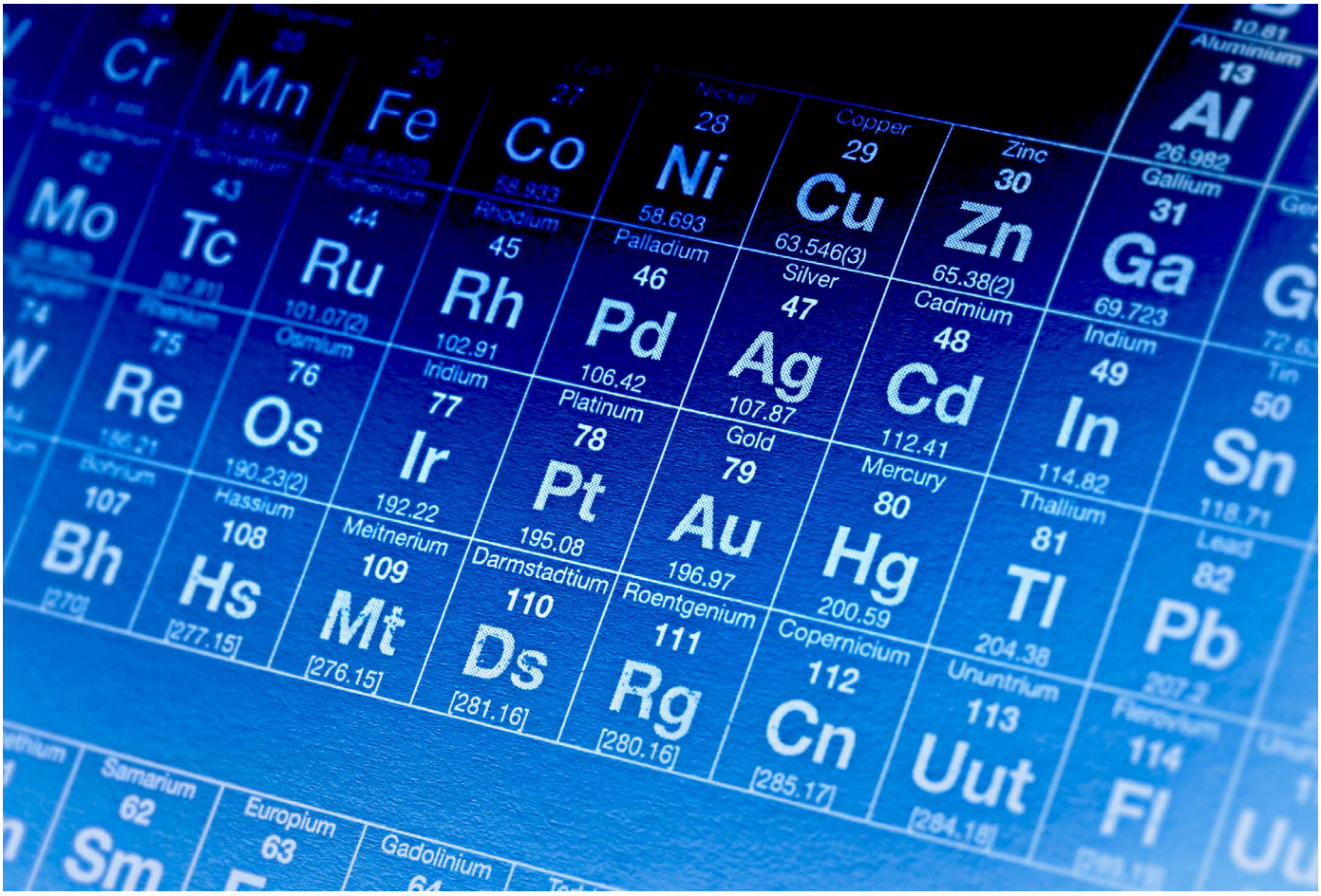
The NMO delivers **strategic insights** to ministries – particularly Economic Affairs and Climate, Foreign Affairs, and Defence – on the global availability of minerals, the geopolitical and economic conditions under which they are sourced, and the international partnerships that would strengthen Dutch and European autonomy. It also supports industry by identifying where materials can be sourced sustainably and how supply chain vulnerabilities can be mitigated.

All activities within this area fall under the NMO programme. The aim is to secure additional structural and research funding for this work, reflecting national recognition of the strategic importance of minerals intelligence.

6.3.3 Green and efficient mining and processing

Industrial actors face mounting pressure to develop more sustainable, socially acceptable, and cost-efficient mining and processing techniques. This domain supports them by providing expert advice on extraction technologies, production processes, and mineral processing methods in an international context.

The unique experimental facilities of TNO's **Well Technology Centre** (5.4.3) provide excellent opportunities for innovation, bringing together subsurface expertise, advanced drilling, chemical and process engineering capabilities, and strong connections with relevant academic groups and other partners.





6.3.4 Environmental and societal impact

In addition to technical excellence, a raw materials strategy demands societal legitimacy. Drawing on lessons learned from Groningen and the resulting general controversy concerning subsurface use, the GDN integrates social scientific expertise with geology to develop new methodologies for involving local communities in decision-making.

The GDN will foster collaboration across government, industry, universities, and civil society. The aim is to collate and develop internationally recognised practices and guidance that help local authorities, ministries, and operators build trust, enhance transparency, and ensure that mineral extraction aligns with societal expectations.

6.3.5 Data infrastructure and intelligence platform

A robust data infrastructure and intelligence platform is essential as a foundation for the four topics outlined above. As part of the GDN's data and information services, sophisticated and resilient information systems will be developed using data science and AI, with a focus on the development and shared use of international datasets and licences. The ambition is to participate in a system of systems for European-level materials intelligence, envisaged as a European layer complementing national exploration programmes, minerals potential maps, and supply chain information.

6.4 Implementation

Raw materials constitute a relatively new but rapidly expanding domain within the GDN, driven by the development, launch, and ongoing implementation of the NMO. As the NMO does not encompass all aspects of the GDN's raw materials agenda, further growth and diversification of this priority area will be essential.

The NMO, together with future raw materials programmes and initiatives, will serve as a vehicle for embedding raw materials across the GDN's three core functions:

- To support **data and information services**, the GDN will streamline sampling and analytical protocols, incorporate raw materials data into the new corporate database GDNR, and establish a public data platform. It will also provide advanced interpretation and modelling tools, including thematic maps, potential maps, and 3D models.
- The GDN will develop an **advisory role** analogous to those for geo-energy and mining, focusing on minerals intelligence, ranging from global trends to local resource assessments. It will advise on legislation requiring public disclosure of subsurface mineral resources, maintain strong industry networks, and engage actively through the media, conferences, and education.
- **Research** will focus on material characterisation and the assessment of resource potential, with particular attention to co-production opportunities alongside sand and gravel extraction, geothermal energy production, and industrial residual streams. Technological innovation will be pursued across exploration, extraction, and processing.



7 Digital strategy

7.1 Recent developments and strategic direction

The GDN's Digital Strategy supports the delivery of its mission by efficiently developing and maintaining the digital environment and capabilities of the organisation to the highest standards. As with many similar organisations, strategy development and implementation have now reached a point at which the rapid advance of IT – particularly AI – is creating two entirely new challenges.

First, a widening gap is emerging between the performance and efficiency of today's systems and ways of working and what is, or will soon be, possible with new technologies. This gap manifests in areas ranging from measurement and monitoring to data handling, processing, and interpretation, as well as in system and software development – essentially across all human-machine interactions and interfaces. It arises for a variety of reasons, including the legal and operational context in which the GDN operates, barriers to change created by sunk investments, and the skills and capabilities available within the organisation.

Secondly, setting fixed objectives and mapping a route towards them is no longer feasible or desirable. Conventional strategic approaches are suited to gradual, plannable technological progress, and not to the adoption and development of today's rapidly evolving technologies. Accordingly, the GDN's Digital Strategy prioritises adaptability and agility over fixed objectives, focusing on how the organisation and its systems can be prepared for continuous, rapid change.

7.2 Approach

7.2.1 Principle-based strategy

The current challenge facing the GDN is to adopt disruptive technologies within a digital transformation that has so far been largely incremental. In research, this process is advancing relatively organically, as researchers tend to experiment with tools that improve their work and reduce costs in a highly competitive funding environment. Moreover, technology and its development are themselves subjects of research. In advisory work, the adoption of new technologies is driven by a dynamic policy and political context, which requires rapid access to and production of information – capabilities that, for example, large language models can provide.

By contrast, in the process-based delivery of data and information services, achieving greater efficiency is not a matter of selecting

Digital transformation of the GDN

Geology is a cumulative science, with geologists relying heavily on existing data. This reliance presents challenges to geological survey organisations, particularly in digitising and managing extensive legacy datasets and entrenched workflows. The GDN began its digital transformation in the 1980s by incorporating digital data from hydrocarbon operators and converting paper archives. Over time, it developed databases that enabled increasingly sophisticated, quantitative models of the subsurface, while also moving to open data and focusing on adding value through knowledge.

A key milestone came in 2015 with the introduction of the BRO, centralising subsurface data management and formalising the GDN's role as a national geoscience data hub. This shift modernised data handling and software development practices and capabilities. Building on these advances, the GDN is now developing the GDNR system to replace legacy infrastructure, improve workflows, and enhance transparency in data-driven operations.

the fastest tool available at any given moment, but rather of optimising workflows designed to deliver repeatable, consistent results. The central question is what should be retained and what should be replaced, while ensuring that the GDN remains operational throughout.

Given the pace of technological change and the diversity of these operational contexts, the GDN adopts a **principle-based strategy**. This type of strategy defines a set of principles that guide decision-making and action, rather than prescribing detailed plans or fixed outcomes. It establishes a framework that enables flexible yet consistent responses to changing circumstances by allowing implementation choices to adapt while remaining aligned with the mission of the digital strategy.

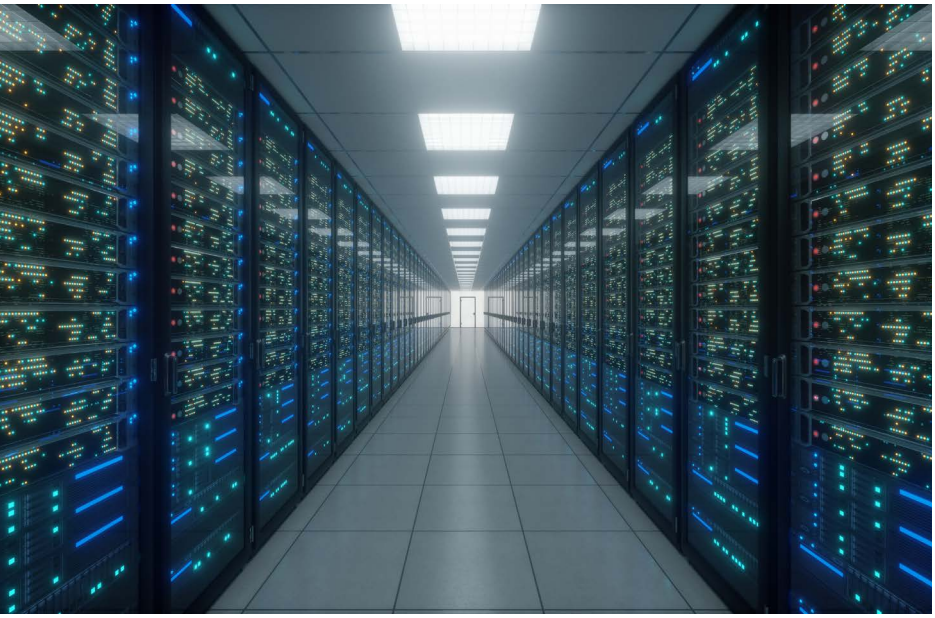
The three principles of the GDN's digital strategy are:

- **Data centricity** – Geological surveys exist to curate data and ensure that they are available for reuse. Putting data first is the overriding principle of the GDN's digital strategy.
- **Agility** – Rapid technological developments not only affect systems but also need to be translated into business processes, organisational structures, and staff competencies.
- **Connectivity** – In recent years, connectivity has become a central theme of the GDN's evolving digital strategy, supporting the transition from a relatively standalone information agency operating alongside similar organisations in its domain to one that is customer-centric and fully connected to its suppliers and clients. 'Connected' is intended in a literal sense, with two key concepts underpinning this approach: **value chains** and **data spaces**.

7.2.2 Key concepts

A **value chain** is a structured sequence of activities that transforms raw data into specific, actionable information and knowledge to support decision-making, with each stage adding value through processing, analysis, interpretation, and contextualisation. The GDN's place within value chains begins with the acquisition of data from third parties and ends with the delivery of value-added products such as research results, maps, models, digital twins, and advice, with intermediate steps involving various forms of processing and analysis. The full value chain extends across all involved parties. It includes upstream data production and downstream decision-making by third parties. Increasingly, data flow from source to destination, through the GDN, with minimal or significantly reduced human intervention. As value chains outlive the technologies that enable them, they serve as the backbone of the transformation that the digital strategy pursues.







Data spaces – A network of organisations and services that interact as if they were communicating vessels requires effective governance. The concept of a data space refers to such a network being regulated through agreements covering data quality, reliability, exchange standards, and clearly defined value chains.

7.2.3 Implementation guidelines

The following set of principles will guide the implementation of the digital strategy, based on the size and impact of individual changes, minimising disruption in data and information services, and maximising experimentation in research and advisory projects:

- **Development under enterprise architecture** – The alignment, development and transformation of the GDN's business processes, information systems, technology infrastructure, and overall objectives are guided by the GDN enterprise architecture, which serves as a strategic framework for ensuring coherence and optimisation across the organisation.
- **Pilot-driven transformation for large changes** – Large changes, such as the development of AI-supported subsurface modelling workflows for the Future-proof land use and Geo-energy priority areas, will be initiated as pilots or virtual test labs. This approach helps avoid disruption to existing subsurface modelling and other set value-adding workflows. Pilots may take the form of research or advisory projects or be funded through dedicated programmes such as PIO. The implementation of pilot results into data and information services workflows will be evaluated and decided on a case-by-case basis.
- **Live transformation for small changes** – Individual tasks contributing to the delivery of data and information services such as data analysis, architecture element generation, workflow discovery, and code generation can be significantly accelerated with AI support. Substituting current approaches with AI will be achieved within existing workflows, with minimal disruption.
- **Piggybacking on ongoing transformations** – The largest ongoing digital transition at the GDN is the migration from the legacy DINO system to the new GDNR, primarily funded by the PIO programme. PIO aims to support the energy transition with new data and information services, facilitating the establishment of the new system and the decommissioning of the old one. Additionally, the programme will incorporate the adoption of new technologies as part of its delivery.

7.3 Operationalisation and governance

7.3.1 Organisation

The digital transformation will be overseen by the GDN's Chief Digital Officer, in close collaboration with programme owners, who are responsible not only for delivering results but also for the adoption of AI, and line managers, who will guide GDN staff through the transformation process. The evolving understanding will be documented in a regularly updated implementation plan and a continuously evolving enterprise architecture, which will also serve as communication tools for the GDN's management team.



One or more dedicated teams will lead the transition by investigating pathways, redesigning workflows and making recommendations for implementation, taking into account the key principles, key concepts, and implementation guidelines. This includes mapping and modelling, a core survey activity that supports several value chains, as well as the transition from the legacy DINO system to the GDNR.

7.3.2 Alignment within TNO

The GDN's parent unit EMT aims to streamline AI development by creating a centralised platform, addressing inefficiencies caused by decentralised efforts. This platform will unify expertise, best practices, resource management, and knowledge sharing while maintaining decentralised development, enhancing AI capabilities across research projects.

An inhouse AI Centre of Excellence will develop and maintain the platform, providing standardised environments and resource oversight to support data scientists and improve collaboration. It will also implement centralised portfolio management to prevent redundancy and encourage component reuse. Development will prioritise impact, effort, and synergies for cost-effective AI solutions.

Additionally, AI capabilities will be strengthened through skill mapping and knowledge sharing, promoting AI literacy via workshops and training. This collaborative approach will maximise AI's potential across research and operations. The aims are to:

- **Avoid duplication**, i.e. developing AI solutions twice in different projects, or developing solutions that have already been, or could better be, developed by third parties.
- **Train LLMs** using GDN and TNO content, with appropriate measures and conditions to ensure security of proprietary data, information and knowledge.
- **Experiment**, developing AI solutions across the GDN's core functions and strategic priorities, and beyond.

7.4 Ethical considerations

Adopting a disruptive technology such as AI necessitates considering AI ethics throughout the full lifecycle of data, models, and services. Drawing on Dutch government frameworks such as the *Government-wide Vision on Generative AI*[3] and the *AI impact assessment*[4], a first principle is that AI systems must

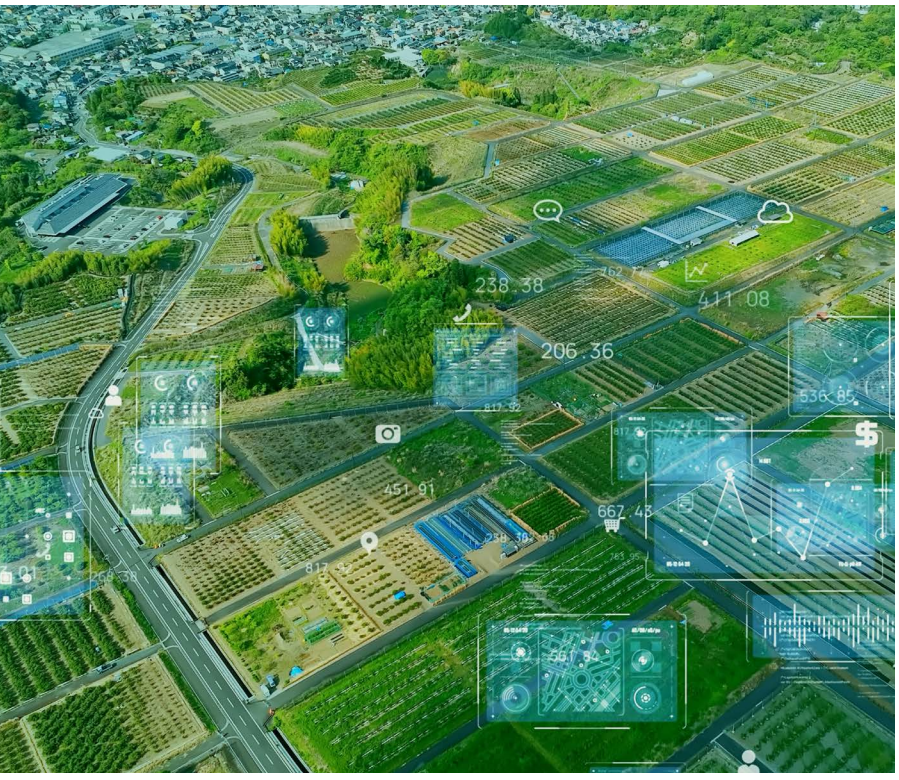
3 https://www.rijksoverheid.nl/documenten/rapporten/2024/01/01/overheidsbrede-visie-generatieve-ai

4 https://www.rijksoverheid.nl/documenten/rapporten/2022/11/30/ai-impact-assessment-ministerie-van-infrastructuur-en-waterstaat

be safe, fair, and aligned with human autonomy and well-being. This requires rigorous *ex ante* risk assessments, continuous monitoring, and clear accountability structures to ensure that automated outputs do not lead to harm or unjust outcomes. Transparency is equally critical: organisations should be able to explain how algorithms function, which data are used, and what limitations apply, recognising that opaque systems undermine public trust and democratic legitimacy.

Secondly, information agencies such as the GDN must address questions of data ownership, provenance, and legality, particularly when using large-scale or generative models. Initiatives such as GPT-NL highlight the importance of using lawfully obtained datasets and ensuring compliance with European regulations, including the EU General Data Protection Regulation (GDPR), as well as of maintaining strategic autonomy and control over critical information infrastructures.

A third consideration concerns fundamental rights and public values. Dutch and European guidance emphasises that AI must respect privacy, data protection, non-discrimination, and human dignity, while remaining subject to meaningful human oversight. In practice, this implies careful data governance, bias mitigation, and careful use of AI when providing advice or conducting research in sensitive domains. The latter condition applies, for example, where the GDN supports mining licensing or studies the effects of mining.



Finally, like any form of automation, the adoption of AI will have consequences for the GDN's staff. While AI has the potential to increase efficiency and productivity, there is growing concern that its widespread use could result in job losses. However, the GDN has chosen to deploy AI primarily to enhance and accelerate its outputs, focusing on reducing time-to-market rather than viewing it as a cost-cutting measure. Guiding and preparing the staff is seen as a key component of the GDN's digital transformation.

7.5 Staff considerations

The GDN anticipates that several workflows will soon be enhanced or replaced by agentic and other AI-based approaches, building on the already significant automation of labour-intensive data processing, interpretation, and modelling procedures. The knowledge and experience encapsulated in these systems have been developed by people who carried out the very tasks that AI now seeks to replicate. The key question is how such knowledge and experience will continue to be developed in the future – so that AI-based processes and agents evolve in tandem with staff, rather than remaining rooted in practices of an increasingly distant past.

Rather than through repetitive manual tasks, human knowledge and skills will increasingly be developed by training AI agents to handle new situations and problems, and by overseeing their performance. This co-evolution of human and AI capabilities will be an exploratory process. The most important strategic choice at this early stage is to acknowledge that AI is fundamentally changing how information and knowledge are created, delivered, discovered, and applied. While the natural tendency in any technical organisation is to focus on the technology itself, the GDN recognises that equal attention must be given to staff development. AI is extremely powerful in its ability to process and analyse vast amounts of data quickly and accurately, identifying patterns and insights beyond human capability. However, because it relies on synthesising existing information and approaches, it is inherently rooted in the past. Creativity and the ability to address new challenges will therefore be the most important human skills of the future.


TNO
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8 Execution

8.1 Introduction

This chapter describes the elements of GDN governance and management that are relevant to strategy execution, including the organisation, operations, programmes, networks, communication, and a strategic agenda that is monitored and updated regularly. Some of these elements are adressed in regularly updated subordinate plans (overview in the table below).

8.2 Governance

8.2.1 Strategy implementation

In both the way the GDN is governed and the way it governs its own organisation, the primary means of implementing the strategy is through continuous consultation and alignment with external and internal stakeholders. The aim is to engage external stakeholders in supporting delivery while enabling internal stakeholders to embed the strategy in day-to-day operations. This section outlines the GDN's governance structure, from the strategic and external level to the tactical and internal level.

Subordinate plan	Pertains to
Strategic agenda	• Defining, allocating, and monitoring strategic actions.
Governance revision	• Attuning the GDN's governance model and practices to the present strategy.
Implementation plan Digital Strategy	• Advancing the steps in the GDN's digital transformation. • Promoting the adoption of new information technologies.
Implementation plan AI Strategy	• Covering the AI components of the Digital Strategy. • Establishing an AI maturity roadmap. • Defining governance and key performance indicators for the AI maturity roadmap.
Science strategy	• Aligning scientific priorities, organisational objectives, talent development, and talent acquisition. • Identifying opportunities for scientific impact and breakthroughs.
Geomodelling strategy	• Shaping the future of geomodelling, with a focus on faster and fit-for-purpose delivery. • Implementing the digital strategy.
Communication strategy	• Engaging effectively with users and stakeholders. • enhancing the public profile of the GDN. • Promoting geoscience and its relevance to society. • Building professional communication capabilities.
International strategy	• Representing the Dutch government on geology-related international matters. • Identifying strategic international partners and learning opportunities. • Supporting international business development. • Developing a Caribbean agenda.

The contract between the State and TNO concerning the GDN defines and connects the GDN's three functions – Data and Information Services, Advisory Services, and Research – as well as the various boards and committees that oversee the organisation and some of its specific responsibilities.

8.2.2 High-level advisory boards

The **Strategic Advisory Board** is the GDN's highest-level advisory body, providing guidance on the development and implementation of the GDN's strategy and comprising representatives of:

- The **state government** – Directors-General of the Ministries of Economic Affairs and Climate (EZK), the Interior and Kingdom Relations (BZK), and Infrastructure and Water Management (I&W).
- **Subnational authorities** – at present the King's Commissioner of the Province of Utrecht, the Mayor of the town of Lochem, and the board secretary of the Dutch Water Authorities (UvW).
- The **academic community** – at present the dean of Civil Engineering and Geosciences, Delft University of Technology.
- The CEO of **EBN**, the state energy company (see 8.3.3).
- The CIO of **Rijkswaterstaat**, the Directorate-General of Public Works and Water Management.
- The chair of the **Mining Council**, an independent advisory council on mining, geothermal energy, and subsurface use.

The GDN's **Scientific Advisory Committee** (GKC, *Geowetenschappelijke Kenniscommissie*) provides scientific reflection on the delivery of the GDN's strategy, discusses relevant societal and scientific developments, and contributes input to the annual research programmes. The GKC currently consists of:

- **Prof. Freek van der Meer** (president), dean of the Faculty of Geo-information Science and Earth Observation (ITC) at University of Twente.
- **Prof. Ramon Hanssen**, professor of Geodesy and Satellite Earth Observation at Delft University of Technology.
- **Prof. Klaudia Kuiper**, professor of Sedimentology and Stratigraphy at VU Amsterdam.
- **Prof. Jantien Stoter**, professor of 3D Geoinformation at Delft University of Technology.
- **Prof. Esther Stouthamer**, professor of Physical Geography at Utrecht University.
- **Prof. Dragan Savić**, professor of Hydroinformatics at the University of Exeter, Global Advisor Digital Sciences at KWR.
- **Prof. Florian Wellmann**, professor of Computational Geoscience, Geothermics, and Reservoir Geophysics at RWTH Aachen University.

8.2.3 Programme governance

Each of the GDN's functions has its own governance and oversight arrangements:

Data and information services

- The Geo-Information Programme (GIP) is overseen by the Geo-Information Committee (GIC), a committee with representatives from the Ministries of Economic Affairs and Climate (mining and deep subsurface), the Interior and Kingdom Relations (responsible for national geospatial data infrastructure), and Infrastructure and Water Management (groundwater, built environment, shallow subsurface).
- The NMO is overseen by a committee with representatives from the Ministries of Economic Affairs and Climate (CRM policy), Infrastructure and the Environment (circularity), Foreign Affairs (raw materials diplomacy), and Defence (raw materials for the defence industry).

Advisory services

- The GDN's Advisory Group for Economic Affairs operates in a formal constellation of organisations that advise the Minister of Climate and Green Growth on mining policy and licensing, which also includes SODM (State Supervision of Mines, concerning mining safety), EBN (Energy Management Netherlands, concerning operations and finance), and the Mining Council (*Mijnraad*, which combines the various perspectives in a single advice).

Research

- TNO programmes its research to maintain and develop a relevant knowledge base for the benefit of society, government, and industry. Its range of programmes is composed of the demand-driven programmes (VPs), focused on domain applications, and exploratory research programmes (ERPs), intended for cross-theme, early-stage research.
- ERP are prepared, usually cross-unit, under the responsibility of TNO's Directors of Science. There are two categories of ERPs: Seed ERPs (one year max.) and Full ERPs (four years max.).

- VP programming is supported by dedicated proposition teams, which connect scientific expertise with market development.
- The GDN runs two research VPs: Geo-energy and Groundwater. It also participates in one ERP (Subsidence) and is involved in establishing two TNO-wide VPs on climate adaptation and spatial planning.

Digital transformation

- Supported by the Architecture Board, and in close consultation with management and programme owners, the GDN's Chief Digital Officer (CDO) is responsible for:
  - Developing and implementing the digital strategy.
  - Strengthening and developing the GDN's digital capabilities.
- The GDN Architecture Board, chaired by the CDO, is responsible for:
  - Developing and maintaining the enterprise architecture.
  - Establishing standards for data, software, and digital platforms.
  - Ensuring architectural coherence across the organisation.
  - Guiding the long-term evolution of the digital and data landscape.

8.2.4 Internal governance and its revision

Governance also plays a key role in ensuring consistent alignment throughout the implementation of the strategy. In response to growth, diversification, and a reorganisation of the EMT Unit, the GDN adopted a six-group organisational structure in 2024, replacing the previous four-group structure. The role of Chief Digital Officer (CDO) and the Architecture Board were established to oversee the GDN's digital transformation. Theme councils were created to manage the strategic priorities for land use, groundwater, geo-energy, and raw materials across the GDN's programmes and primary functions. Each council comprises selected senior subject-matter experts and is tasked with improving coherence, avoiding duplication, and identifying potential blind spots. Since 2024, these councils have provided guidance to programmes during the initial stages of the annual planning cycle.

Structure follows strategy: the current revision of the GDN's internal governance, linked to MTP29 and an evaluation of the reorganisation, includes several organisational changes:

- The theme councils and market teams will be integrated into proposition teams.
- The Chief Digital Officer will become a member of the Management Team.
- The Architecture Board will transition from a subset of the Management Team to an expert advisory group.
- One or more transition teams will be established to support implementation of the Digital Strategy (cf. Chapter 7).
- Science will have a stronger voice in management decision-making through the Science Group, an existing GDN platform that monitors developments in academia, advises on research programming, and promotes collaboration across scientific disciplines.



8.3 Human resources

8.3.1 Strategy implementation

The GDN's strategy can only be delivered and sustained by a well-trained workforce, supported by attractive opportunities for skills development and career progression. In addition to standard activities that support individual and organisational growth, particular attention within HR will be given to career development and future prospects in the context of AI adoption (see 7.5). This section focuses on growth and diversity, which go hand in hand in the current tight labour market, where competition for technically and scientifically skilled professionals continues to intensify.

8.3.2 Growth

Over the past decade, the GDN has grown considerably, by 12% between 2015 and 2021 and 40% between 2021 and 2024 (Fig. 3). The recent growth is the result of success in securing competitive funding and contract research, and an expansion of public tasks, particularly in the energy and materials transitions (PIO and NMO programmes, respectively). To manage growth, a reorganisation was implemented in 2024, when the current six departments were created from four preceding ones. Further growth is expected in the upcoming years.

The GDN has a relatively low staff turnover rate, which is why the organisation generally chooses to hire recent graduates and young professionals in order to maintain a healthy age distribution. The combination of recent growth and typical recruitment ages, ranging from the mid-20s to early 30s, explains why employees in their 30s represent the largest age group, accounting for one third of the GDN workforce (Fig. 4). Employees in their 40s are somewhat underrepresented, likely due to the adverse economic conditions of the early 21st century. The larger size of the 50+ cohorts reflects the more favourable conditions of the late 20th century.



8.3.3 Diversity

With 70% of its staff being male, the GDN is slightly less gender-diverse than TNO as a whole (Fig. 5). This can be attributed to (1) the demographics of geoscience staff, where the male-to-female ratio reflects the historical graduation mix (over 80% male in the oldest cohorts (who graduated in the 1980s), shifting to roughly 50-50 in more recent years), and (2) the predominantly male IT staff.

The GDN is slightly more ethnically diverse than TNO overall. Research is inherently international, which is why GST and HRE have the highest proportions of international staff. However, government service delivery requires key personnel to be fluent in Dutch, so the proportions of internationals in SSM, GIT, GDIM, and AGE are lower.

8.4 Networks and cooperation

8.4.1 Strategy implementation

Today's and tomorrow's grand challenges are complex and require a multidisciplinary approach. The GDN positions itself as a collaborative partner within academic and professional networks. Collaboration with other institutes active in the geoscience and geospatial domains is guided by the value chain and connectivity principles set out in the GDN's digital strategy. In relation to the academic community, this involves aligning research questions and geoscience (and related) curricula with the pressing issues of the future.

Analogous to the GDN's position within its external network, the delivery of its strategy in relation to its parent organisation depends on fully leveraging the scientific disciplines and professional network across the wider TNO organisation. This will be achieved through the pursuit of multidisciplinary research and the coordinated management of stakeholder interactions.

8.4.2 European cooperation

The GDN's international agenda is primarily European, driven by the European Commission's objectives of achieving strategic autonomy and a net-zero economy, both of which rely on geological data and information. European cooperation is facilitated by EuroGeoSurveys, a small Brussels-based organisation that represents Europe's

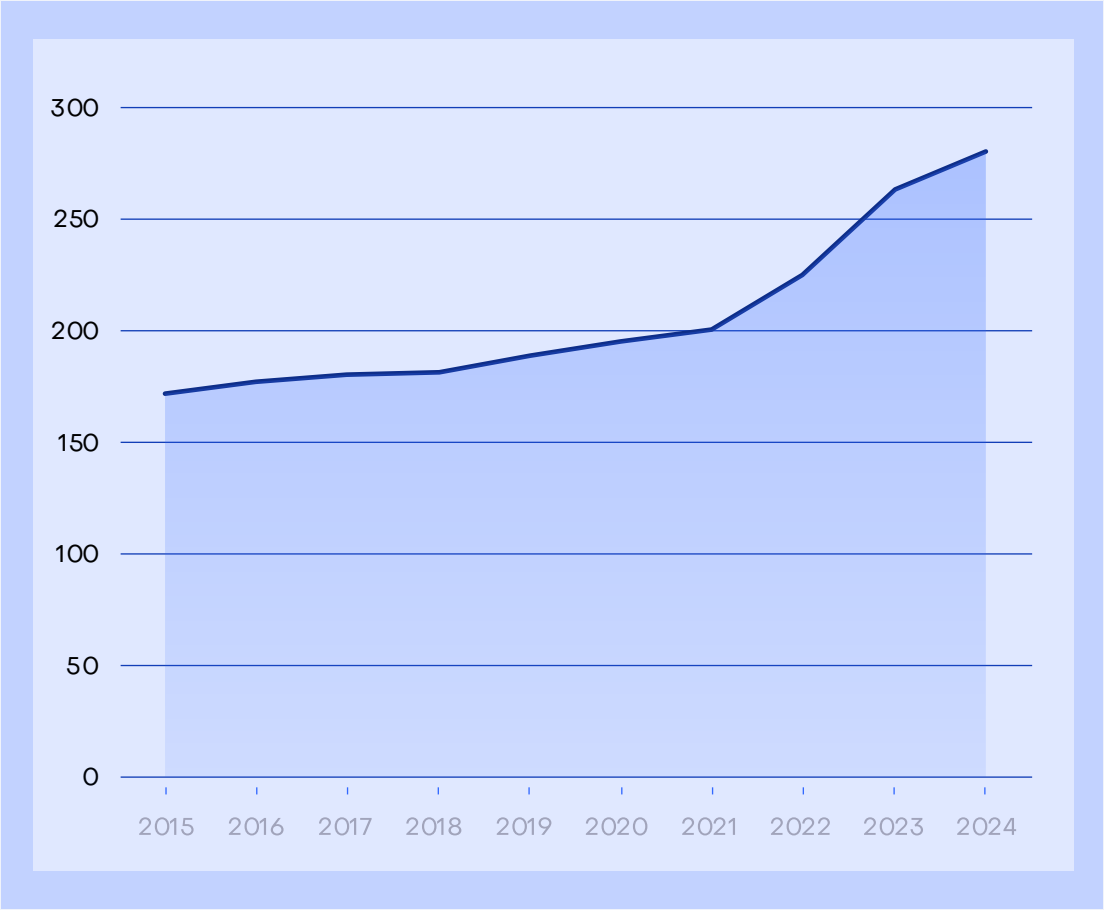


Figure 3. Staff size of the GDN in FTEs from 2015 to 2024.

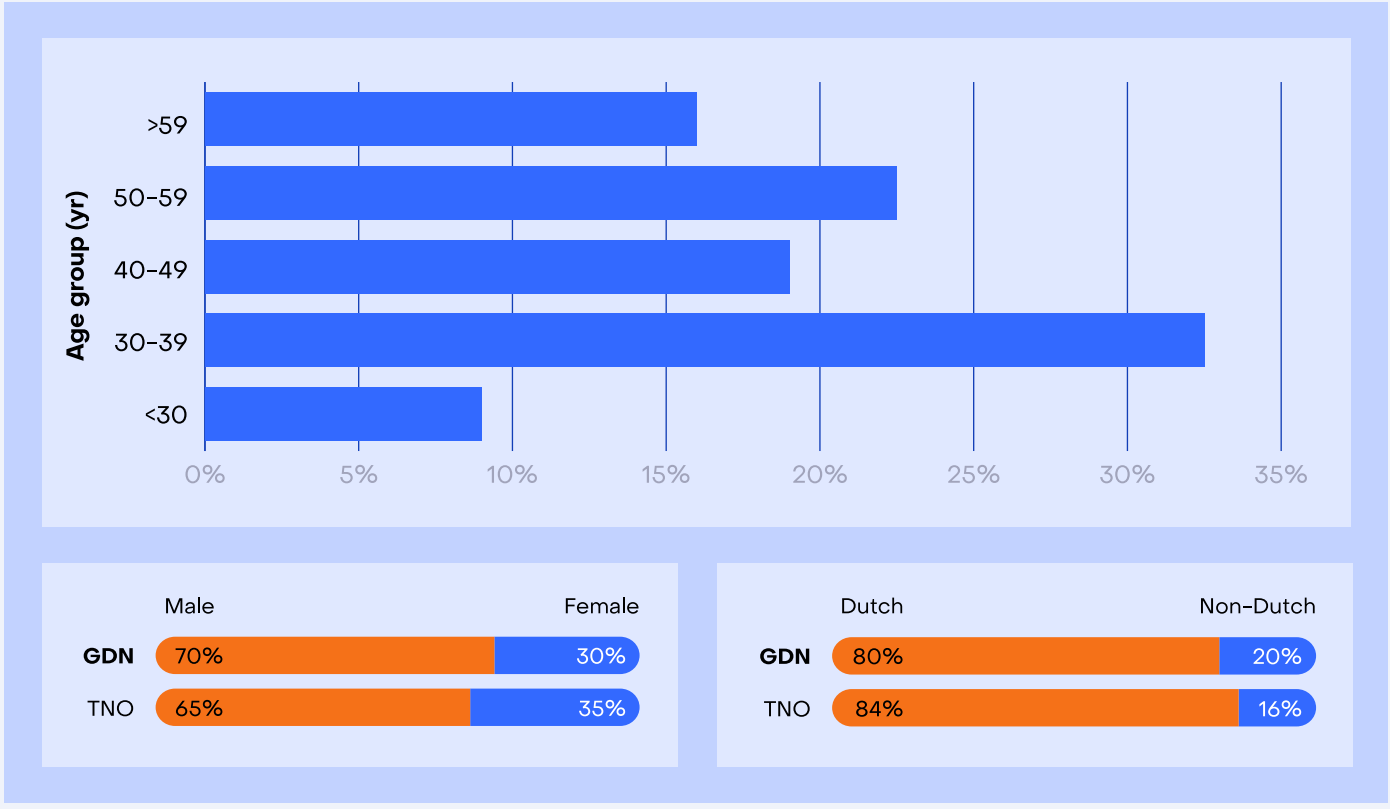


Figure 4. Personnel key figures. Left panel: age distribution in 2024. Right panel: male/female and Dutch/non-Dutch ratios in 2024.

geological surveys and supports networking and collaboration. EuroGeoSurveys currently has 37 members, including the geological surveys of 26 EU Member States (all except Bulgaria) and six of the nine EU candidate countries: Albania, Bosnia and Herzegovina, North Macedonia, Serbia, Ukraine, and Kosovo.

EuroGeoSurveys' mission is to enable the sustainable and responsible use of the Earth's subsurface environment and resources. Its vision is to establish the Geological Service for Europe as the EU's scientific reference partner, providing knowledge of the Earth's subsurface as the foundation for a sustainable future in Europe. EuroGeoSurveys' strategy has three components:

- **Research** – conducting joint research with policy impact.
- **Infrastructure** – harmonising pan-European geological data and establishing a Geological Service for Europe.
- **Outreach** – sharing knowledge, capacity, and research infrastructure.

The Dutch implementation of the EU Critical Raw Materials Act, including the establishment of the NMO and the development of a network among similar organisations in Europe, demonstrates how rapidly EU policies can be enacted at Member State level. The Net-Zero Industry Act is expected to have a similar impact, shaping the GDN's role in CO_2 storage. More broadly, the European science and policy arenas are becoming increasingly important to both TNO and the GDN in terms of agenda-setting and funding.

8.4.3 Sector partners

The main academic partners of the GDN are the geosciences faculties of Utrecht University, Delft University of Technology, and VU Amsterdam. They cover the GDN's core disciplines: sedimentary geology (Quaternary geology, sedimentology, physical geography), hydrogeology, structural geology and tectonics, geostatistics/mathematical geology, (exploration) geophysics, geomechanics, economic geology, petroleum geology, geochemistry, and (geo)information science, as well as supporting and complementary disciplines: reservoir engineering, engineering, economic geology, and remote sensing.

These academic partnerships primarily concern research (PhD projects, endowed chairs). As these universities also train the majority of the GDN's staff, we choose to be involved



in education as well (classes in the fields of applied, economic, and regional geology).

The following research and knowledge institutes also provide information or advice on the Dutch subsurface:

- **Wageningen Environmental Research** – associated with Wageningen University WUR, partner in the BRO as the national soil survey.
- **Deltares** – applied research institute for delta issues, including subsurface and groundwater systems).
- **RIVM** (National Institute for Public Health and the Environment) – partner in soil and groundwater quality monitoring.
- **KNMI** (Royal Netherlands Meteorological Institute) – partner in seismic hazard assessments.

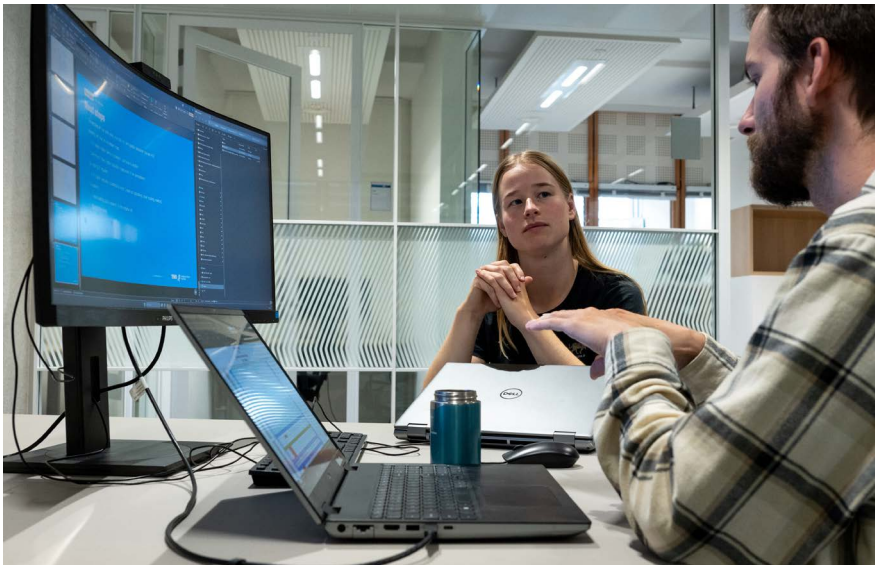
In addition to these institutes, there are two other Dutch organisation that have a strong basis in the earth sciences and a formal advisory role in mining:

- **EBN** (Energie Beheer Nederland) is a state-owned energy company that represents public interests in the Dutch energy sector by investing in energy projects, facilitating public-private cooperation, and helping to develop a sustainable, reliable, and affordable energy system for the Netherlands.
- **SodM** (State Supervision of Mines) is the independent regulator of mining and energy activities in the Netherlands, overseeing safety, environmental protection, and regulatory compliance in the use of the subsurface, while advising the government on related risks and policy decisions.

8.4.4 Academic positions and TNO principalships

In 2022, the GDN adopted a professorship policy to strengthen its research and academic network by establishing or supporting a series of chairs, endowed chairs, and other academic positions (fellows, associate professors, guest lecturers), which:

- Support the development of key geoscience and related technology domains.
- Attract talented university graduates.
- Contribute to a significant increase in the number of PhD research projects in the EMT unit (see below).
- Offer attractive career opportunities to talented GDN scientists.
- Enable contributions to and influence over geoscience and related curricula.



Analogous to university professorships, TNO principalships represent the highest level on the staff career ladder. The GDN currently has two principal scientists, who have close ties to academia, and two principal consultants. The ambition is to increase this to one principal per group, and ultimately for each primary science discipline and application domain. In addition to these content-oriented principalships, the GDN has a principal business developer and one principal project manager.

8.4.5 PhD research

Under the motto '100 PhDs', the GDN's parent unit EMT is making a sustained effort to increase its number of affiliated or employed PhD researchers and secure access to fundamental research. As Dutch PhD projects last 4 years, maintaining this number requires starting around 25 PhD research projects each year. The GDN is currently involved in, or has recently contributed to, 50 PhD projects through endowed professorships, affiliated researcherships, and, in a minority of cases, direct funding.

The GDN's policy with regard to its involvement in PhD projects it funds or co-funds is to:

- Consider them an investment in future staff, i.e. being involved in the PhD candidate selection process, screening them for a potential subsequent position at the GDN.
- Allocate sufficient time for supervision (along with that provided by the university supervisor).
- Require that the PhD student spends 50% of their time at the GDN.

8.4.6 Cooperation within TNO

Energy and Materials Transition (TNO-EMT) – The four divisions of GDN's parent unit EMT each have their own focus areas and capabilities, but they are designed to be complementary in achieving shared objectives related to net-zero and circularity (1.1.3):

- **EMT Industry** focuses on achieving a carbon-neutral and circular industrial sector, with particular emphasis on energy-intensive and processing industries. It draws on strong expertise in process technology and chemistry.
- **EMT Energy Supply** focuses on developing efficient energy production and storage infrastructure, both onshore and offshore, with attention to the effective, ecological, and circular production and use of all components related to wind and solar energy.
- **EMT System Solutions & Environment** supports effective policy and behavioural change in response to the complex energy and materials transitions. It does so through integrated analysis at all relevant scales and across both short and long-term time horizons.

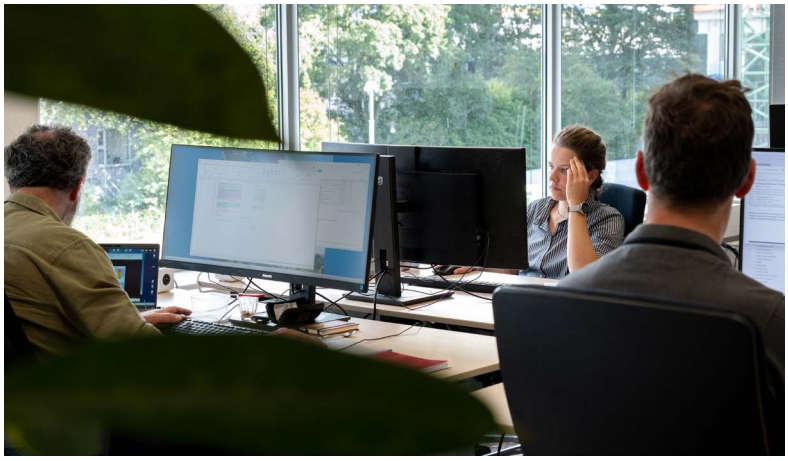
Cross-divisional themes include critical raw materials, the effects of mining, geo-energy production optimisation, and the heat transition. In these areas, other divisions typically address above-ground and/or production infrastructure, circularity, and socio-economic aspects.

Beyond its specific scientific and application domains (1.1.3), the GDN contributes the experience of functioning as a national information agency and designated policy adviser – roles that the other EMT divisions are less familiar with. The funding and governance models associated with the GDN's public tasks currently serve as a model for the design and promotion of a Knowledge Centre for the Energy Transition.

The **Mobility and Built Environment unit (TNO-MBE)** specialises, among other things, in dynamic loading and the effects of climate on buildings – both physically and in terms of related damage, health, and economic risks. The GDN relies on this expertise to assess risks and potential damage resulting from seismicity caused by mining activities and subsidence, which can be related to water table management and/or mining activities.

The GDN and TNO-MBE jointly implemented the SDRA, a public-domain tool for seismic hazard and risk analysis originally developed by the national oil and gas operator NAM to evaluate hydrocarbon production scenarios. In addition to predictive applications, the combined expertise of the GDN and TNO-MBE is also used for forensic purposes. In the Groningen Gas Field area, it was applied to attribute observed building damage and support damage settlement processes following the termination of gas production.







The **TNO Vector Centre for Societal Innovation and Strategy**, part of the ICT, Strategy & Policy unit (**TNO ISP**), focuses on social innovation and strategy. Its areas of expertise include governance, business, economics, finance and innovation, and transition policy. TNO Vector helps stakeholders understand the broader context of their challenges by identifying the necessary multidisciplinary knowledge, developing strategic frameworks, and fostering robust, evidence-based decision-making. The unit works in areas such as urban development, sustainable industry, and innovation systems. TNO Vector supports the GDN in projects with a strong socio-economic component, particularly mining policy and the NMO. TNO Vector's parent unit TNO-ISP will provide strategic and technical support to the GDN's digital transformation.

The **Defence, Safety and Security unit (TNO-DSS)** conducts scientific research, develops technologies, and creates innovations in the safety and security domain as a partner to the Dutch armed forces and public security organisations, working closely with private companies and national institutions. The GDN cooperates with TNO-DSS on critical raw materials for military technologies.

8.5 Communication

The GDN engages in four modes of communication:

- **Technical user support** via the GDN service desk.
- **Marketing**, supporting business development, via TNO's corporate Marketing & Communication.
- **Strategic communication** aimed at stakeholders and the general public to support the delivery of the GDN's mission and strategic priorities.
- **Internal communication** aimed at enabling a dialogue between management and staff about the mission and strategic priorities.

Strategic and internal communication are addressed in the GDN Communication Strategy, which outlines its direction and professionalisation ambitions. It aims to increase impact by sharpening focus, deploying communication more strategically, and aligning more closely with organisational priorities. These ambitions include adopting a more proactive approach, producing content more quickly and creatively, applying data-driven methods, and strengthening expertise in stakeholder and technical communication.

Externally, the GDN uses communication as a strategic instrument to make subsurface knowledge visible, accessible, and applicable, thereby supporting informed decision-making and public trust. Clear governance arrangements ensure consistent and role-conscious deployment, with communication efforts guided by strategic relevance and societal impact.

Geoscience and geoscience organisations are rarely at the forefront of politicians' and policymakers' minds, despite the role they play in addressing some of society's most fundamental needs, as reflected in MTP29's strategic priorities: a safe living environment, water, energy, and raw materials. Clear communication is therefore essential to the successful implementation of the GDN's strategy.