Environmental-economic accounts: Sources and methods

Third edition

New Zealand Government

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Stats NZ Tatauranga Aotearoa
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Contact
Stats NZ Information Centre: info@stats.govt.nz
Phone toll-free 0508 525 525
Phone international +64 4 931 4600

www.stats.govt.nz

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Purpose

Environmental-economic accounts: Sources and methods presents an introduction to the accounts, and the data sources and methods used for each of Stats NZ's environmental-economic accounts.

Environmental-economic accounting shows the interactions between the environment and the economy. It can be used to assess whether patterns of economic activity are depleting or degrading our resources; and to show the value of natural resources, who benefits from natural resource use, and what actions are being undertaken to protect the environment.

The United Nations' System of Environmental-Economic Accounting (SEEA) is the internationally accepted statistical standard that specifies how environmental and economic information can be integrated coherently and impartially. SEEA uses concepts, definitions, and classifications consistent with those under the System of National Accounts, which is used by Stats NZ for producing economic statistics such as gross domestic product. Direct comparisons between environmental and economic information can be made under SEEA. The comparisons can lead to a clearer understanding of environmental-economic trade-offs and provide a more complete picture of a country's economic and environmental performance.

SEEA brings individual information together to inform integrated policies and evaluates the trade-offs between different policies and the impacts of these policies across aspects of the economy, the environment, and society.

Stats NZ redeveloped its environmental accounts because of renewed interest in environmental accounting. This document provides a technical background to understanding the compilation and interpretation of the accounts.

The next section outlines what's new in this third edition. The report then begins with an introduction to the SEEA framework. It describes the measurement of stocks and flows of natural resources in broad terms, and then provides a description of the specific sources and methods for each account.

What's new in the third edition

The third edition captures the changes and updates to environmental-economic accounts' sources and methods since 2019. These include updates to the methods used to compile greenhouse gases by industry and households (the air emissions account), and new sections on tourism, regional, and consumption-based emissions.

We used new methods to allocate emissions to a more detailed industry level. Other methodological improvements and data sources were used to improve allocations to industry and incorporate additional greenhouse gases.

The 'regional emissions' section provides an overview of the concepts, data sources, and methods for the greenhouse gases by region (industry and household) series due to be released on 23 July 2020.

The 'consumption emissions' section provides an overview of the concepts, data sources, and methods for the greenhouse gases (consumption-based) series due to be released late July/August 2020.

Introduction to environmental-economic accounting

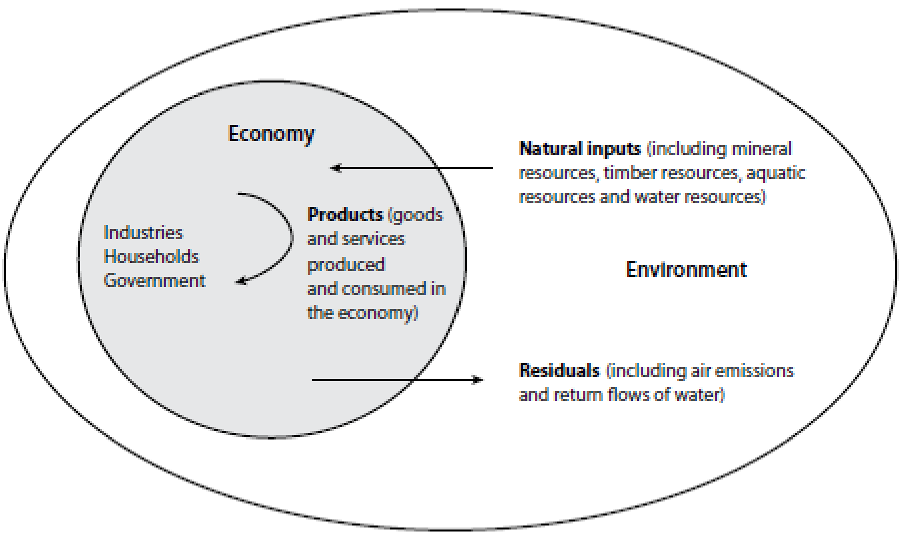
Environmental-economic accounting aims to demonstrate the range of impacts the economy has on the environment, the dependencies of economic activity on the environment, and the economic transactions related to environmental outcomes. In measuring the value and volume of environmental assets, environmental-economic accounting is useful in the context of understanding natural capital and its contribution to well-being. Figure 1 shows the natural inputs, products, and residuals that flow between the economy and the environment.

Environmental-economic accounting is relevant to the concept of natural capital. Natural capital, although not explicitly defined in the SEEA, is generally referred to as the stock of environmental assets, including geology, air, soil, water, and all living things that provide ecosystem services.

The concept of natural capital incorporates a broad perspective on the set of services from ecosystems assets, which may be beyond the measures of environmental assets described in the SEEA central framework (which includes ecosystems).

Figure 1

Physical flows of natural inputs, products and residuals



Source: United Nations (2014b)

Environmental-economic accounts:

- measure the value and volume of many New Zealand natural resources (through monetary and physical stock accounts)
- identify the industries using New Zealand's natural resources (natural inputs) and the extent of emissions and discharges (residual flows) to the environment resulting from economic activity (through physical flow accounts)
- measure the amount of economic activity undertaken for environmental purposes, such as expenditure on protection and management and other transactions including taxes, subsidies, grants, and rent (through environmentally related economic transaction accounts)
- can show the extent, condition, and services related to ecosystems
- can be integrated with economic and social data to form combined data presentations.

A note on terminology

Publications use different terms to define both the measurement of stocks and the flows of environmental assets. These terms include 'natural resource accounts', 'natural capital accounts', 'environmental accounts', and 'environmental-economic accounts'. No formal distinction exists between these terms and they are often used interchangeably. We use the broader and more all-encompassing term 'environmental-economic accounts'.

The System of Environmental-Economic Accounting 2012 (SEEA) is based on the same accounting principles, concepts, and definitions used for compiling economic statistics, such as gross domestic product (GDP) under the System of National Accounts (SNA).

GDP is a robust, internationally comparable measure of economic growth, but it has a limited view of the environment. For example, it measures oil extraction from the environment as an increase in GDP, but it does not account for oil as a non-renewable resource leading to the depletion of its stock levels. Similarly, although the cost of cleaning the environment after an oil spill are accounted for in GDP (as increases), effluent and other discharges into the environment from social or economic activity are not (as decreases). The SEEA framework addresses these issues by expanding the SNA framework to cover the environment.

Economic growth and human well-being are dependent on the services provided by the environment, such as the provision of raw material and energy, absorption of waste, and other amenities. A common framework enables analysis between the environment, economy, and society. SEEA accommodates this type of analysis by integrating environmental and economic data on a consistent basis.

Environmental-economic accounts measure New Zealand's total natural wealth. Information from the accounts can improve resource management and will help determine whether natural resources are being used efficiently on a national basis and across sectors. The accounts can be used to assess the physical and monetary extent of environmental depletion and degradation.

Environmental-economic accounts serve the basic functions of an accounting system. Policymakers, businesses, and individuals use the information to track important trends and to determine the economic importance of changes to environmental resources.

New Zealand's economy is heavily reliant on its natural resources. To manage our environment efficiently, it is important to measure its stocks and flows to better inform the following topics.

- Resource management – can be improved through the ability to assess the physical extent of environmental depletion and degradation.
- Policy analysis – natural resource accounts help analyse the effectiveness of current economic and environmental policies. They provide the information needed for making better use of our resources by analysing sectoral economic performance and measuring total natural wealth.
- Indicator development – accounting data can be expressed in alternative ways or can be integrated with economic and social statistics to compile indicators. For example, a comparison of the proportions of indigenous and exotic forests, or carbon dioxide equivalent emissions per unit of GDP.
- Sustainable development strategies and policies – information about environmental and economic interactions help improve sustainable development strategies and policies.

Stats NZ's environmental-accounting history

Stats NZ's environment team, set up in 2001, was initially funded by the Ministry for the Environment. New Zealand was then the only OECD country that had yet to compile a suite of environmental accounts. From 2001 to 2005, Stats NZ created the natural resource accounts based on the SEEA framework. The focus was to establish stock and flow accounts measured in monetary and physical terms.

The accounts did not cover the full range of potential accounts, and data gaps existed in all of them. Most accounts provided estimates at the national level, with minimal sectoral or regional breakdown. From 2001 to 2011 Stats NZ produced 18 publications on environmental accounting covering energy, environmental protection expenditure, forestry, fish, the marine economy, minerals, and water.

The accounts' scope and frequency were reduced after 2009 as focus shifted to reporting on sustainable development and to developing an environmental domain plan. In August 2012, the Cabinet Committee for Economic Growth and Infrastructure concluded that SEEA accounts "need to be produced more frequently to improve the utility of the information".

Development of Stats NZ's environmental-economic accounts began while the SEEA was still experimental. Renewed concerns about understanding well-being 'beyond GDP' (eg, Stiglitz et al, 2009), the need to better account for nature, and the adoption of SEEA as a statistical standard in 2012, led to regular SEEA production worldwide.

System of Environmental-Economic Accounting

SEEA is a conceptual framework for understanding the interactions between the environment and the economy. The SEEA began its development following the 1987 Bruntland Report, which was the first document to define sustainable development. SEEA is produced by the United Nations, European Commission, Food and Agriculture Organization, Organisation for Economic Co-operation and Development, International Monetary Fund, and World Bank Group.

The broad nature of SEEA means it is suitable for all countries and all aspects of environmental accounting. A country, however, can choose to implement different aspects of SEEA depending on its needs and priorities.

The different publications within the SEEA 'family' are discussed below.

Central framework

The **central framework** covers the concepts, definitions, classifications, accounting rules, and tables for the stocks and flows of a range of environmental assets (in both physical and monetary terms), and for environmentally-related economic transactions. It was adopted by the United Nations Statistical Commission (UNSC) in 2012 as the international statistical standard for environmental-economic accounting, to be implemented in a flexible and modular approach.

The central framework provides guidance on assembling economic and environmental information in a consistent and comparable way using national accounting principles and techniques. The coverage includes accounting for different types of physical flows (such as energy, water, waste, and air emissions) and for different types of environmental assets and natural resources (such as minerals, soil, timber, fish, and water).

The outputs consist of a comprehensive set of tables and accounts on the environment and its relationship with the economy. Generally, accounts prepared under the central framework are at the national level for integration with national economic accounting. However, in theory, these could be produced at a local or regional level provided the same concepts, classifications, and definitions are applied.

Many countries regularly produce environmental-economic accounts based on the central framework, including Australia, Canada, the Netherlands, and the United Kingdom. Water, energy, and air emission accounts tend to be usual accounts produced using the central framework.

Experimental ecosystem accounting framework

The **experimental ecosystem accounting framework** extends the central framework into the domain of ecosystem condition, extent, and services, and has a holistic view of environmental assets. Like the central framework, its strength is its capacity to integrate environmental information with standard measures of economic activity. Endorsed by the UNSC as international guidance in 2013, it uses the same principles, structure, and accounting approach as the central framework to maintain coherency.

The ecosystem accounting framework has a systems rather than an individual resource perspective on environmental assets. The central framework assesses environmental assets individually (eg, timber, water, and fish). In contrast, the ecosystem accounting framework perspective is on a given ecosystem and the range of ecosystem services provided. It assesses how individual environmental assets interact as part of natural processes within a spatial area, to provide a range of services for economic and other human activity. It has a broader scope than the physical asset boundary of SNA because it focuses on assets that have an economic use.

The ecosystem accounting framework aims to provide information on the capacity of an area or system to provide ecosystem services and how these services change over time. It monitors ecosystem degradation and conveys evidence and data gaps on important services and characteristics. Ecosystem accounting makes extensive use of subnational data and accounts can be compiled at any scale within a nation. The use of the same concepts, classifications, and definitions across geographic scales provides consistency and the ability to aggregate to the national level.

Ecosystem assets are the basis upon which the ecosystems function and provide ecosystem service flows. Ecosystem services provide the link between ecosystem assets and the benefits received by society. Ecosystem service flows are classified into three broad categories of provisioning services, regulating services, and cultural services.

- **Provisioning services** generate the ‘goods’ in ecosystem goods and services. They reflect the material and energy provided by ecosystems, such as timber, fish, or plants that are harvested.
- **Regulating services** represent the capacity of ecosystems to control the climatic, hydrological, and bio-chemical cycles, as well as biological processes.
- **Cultural services** are generated from the physical setting, location, and characteristics of ecosystems. They are the emotional, intellectual, and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection.

Some countries have produced initial ecosystem accounts, but none has yet developed a complete set of ecosystem service accounts.

SEEA manuals produced to date include **Extensions and applications**, which outlines applications of environmental-economic accounting such as decoupling indicators and input-output analysis. Manuals have been produced for **SEEA-Water**, **SEEA-Energy**, and **SEEA-Agriculture**, **forestry and fisheries** (see Methodology on the UN's SEEA page to access these manuals).

SEEA account types

SEEA covers three broad types of account: stocks, flows, and transactions.

Stocks

The economy's use of natural inputs is linked to changes in the stock of environmental assets that generate those inputs. Environmental assets are the naturally occurring living and non-living components of Earth, together constituting the biophysical environment, which provide benefits to humanity. Although they are naturally occurring, many environmental assets are transformed to varying degrees by economic activities. SEEA has two perspectives on environmental assets.

- Central framework focuses on individual components of the environment that provide materials and space to all economic activities, for example, resources such as mineral and energy, timber, water, and land.
- Experimental ecosystem accounting framework focuses on the interactions between individual environmental assets within ecosystems. It looks at the broad set of material and non-material benefits that accrue to the economy and other human activity from flows of ecosystem services. Ecosystems are dynamic communities of plants, animals, and microorganisms interacting with their non-living environments as a functional unit. Examples are terrestrial (eg, forests and wetlands) and marine ecosystems. Often, different ecosystems interact at local and global levels.

Flows

Flow accounts use physical units to measure the flows of materials and energy that enter and leave the economy and the flows of materials and energy within the economy. These measures are called physical flows. In broad terms, flows from the environment to the economy are recorded as natural inputs (eg, flows of minerals, timber, fish, and water). Flows from the economy to the environment are recorded as residuals (eg, solid waste, air emissions, and return flows of water).

Transactions

SEEA records the flows of economic activities related to the environment, such as expenditures on environmental protection and resource management, and the production of environmental goods and services.

Records of economic activities undertaken for environmental purposes are called functional accounts. The SEEA framework provides a more complete view of the environmental aspects of the economy by considering environmental transactions such as taxes, subsidies, grants, and rent.

Combining physical and monetary accounts

The physical and monetary accounts complement each other. To maintain consistency with the economic accounts, it is preferable to measure the value of natural resources using exchange values. Some assets may only be measured in physical terms, such as soil resources, many water resources, and ecosystems, as there is no economic exchange of these assets. Changes within these assets often can be measured (eg, the degradation and depletion of soil resources or the volume of water in lakes), but not changes within the opening and closing stocks.

The physical accounts show what is actually happening in the environment and are expressed in terms that are easy to understand. For example, the accounts can show how expansive the forests of New Zealand are, or how much coal is left in our mines.

Monetary accounts are expressed in a common unit of measurement (ie, New Zealand dollars) allowing different resources to be compared using the same units. Valuation is calculated in a way that is consistent with SNA, meaning monetary estimates can be linked to the current national accounts. Because monetary accounts can be more difficult to interpret, it is important to understand its underlying concepts, such as net present value and exchange value.

When monetary and physical accounts are combined, the change in an environmental asset's value is due to price or quantity effects, or both. This applies to both stock and flow accounts.

Coverage

SEEA covers a broad range of environmental assets, residuals, and environmentally related economic transactions. Table 1 describes stock and flow accounts, table 2 covers transaction accounts.

Table 1

SEEA stock and flow accounts				
Account	**Type of account**			**Information it provides**
	Physical stock	**Physical flow**	**Monetary stock and flow**	
Air emissions		x		Generation of air emissions by resident economic units (industry and households) and by substance type.
Ecosystem condition and extent	x			Overall quality of the ecosystem asset and its size.
Ecosystem services		X	x	Provisioning, regulating, and cultural ecosystem services from a specified ecosystem (eg, agricultural or forested land, inland waters). Most services are specified in physical terms, although services that are traded are estimated using market prices.
Economy-wide material flow		x		Aggregate overview of the material inputs and outputs of an economy, including inputs from the environment, outputs to the environment, and the physical amounts of imports and exports.
Energy	x	x	x	Energy flows from the initial extraction or capture of energy resources from the environment into the economy, to the flows of energy within the economy in the form of the supply and use of energy by industries and households. Also, the flows of energy back into the environment.
Fish	x	x	x	Total biomass of all species that are subject to harvesting activity or cultivated within the national boundary.
Timber	x	x	x	Volume and value of timber resources at the beginning and end of an accounting period and change in the stock (natural growth and removals) over the accounting period.
Land	x		x	Land use and land cover data, useful for assessing impact of urbanisation, intensity of crop and animal production, and afforestation and deforestation.
Minerals	x		x	Quantities and values of stocks and resources and the changes in these over accounting periods. Flows of extraction, depletion, and discoveries provide information on individual resource availability.
Waste		x		Generation of solid waste and management of flows of solid waste to recycling facilities, controlled landfills, or directly to the environment.
Water	x	x	x	Water flows from the initial abstraction of water resources from the environment into the economy, to the water flows within the economy in the form of supply and use by industries and households, and finally flows of water back to the environment.

Table 2

SEEA transaction accounts	
Account	**Information it provides**
Environmental goods and services sector	Considers environmental activities from the supply perspective and presents information on the production of environment goods and services. Assists in understanding the economic response to the challenges of environmental degradation and the depletion of natural resources.
Environmental protection expenditure	Identifies and measures society's response to environmental concerns through the supply of and demand for environmental protection services and through the adoption of production and consumption behaviour aimed at preventing environment degradation.
Environmental taxes	Records the amount of energy, transport, pollution, and resource taxes paid to government for something that has a proven scientific negative impact on the environment.

The marine economy, which is not specifically described in the SEEA framework, is a satellite account. Satellite accounts are governed by and consistent with SNA and most use reworked versions of key SNA tables. Satellite accounts 'cut across' traditional industry definitions to group common activities. They are used to increase the understanding of and provide analysis for specific sectors or functional activities within the national economy, making them 'satellite' to the 'core' accounts. Common examples include transport, health, and tourism.

SEEA recommends that countries adopt its production in a modular approach; it does not require countries to produce all accounts. Countries are encouraged to produce accounts that have most value and relevance to the issues they face.

SEEA myth busting

There are some perceptions on what SEEA can or cannot do.

Myth 1: SEEA is only concerned with national-level estimates, so is not useful for regional analysis

SEEA allows the combination of environmental and economic data, but this can be done at regional or local levels where the data was compiled according to national accounting principles.

National-level SEEA accounts can be used to benchmark regional-level analyses so that the regional study maintains consistency with national-level data.

Often, the barrier to fine-scale analysis is not due to SEEA, but to the availability of data. In concept the SEEA can be compiled at any level of detail.

Myth 2: SEEA does not account for the quality of the environment

The central framework does not directly address the quality of the environment but does provide guidance on compiling accounts that show pressures on the environment (eg, residual flow accounts). The experimental ecosystem accounting framework is strongly focused on the condition of ecosystems. Underlying this myth is the perception that the ecosystem accounting framework is not part of SEEA when in fact it is.

Myth 3: SEEA is about 'commodifying' natural capital

The central framework values in monetary terms only those environmental assets exchanged in markets. However, SEEA clearly distinguishes environmental assets in terms of whether they are or are not available for economic use. SEEA does not promote any particular action from the valuation of environmental assets: this stems from the interpretation placed upon the accounts by users.

SEEA provides a framework for measuring the cost of depletion. It covers the economic benefits received from the use of natural capital in terms of production, but also the effect that the depletion of resources has on GDP.

Myth 4: A complete set of SEEA accounts means data is available for all rows and columns for all accounts

The number and completeness of SEEA accounts depend on the needs of a country. Some accounts may not be relevant for some countries.

A particular account does not need to describe and quantify all possible sources of stock change, industry, ecosystem, or species type. In many cases, data may not be available. However, the accounting framework promotes a coherent way of thinking about how the interactions between the environment and economy occur, even if no data is available to quantify them.

System of National Accounts

SNA is an internationally agreed set of guidelines that give a comprehensive and consistent description of economic activity in each country. This description helps monitor the behaviour of the economy, and assists with macroeconomic analysis, economic policy, and decision-making.

The standards are internationally accepted and implemented, so economic performance can be comparied between countries. SNA comprises various accounts including current accounts, capital accounts, production accounts, accumulation accounts, balance sheets, and satellite accounts.

Generally, the national accounts are intended to record economic transactions that have been observed and can be expressed in monetary terms. This approach has the disadvantage of failing to identify either the scale of environmental damage or the extent of the resource depletion caused by these transactions.

Satellite accounts were introduced to address these perceived limitations within SNA. In the satellite accounts, the national accounts aggregates are amended to treat natural resources as capital in the production of goods and services. They also record the cost of use (depletion or degradation). Many cost and capital items needed to account for natural resources are already identified separately. Others will need to be disaggregated further and reclassified, while others will need to be added. In SNA, only produced assets are included explicitly within net value added.

Similarities and differences between SEEA and SNA

SEEA is a satellite system of SNA and consistency between both is essential for integrating environmental and economic data. SEEA and SNA share the same accounting rules, concepts, and principles to facilitate this integration.

Examples of shared principles and concepts include:

- domestic production – under SEEA and SNA, only activities of resident economic units are included, those for non-residents are excluded (whereas most environmental statistics are collected on a territorial basis)
- use of the same standard industry or product classifications to allocate activities, resource use, or residuals to households and industry
- use of the 'exchange value' principle in expressing stocks and flows in monetary terms
- timing of recording.

In monetary terms, the asset boundaries of the SEEA central framework and SNA are the same as the production boundary that defines the set of benefits used to value the assets. In ecosystem accounting the production boundary is broader allowing for larger values of assets. Only environmental assets with an economic value that can be measured using the valuation scope of SNA are included in the SEEA central framework (eg, natural resources and land).

In physical terms, the asset boundary of the SEEA central framework is broader as it includes all natural resources and land areas of an economic territory that may provide resources and space for use in economic activity. Thus, the scope in physical terms is not limited to the assets with economic value as defined by the SNA. It is recommended that environmental assets with no economic value be clearly distinguished. In the SEEA experimental ecosystem accounting framework, the production boundary is broader allowing for a wider range of assets to be measured.

Stock accounts

Stock accounts show the amount, in physical units and monetary values (where market prices are available), of an environmental asset and the additions and reductions to those stocks.

Introduction to stock accounts

Integrated economic and environmental accounting requires measuring the stocks of assets, which are presented in a stock account. The two main objectives of a stock account are to measure the absolute level of natural resources at a point in time as an indication of New Zealand's wealth, and to show any change in stock levels over a certain period. The change in stock level is determined by calculating the difference between the opening and closing balances. The stock accounts can also be linked to flow accounts by recording the associated harvest or extraction.

SEEA methodology distinguishes between two types of assets included in stock accounts: economic assets and environmental assets.

Economic assets

For a natural resource to be considered an 'economic asset' and included in SNA ownership rights must exist over the natural resource and it must bring economic benefit to the owners.

Under SNA, natural resources can either be fixed assets or work-in-progress. They are classified as a fixed asset if the same asset repeatedly or continually produces products, such as apple trees, or are classified as work-in-progress if they produce only once, such as forests for wood harvesting. Fisheries can be an example of both a fixed asset and work-in-progress. Fish used for breeding are considered a fixed asset, while fish cultivated for sale are considered work-in-progress.

Environmental assets

In SEEA, environmental assets are "natural assets that function as a source of materials and energy as well as of environmental services of waste absorption, ecological functions, such as habitat or flood and climate control and other non-economic amenities such as health or aesthetic values. Therefore, uncultivated forests, wild animals, fish within the exclusive economic zone (EEZ), and all ecosystems are included in the SEEA asset boundary" (United Nations, 2014b).

Under SEEA not all elements are considered environmental assets. Some elements by themselves do not directly provide benefits, but the larger element within which they belong, such as an ecosystem, provides direct benefit. It is the ecosystem that is considered an environmental asset. The parts that make this up are not considered environmental assets in their own right. For example, "the countless species involved in decomposing organic matter in forests do not themselves provide either use or non-use environmental benefits to humans [with the exception of those used for medicinal purposes or as a food source] and are not, therefore, considered environmental assets in the SEEA. The forest ecosystems of which they are an element clearly do benefit humans…and therefore, qualify as environmental assets in the SEEA" (United Nations, 2014b).

Some environmental assets appear more than once within the classification; once in their own right and again as an integral part of another asset. Timber, for example, is an asset in its own right, but it also plays an important role as part of an ecosystem. This highlights the two perspectives SEEA takes on environmental assets. It does not normally cause problems in double-counting, in monetary terms, because usually only a monetary value can be established for the 'integrated' asset.

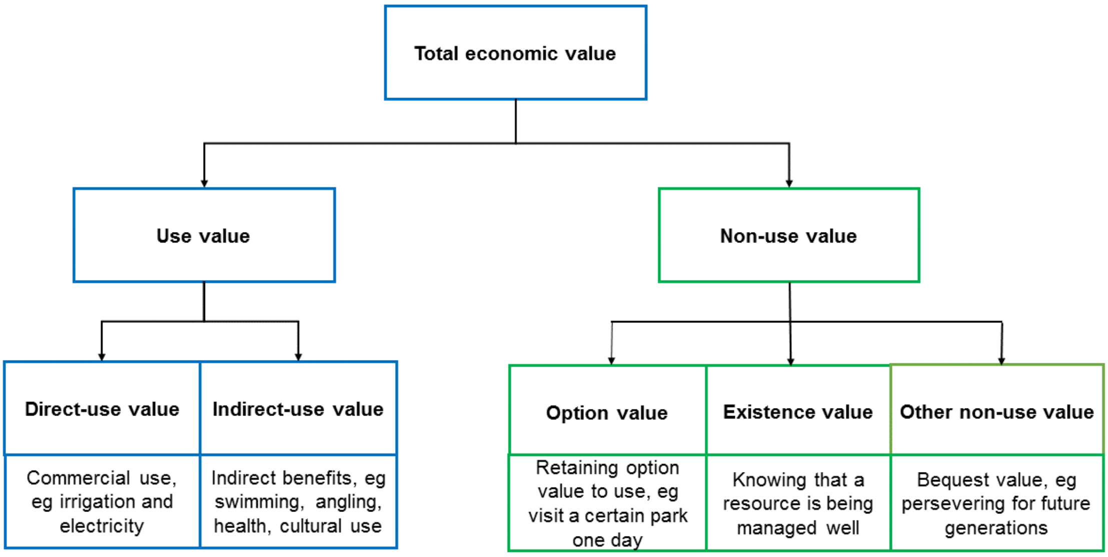
Use and non-use values

Where available, an asset value can be combined with those for alternative uses of an asset to indicate whether the asset is being used efficiently. Figure 2 shows how the total economic value of an environmental asset consists of its use and non-use values over its lifetime. Asset values measure the direct-use value of environmental assets. Direct-use values are easier to measure because market values are often available. Non-use values are harder to measure but are in scope of ecosystem services under the SEEA ecosystem accounting framework.

A natural resource may retain an option value for future production, even if its current use value is close to zero (eg, coal could have a future value as cost-effective carbon-capture technologies are being developed).

Figure 2

Total economic value of environmental assets



Source: Kaye-Blake et al, 2014

General structure of stock accounts

For each asset, the structure of the account works like a balance sheet (table 3 shows the basic accounting form of a stock account). Changes between the opening and closing stock levels are a result of both economic activity and environmental processes.

Table 3

Basic accounting form of a stock account
Opening stock
Additions to stock
Growth in stock
Discoveries of new stock
Upward reappraisals
Reclassifications
Reductions of stock
Extraction
Natural loss of stock
Catastrophic losses
Downward reappraisals
Reclassifications
Revaluation of the stock[1]
Closing stock
1. Monetary accounts only

The coverage of the monetary accounts is relatively limited as not all natural resources can be valued in monetary terms (eg, soil). For resources that can be valued, there may be issues on the appropriate valuation method. Monetary accounts should generally be used in conjunction with the physical accounts so that it can be assessed whether the value of the resource is changing due to physical or price effects.

In practice, only partial information may be available to describe the change in stock, for example, data may only be available for total additions and total reductions to stock. However, whether data is available or not, SEEA provides a framework for thinking about the reasons why stocks may change.

Table 4 shows the range of assets included in the SEEA central framework.

Table 4

Assets included in the SEEA central framework
Mineral and energy resources
Oil resources
Natural gas resources
Coal and peat resources
Non-metallic mineral resources (excluding coal and peat resources)
Metallic mineral resources
Land resources
Soil resources

Assets included in the SEEA central framework
Timber resources
Cultivated timber resources
Natural timber resources
Aquatic resources
Cultivated aquatic resources
Natural aquatic resources
Other biological resources (excluding timber resources and aquatic resources)
Water resources
Surface water
Groundwater
Soil water

Measurement units

Stock accounts describe the state of assets at a given point in time. According to the nature of the assets, and the purpose of the accounts, the unit of measurement may simply be a count of individual items, or an additive measure that allows for additions and subtractions from the stocks, such as area, volume, or mass. Assets can also be valued in monetary terms if prices are available.

Another way of measuring natural assets in physical terms is by aggregating different assets. By using conversion factors, different physical units of measurements are expressed as ‘equivalents’. Expressing tables in equivalents will usually make the tables more useful analytically.

Measuring quality changes in an asset could be used in a stock account for resources where the total stock is too vast to measure, or measurement is otherwise impractical or of no real benefit. Assets can be classified according to their inclusion in a given quality class. Stock accounts describe not only changes in quantity but also changes in quality that can be measured by changes in classification. An asset in a given quality class may change to another class, for example, land may change from ‘agricultural land’ to ‘land underlying buildings’. In general, complex environmental assets, such as ecosystems and air, cannot be fully described by their monetary value or by any other additive measure. The quality of the asset may be used as an alternative description, for example, how the quality of air changes over time.

Whatever physical measurement unit used for a particular asset, several important points should be noted:

- the units should be consistent and comparable over time
- different assets can have different physical units of measurement
- a stock account can be compiled, for example, by quality classes, species, or ownership
- not all assets can have total stock volumes because they are not available or particularly useful, for example, soil and water
- consistency and comparability in measurement units mean changes between the opening and closing levels of stock can be accurately measured.

Accounting for natural resources in monetary terms

Measuring stocks in monetary terms focuses on individual environmental asset values and changes in those values over time. The monetary valuation of assets focuses on the benefits that accrue to economic owners of environmental assets and assists in a broader understanding of national wealth.

This approach to measuring stocks of environmental assets aligns with measuring economic assets in the national accounts. Other social benefits that may accrue to current and future generations are not incorporated here but may be developed over time as we develop ecosystem accounts.

Resource rent

Resource rent is the current value of the environmental asset. The resource rent from an environmental asset is based on the economic rent concept. Resource rent reflects the surplus value accruing to the extractor or user of an environmental asset calculated after all costs and normal returns are taken into account (United Nations, 2014b, p140). It is the current value after accounting for both supply and demand factors. The resource rent amount is always derived relative to the returns earned by other firms on average over time (ie, normal returns) and may be positive or negative. Economic theory suggests that a resource rent should be positive in the long term unless there is open access to the resource, in which case the resource rent will be zero. It reflects the gross return attributable to the environmental asset, or income generated by the use of such assets. It provides the basis for computing the asset value using the net present value (NPV) approach.

The three main approaches to estimating resource rents are:

1. **Residual value method** – resource rent is estimated by deducting user costs of produced assets from gross operating surplus after adjusting for any specific subsidies and taxes. This is outlined in more detail in table 5. Operating costs consist of intermediate consumption, compensation of employees, and other taxes and subsidies on production. The user cost of a produced asset includes any consumption of fixed capital on the asset and a return to the owner of the produced asset. For Stats NZ, the residual value method is used in the estimation of renewable energy values, and for calculation of resource rents for forestry and logging and minerals.
2. **Appropriation method** – resource rent is estimated using the actual payments made to owners of environmental assets.
3. **Access price method** – resource rent is estimated from the purchase of licenses and quotas which determine the market price of the rights to access the resource. This method is used in estimating the value of the fish stock.

Table 5

Deriving resource rent from environmental assets
Output
- operating costs
= gross operating surplus (SNA basis)
- specific subsidies on extraction
+ specific taxes on extraction
= gross operating surplus (for resource rent derivation)
- user cost of produced assets
= resource rent

In theory, all these methods will generate the same estimates of resource rent. However, the applicability of the appropriation and access price methods depends more heavily on institutional arrangements in a country. For these reasons, when estimates of resource rent based on the residual value method are compiled, they should be reconciled, where possible, with estimates obtained using other methods.

Net present value approach

Net present value (NPV) approach values the asset as the net present value of future benefits accruing from holding or using the asset. The logic of the NPV approach requires estimating the stream of resource rents that are expected to be earned in the future, and then discounting these resource rents back to the present accounting period. This provides an estimate of the value of the asset at that point in time. The asset value represents the discounted future income stream, and therefore, the benefits to accrue to future as well as current generations.

The scope of an asset valuation calculated using the NPV approach is limited to the scope of the future income streams that are included. In the SEEA central framework, the asset values are therefore limited to the value of the natural resource that is currently being used for economic gain.

An integral part of the NPV methodology is the application of a discount rate, which discounts the value of the asset over the period, from the date of valuation to the expected maturity date of the asset. NPV values the asset at a point in time, and depending on current market prices, the physical characteristics and the discount rate chosen.

NPV approach requires:

- the estimated current market income of the resource (the resource rent)
- assumptions or projections around the future income stream of the resource
- lifespan of the resource
- a discount rate.

Choice of discount rate

A discount rate is a time preference for money, reflecting that income received in the future is not as valuable as income received today. By discounting future income so that it is comparable with income earned today, an asset's value, based on future income, can be estimated. Choosing the discount to be used in estimating an asset's value is a pivotal variable and is often the subject of considerable debate (United Nations, 2014a).

SEEA outlines a number of approaches and considerations to be taken into account when selecting a discount rate and recommends the use of a market-based discount rate. In Europe, legislation requires countries to compile a selection of SEEA accounts. In these cases, a country's treasury department may well prescribe the rates to be used. The New Zealand Treasury's current discount rates are primarily targeted to inform cost-benefit analysis of generally publicly owned assets and may or may not be applicable for use in environmental accounting.

Use of asset accounts

Asset accounts provide the basis for assessing natural wealth. In SEEA, asset accounts include both produced capital and natural capital. The accounts can be used to estimate the extent to which New Zealand maintains the value of its natural wealth, thereby helping to ensure a steady flow of future income from the sustainable use of environmental resources.

Accounting for natural wealth and its distribution provides measures of the availability of natural resources for productive and financial activities, and of the concentration of economic power within and among nations. The composition of a country's natural wealth is important. A developing nation's economy may show large increases in the share of cultivated assets to total assets, while for developed nations this ratio may show little change over time.

Link between the stock and flow accounts

Environmental accounts consist of stock accounts and flow accounts. Stock accounts show the opening and closing stock level of the specific asset, and the changes that occurred during the time period. The flow accounts are linked to the stock accounts. Given the stock changes specified in the stock account, the flow accounts describe these changes further, particularly the economic harvesting or extraction of the resource. They show how the natural resource has been supplied and used within the economy, and by whom.

Flow accounts

Flow accounts show the supply of resources from the environment to the economy, the use of resources within the economy, and the flow of resulting products and residuals to the environment.

Introduction to flow accounts

Understanding the physical flows between the environment and the economy helps to identify the consequences of economic activities on natural resources and ecosystems. It is the purpose of flow accounts (also referred to as supply and use accounts) to record these flows.

Flow accounts aim to capture the natural resources used as inputs to the production and consumption processes, and the outputs including disposal of solid waste and other residuals (such as to air or water) from the economy back into the environment. They can also help highlight the origin or destination of some specific natural resources, materials, or residual flows within the economy, or between the economy and the environment. Flow accounts are measured in physical terms.

Flow accounts have a number of purposes, including:

- revealing the economic flows generated by harvesting or extracting the resource
- identifying potential threats to the environment from residual flows and the economic source
- providing information needed to construct environmental performance indicators that help analyse further the environmental impacts of particular economic and social activities (eg, emissions per unit of GDP).

Flow accounts can be compiled at different levels of aggregation if data can be converted into compatible units or equivalents. Examples of physical weighting procedures used internationally include the conversion of greenhouse gas pollutants into carbon dioxide equivalents, and the conversion of sulphur and nitrogen oxides and ammonia into acidification equivalents.

Types of flows

Flows are characterised according to their origin and destination.

- **Natural input** flows are renewable or non-renewable physical inputs that can be withdrawn from the natural environment for economic use (eg, timber from forests to sawmills). When natural resources are harvested or extracted for sale or economic use, they have entered the economic sphere, and will be classified further as products. Table 6 shows the list of natural resource inputs included in SEEA.
- **Product** flows consist of the flows within the economic sphere (eg, wood products from sawmills to furniture manufacturers, and furniture to consumers). They are products resulting from production and include both goods and services. Physical flows of goods are the most important, but there may also be services related to the delivery of goods.
- **Residuals** include all physical outputs discharged from the economic sphere back into the natural environment (eg, timber treatment chemicals). Residuals can be reabsorbed into the economic sphere by recycling or waste (water) collection and incineration activities. As a result, these residual inputs are converted into products, or outputted as less harmful residual flows. Pesticides, fertiliser, and compost are examples of products whose use and function is brought into the environment on purpose, and so are related to flows from the economy into the environment.

Further distinctions about flows can be made, including flows between the economic and the environmental spheres, flows of products within the economy, and flows between the national economy and the rest of the world.

Table 6

Natural resource inputs in SEEA
Extraction used in production
Mineral and energy resources
Oil resources
Natural gas resources
Coal and peat resources
Non-metallic mineral resources (excluding coal and peat resources)
Metallic mineral resources
Soil resources (excavated)
Natural timber resources
Other natural biological resources (excluding timber and aquatic resources)
Water resources
Surface water
Groundwater
Soil water
Natural resource residuals
Inputs of energy from renewable sources
Solar
Hydro
Wind
Wave and tidal
Geothermal
Other electricity and heat
Other natural inputs
Inputs from soil
Soil nutrients
Soil carbon
Other inputs from soil
Inputs from air
Nitrogen
Oxygen
Carbon dioxide
Other inputs from air
Other natural inputs not elsewhere classified

Analytical indicators

One purpose of flow accounts is to provide information that enables the construction of environmental performance indicators. These indicators help assist the analysis of the environmental impacts resulting from certain economic activities, such as domestic consumption and production, and international trade. Flow accounts are often used to show how 'resource efficient' the economy is, and how efficiency has changed for particular industries and sectors.

Greenhouse gas intensity, for example, measured as total greenhouse gases over chain volume gross value added, shows how greenhouse gas emissions are changing relative to the economy and whether emissions are increasing or decreasing in line with economic activity. The use of common classification systems is instrumental in making comparisons between environmental and economic data.

Environmental activity accounts

In addition to accounting for the stocks and flows of natural resources, SEEA also includes a set of accounts called environmental activity accounts. The accounts record the range of transactions, in monetary terms, between economic units (eg, firms, households, or government) that may be considered environmental.

Introduction to environmental activity accounts

Generally, environmental activity accounts record the transactions on an activity (ie, expenditure) undertaken to preserve and protect the environment. Further, a range of transactions, such as taxes and subsidies, reflects efforts by governments on behalf of society to influence the behaviour of producers and consumers with respect to the environment.

The accounts enable an understanding of the economy's response to environmental change. They can identify not just the extent of the transactions being undertaken, but also which economic units are involved in the transactions.

Most of these environmental transactions are recorded within the core national accounts framework, but many cannot be easily identified owing to the structure of the accounts or the types of classifications used. SEEA provides appropriate definitions and accounts for organising information in a manner consistent with the national accounts.

Purpose of the accounts

A strong motivation for undertaking this work is to identify an environmental component within the key aggregates of SNA. Further, in combination with information on the changing pressures on the environment, information on these transactions may be used to help assess whether economic resources are being used effectively to reduce pressures on the environment and maintain the capacity of the environment to deliver benefits.

Scope of environmental activities

Traditional industry and product classifications do not identify the economic activities, products, and producers that are characteristic of the environment. Alternative classifications are needed for these by considering the purpose of each activity.

A distinction is drawn between economic activities that should be considered environmental, and other economic activities that are closely associated with the environment or that use the environment directly in their production processes (eg, extraction of mineral and energy resources). These activities may be considered 'environmentally related' but to varying degrees, as all economic activities require a functioning environment and interact with the environment in some way. Hence, an exhaustive categorisation and description of all environmentally related activities are not pursued in SEEA.

The scope of environmental activities encompasses economic activities whose primary purpose is to reduce or eliminate pressures on the environment or to make more efficient use of natural resources. Examples of these activities are restoring polluted environments, conservation and resource management, and investing in technologies designed to prevent or reduce pollution.

The various activities are grouped into two broad types of environmental activity: environmental protection and resource management (see table 7).

Table 7

Classification of environmental activities	
Environmental protection	**Resource management**
Protection of ambient air and climate	Management of mineral and energy resources
Wastewater management	Management of timber resources
Waste management	Management of aquatic resources
Protection and remediation of soil, groundwater, and surface water	Management of other biological resources
Noise and vibration abatement	Management of water resources
Protection of biodiversity and landscapes	Research and development activities for resource management
Research and development for environmental protection	Other resource management activities
Other environmental protection activities	

Types of environmental activity accounts

Environmental activity accounts in SEEA include:

- environmental protection expenditure account (EPEA)
- environmental goods and services sector (EGSS)
- a range of other transactions, including environmental taxes and subsidies, permits and licences to use environmental assets, and transactions relating to fixed assets used in economic activities related to the environment.

EPEA closely follows the concepts, definitions, and accounting rules of the core national accounts. However, some degree of deviation from SNA is required when considering either environmental specificities or the measurement objectives of the EPEA, which are more targeted than the broader macroeconomic focus of the core national accounts.

EGSS focuses on the supply of environmental goods and services. These statistics include information on the production of the range of environmental goods and services, including environmental protection and resource management specific services, environmental sole-purpose products, and adapted goods.

Both EPEA and EGSS statistics provide information that assist in understanding society’s response to the challenge of environmental degradation and depletion of natural resources. They also show the potential for economic activity to be based on environmentally friendly and more resource-efficient activities. However, each set of information presents a different coverage of and perspective on environmental activities.

Environmental protection expenditure

The environmental protection expenditure account (EPEA) presents information on the amount of expenditure by central and local government on activities whose primary purpose is the prevention, reduction, and elimination of pollution and other forms of degradation of the environment (United Nations, 2014b, para 4.12). This can include resource management activities, which are activities whose primary purpose is preserving and maintaining the stock of natural resources and hence, safeguarding against depletion (United Nations, 2014b, para 4.13).

The estimates currently produced are experimental as further work is required to align available data to the conceptual framework of SEEA. The account is also partial as the scope of the account needs to be expanded to cover the market sector.

EPEA is an environmental activity account. A fully developed EPEA closely follows the concepts, definitions, and accounting rules and structure of the core national accounts to facilitate comparisons with economic statistics.

EPEA aims to enable identification and measurement of society's response to environmental concerns through the supply of and demand for environmental protection services, and through the adoption of production and consumption behaviour aimed at preventing environmental degradation. EPEA provides information on the output of environmental-protection-specific services produced across the economy.

EPEA can therefore be used to analyse the extent of environmental protection activities and to assess how expenditure on environmental protection is financed. The accounts can also be used to derive indicators for highlighting change in key areas, such as the expenditure on pollution prevention and abatement, the contribution made by environmental protection activities to the economy, and the shift to pollution-preventing technologies.

Analytical extensions of EPEA include valuating the influence of environmental protection costs on (domestic or international) competitiveness, implementing the 'polluter pays' principles, and determining the cost-effectiveness of environmental control mechanisms. EPEA may also be analysed alongside the environmental taxes account to examine the extent to which different economic agents internalise the actual costs of environmental protection in their decision-making, and the extent to which different economic instruments prevent environmental degradation. The analytical value of EPEA can be enhanced by comparing it to biophysical data, such as the amount of waste treated or the quality or quantity of air emissions.

Central government

Central government environmental protection expenditure is sourced from the government finance statistics produced by Stats NZ. Data are based on departmental expenditure (obtained via the Crown Financial Information System (CFIS)) for those departments whose primary purpose is to provide environmental protection. Government expenditure in the government finance statistics is classified according to the Classification of Function of Government. Central government EPE cannot be disaggregated by type of environmental protection as the data is fit for purpose only at the total environmental protection expenditure level.

Government final consumption expenditure for units whose primary purpose is to provide environmental protection is used as a measure of environmental protection expenditure for central government. As output is performed on a non-market basis, it is valued as the sum of costs in the absence of a market price.

Final consumption expenditure has been calculated as the sum of intermediate consumption, compensation of employees (which includes salaries and wages, Accident Compensation Corporation (ACC) levies, employer superannuation contributions, and fringe benefits), indirect taxes, and accounting depreciation.

Measuring non-market output, or output for own use, requires excluding non-production expenditure items such as interest, grants, and subsidies that are in the government finance statistics.

Gross fixed capital formation is the additions less disposals of fixed assets. It includes, among other items, furniture, computer software and hardware, land improvements, transport equipment, non-residential buildings, other construction, and plant, machinery, and equipment.

Estimates are in current prices, exclusive of GST, and therefore reflect increases in unit costs as well as real output.

Local government

Final consumption expenditure and gross fixed capital formation are compiled using the same definitions used for central government environmental protection expenditure. Estimates are in current prices, exclusive of GST, and therefore, reflect increases in unit costs as well as real output.

Information on these five environmental protection categories are included.

- **Wastewater** includes sewerage network (including mains), reticulation of sewage, sewerage treatment: oxidation ponds and on land disposal, stormwater (the water that runs off surfaces such as roads, driveways, footpaths, and rooftops). Also includes culverts and open drains. Excludes land drainage in non-urban areas as this should be included in land and soil management.
- **Solid waste/refuse** includes collection and disposal (aftercare, landfill operations, street and roadside rubbish bins), and recycling collection and recovery (recycling centres, reusable materials depots, and roadside recycling).
- **Air and water quality** includes any measurement and analysis of air and/or water quality and education. Also includes dairy effluent.
- **Land and soil management and river control** includes shelter belts, management of contaminated sites, and soil conservation to reduce erosion. For non-urban areas, includes any drainage of the land (eg, run off), flood protection schemes and river control functions, maintenance, works, and monitoring.
- **Pest management** includes both animal and plant. Pests are defined as organisms that are capable of causing, at some time, a serious adverse and unintended effect on people and/or the environment and can include rabbits, stoats, birds, possums, feral goats, wasps, and invasive weeds and pest plants.

Local government financial information is collected by ‘activity’ (eg, stormwater, environmental protection, solid waste) through the local authority census (LAC). This activity data, for the categories described above, are available for both final consumption expenditure and gross fixed capital formation.

Final consumption expenditure includes:

- consultants, experts, and legal advice
- insurance premiums
- employee costs (salaries and wages, ACC levies, and superannuation contributions)
- depreciation and amortisation
- purchases and other operating expenditure
- indirect taxes.

The estimates of depreciation and amortisation from LAC are based on financial accounting concepts. Under SEEA, economic depreciation should be used. However, we expect the effect of this to be small.

The concepts being applied to the environmental-accounting estimates differ from those applied to local authority statistics. LAC's definition of environmental protection includes non-production expenditure items, such as interest payments, subsidies, and grants, which are excluded for environmental accounting purposes.

The local government component includes data from regional councils, unitary authorities, city councils, and district councils. Data are based on June years available from 2009 reflecting the availability of data by environmental protection category.

Data quality

EPEA is currently experimental as further work to extend the coverage and alignment to national accounts is required.

Stats NZ has taken all possible reasonable steps to ensure the quality of the data. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The estimates include a breakdown of all environmental protection expenditure for local government only. Estimates by type of environmental protection expenditure for central government are not available. Environmental protection expenditure for market-based producers and non-profit institutions serving households are not included.

Accuracy

We are confident with the estimates as the differences in concepts despite some conceptual issues (see coherence/consistency below).

Timeliness

Data are consistent with the latest available national accounts release. The report covers data until the year ended March consistent with the latest period available from the national accounts at the time we compiled the latest SEEA report.

Coherence/consistency

The methodology used here is broadly consistent with guidance in SEEA. However, while adjustments to the national accounts, such as financial intermediate services indirectly measured and research and development, have not been applied to the estimated environmental protection expenditure, we expect the impact of these adjustments to be small.

The concept of depreciation used is based on accounting depreciation, not consumption of fixed capital.

Time-series consistency has been ensured. Data are available from 2009.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data are available in CSV format with the report.

Interpretability

The report contains the appropriate information to interpret these estimates. Interpretability can be enhanced by comparing these estimates with total final consumption expenditure and investment produced by the national accounts.

Environmental taxes

The environmental tax account is an environmental activity account. It records transactions undertaken within the economy for reducing the negative effects of activity on the environment.

Environmental taxes reflect efforts by governments, on behalf of society, to influence the behaviour of producers and consumers with respect to the environment (United Nations, 2014b, para 4.1). There is considerable interest in the use and effectiveness of these taxes as they show a direct response of countries to manage environmental change through economic instruments. Environmental taxes are one of six SEEA accounts that European Union countries are required to produce under legislation (see Environmental accounts – establishing the links between the environment and the economy).

In addition to SEEA guidance, compiling environmental tax accounts is further described in Eurostats' Environmental taxes: A statistical guide – 2013 edition.

Defining environmental tax

The SEEA central framework defines environmental tax as a tax whose tax base is a physical unit (or a proxy of a physical unit) of something that has a proven specific negative impact on the environment.

The SEEA central framework (United Nations, 2014b, para 4.150) states that, in practice, this definition is applied by looking at all the various taxes levied in a country and determining whether the tax base in each circumstance is something that has a negative environmental impact.

The Eurostat guidance emphasises that:

1. taxes may be collected with more than one purpose but will generally be included if they apply to products or activities that have an adverse effect on the environment
2. tax accounts be consistent with the definition of taxes within SNA.

Environmental taxes can be one of four bases (referred to subsequently and in the report as types): energy, transport, pollution, and resource.

Energy taxes (including fuel for transport)

- Energy products used for transport purposes
  - unleaded petrol
  - leaded petrol
  - diesel
  - other energy products for transport purposes (eg, LPG, natural gas, kerosene, or fuel oil).
- Energy products for stationary purposes
  - light fuel oil
  - heavy fuel oil
  - natural gas
  - coal
  - coke

  - biofuels
  - electricity consumption and production
  - district heat consumption and production
  - other energy products for stationary use.
- Greenhouse gases
  - carbon content of fuels
  - emissions of greenhouse gases (including proceeds from emission permits recorded as taxes in the national accounts).

Transport (excluding fuel for transport)

- Motor vehicles import or sale (one off taxes)
- Registration or use of motor vehicles, recurrent (eg, yearly taxes)
- Road use (eg, motorway taxes)
- Congestion charges and city tolls (if taxes in national accounts)
- Other means of transport (ships, airplanes, railways, etc)
- Flights and flight tickets
- Vehicle insurance (excludes general insurance taxes).

Pollution

- Measured or estimated emissions to air
  - measured or estimated NOx emissions
  - measured or estimated SOx emissions
  - other measured or estimated emissions to air (excluding CO_2)
- Ozone-depleting substances (eg, chlorofluorocarbons or halons)
- Measured or estimated effluents to water
  - measured or estimated effluents of oxydisable matter (biochemical oxygen demand, chemical oxygen demand)
  - other measured or estimated effluents to water
  - effluent collection and treatment, fixed annual taxes
- Non-point sources of water pollution
  - pesticides (based on eg, chemical content, price, or volume)
  - artificial fertilisers (based on eg, phosphorus or nitrogen content or price)
  - manure
- Waste management
  - collection, treatment, or disposal
  - individual products (eg, packaging, beverage containers, batteries, tyres, lubricants)
- Noise (eg, aircraft take-off and landings).

Resources

- Water allocation
- Harvesting of biological resources (eg, timber, hunted and fished species)
- Extraction of raw materials (eg, minerals, oil, and gas)
- Landscape changes and cutting of trees.

These transactions are recorded in SNA but are not specifically related to the environment. The environmental taxes presented in national accounts (industry production and investment) are a subset of the total taxes on production and imports.

Annual national accounts sources and methods defines taxes as compulsory, unrequited payments, in cash or in kind, made by institutional units to government units. They are described as unrequited because the government provides nothing in return to the individual unit making the payment, although governments may use the funds raised in taxes to provide goods or services to other units, either individually or collectively, or to the community as a whole.

The full classification of taxes on production and on imports consists of:

- taxes on products, for example excise duty on alcohol, or the gambling levy
- value added tax (VAT) – in a New Zealand context, GST
- taxes and duties on imports, excluding VAT
    - import duties, this means taxes levied on imports that are specific to importing
    - taxes on imports excluding VAT and duties – in New Zealand these include excise duty on alcohol imports, as the rate is consistent with the excise duty on domestic alcohol production
- export taxes
- other taxes on production – this includes taxes not elsewhere covered, including land rates and taxes on pollution such as carbon taxes.

SNA 2008 (SNA08) notes that governments are increasingly turning to issuing emission permits as a means of controlling total emissions. The permits do not involve using a natural asset (no value is placed on the atmosphere, so it cannot be considered an economic asset) and are therefore classified as taxes even though the permitted 'activity' is one of creating an externality. It is inherent in the concept that the permits will be tradeable and that there will be an active market for them. These permits are recognised as tax revenue within the national accounting framework to the extent to which payment is received by government. In 2018, Stats NZ updated the treatment of ETS transactions to be more aligned with international economic-accounting standards for the treatment of carbon credits. Specifically, the tax level is set to zero when the government allocates credits to emitters under the ETS but does not require payment. This treatment is replicated in the environmental taxes account. This contrasts with the New Zealand Treasury treatment of the ETS, where tax revenue is based on the value of surrendered permits.

Goods and sales tax (GST) is not considered an environmental tax even though in some instances GST may be levied against the consumption of goods which have a negative effect on the environment (eg, GST on electricity or equipment which combusts fuels).

Data source

Data for the environmental tax account is sourced from the national accounts. The New Zealand System of National Accounts measures taxes on production in a standard way across all industries. National totals are derived through the Treasury's CFIS, a secure website that collects actual and forecast information from government departments, Crown entities, and state-owned enterprises. Taxes are allocated on a proportional basis to industries. The proportions used are derived mainly from taxes and subsidies data collected though the annual enterprise survey (AES).

Method

An assessment is first made on whether the tax base in each circumstance is something that has a negative environmental impact. The following are useful guides for making these decisions: SEEA 2012, Environmental taxes – a statistical guide – 2013 edition, and Environmental taxes: 2014.

The individual taxes are then allocated to industry. Where specific information is available, generally supplied by the administrative agency responsible for each tax, then we could do this with some confidence. Where taxes are allocated using proportions derived from AES, they are generally allocated at the total aggregated level within the national accounts systems. For this reason, we are less confident in the industry allocation for some taxes and therefore, the figures for breakdown of environmental taxes by industry should be interpreted with caution.

Tax proportions for the following agriculture industries are particularly limited:

- AA111 horticulture and fruit growing
- AA121 sheep, beef cattle, and grain farming
- AA131 dairy cattle farming
- AA141 poultry, deer, and other livestock farming.

It is therefore hard for these industries to separate local authority rates (which are not covered under environmental taxes) from other taxes. To be able to proceed with an industrial breakdown of environmental taxes, we assumed that for energy and transport taxes the AA1 industries have similar levels of tax payments to the AA2 and AA3 industries below. This is an area for future improvement but consistency with the national accounts taxes on production needs to be maintained.

- AA211 forestry and logging
- AA311 aquaculture
- AA312 fishing
- AA321 hunting and trapping
- AA322 agriculture, forestry and fishing support services.

Environmental taxes data are available at the New Zealand Standard Industrial Output Categories NZSIOC) level 1 classification, which is a 19-class aggregation of all ANZSIC06 industrial codes. Ideally, we would produce environmental accounts at the more detailed NZSIOC level 3 classification to be consistent with the annual national accounts. This work will be prioritised for the next release of environmental taxes.

For all industries except AA1 agriculture, proportions are available from AES for the years 2007–16. Before 2007 the proportions were available under the ANZSIC96 classification rather than ANZSIC06.

Although backdating was done for the taxes on production and imports series in the national accounts, it was not done at a sufficiently detailed level to be able to re-compile environmental taxes. For this reason, we held the 2007 AES proportions constant for the 1999–2007 period.

Presentation of environmental taxes and total taxes

We present environmental taxes in total and by tax category (tax base), industry, and as a comparison to all revenue from taxes and social contributions. The Eurostat manual recommends presenting the share of environmental taxes to total revenue from taxes and social contributions as an indicator. Where total revenue from taxes and social contributions includes all taxes (D.2, D.5, and D.91) and actual or imputed social contributions (D.611 and 6.12). Presentation of this indicator means any shift in the tax burden as part of green tax reform can be examined over time. This indicator is also useful for international comparability.

Table 8

Taxes glossary
Taxes on production and imports (D2) These include: Taxes on products (D21) Other taxes on production (D29)
Current taxes on income, wealth, etc. (D5) These include: Taxes on income (D51) Other current taxes (D59)
Capital taxes (D91)
Net social contributions (D61) These include: Employers' actual social contributions (D611) Employers' imputed social contributions (D612)
Note: Social contributions are actual or imputed payments to social insurance schemes to make provision for social insurance benefits to be paid. (SNA08 8.16 p158). Capital taxes consist of taxes levied at irregular and infrequent intervals on the values of the assets or net worth owned by institutional units or on the values of assets transferred between institutional units as a result of legacies, gifts inter vivos or other transfers. (SNA08 10.207 p217).
Source: System of National Accounts 2008

Data quality

Stats NZ has taken all possible reasonable steps to ensure the quality of the data. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The estimates include a breakdown of all environmental taxes by tax type. We also show total environmental taxes paid by industry and households. These figures are directly comparable with those in the national accounts.

Accuracy

We are confident with the figures for total environmental taxes and their breakdown by tax type. For most of these taxes, particularly the larger amounts, we are also confident in the allocation to industry. A source of uncertainty is the use of proportions derived from various sources to allocate remaining taxes to industry and to split taxes between those paid by households and by industry.

Timeliness

Data are consistent with the latest available national accounts release. The report covers data until the year ended March consistent with the latest period available from the national accounts at the time we have compiled the latest SEEA report.

National accounts data are provisional for the most recent year. Future updates of the SEEA report will incorporate national accounts revisions to the most recent year and where applicable, any other national accounts revisions, for example, due to updates on the classification of methodology.

Coherence/consistency

The methodology used here is consistent with guidance in both SEEA and the Eurostat guide. Time-series consistency has been ensured. Data are available from 1999 to 2016.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data are available in CSV format with the report.

Interpretability

The report contains the appropriate information to interpret these estimates. Interpretability can be enhanced by comparing these estimates with total taxes produced by the national accounts.

Fish

For the fish account we used the SEEA central framework’s concepts, methods, and definitions.

The methodology used was adopted following the recommendations of the SEEA central framework and *Handbook for integrated environmental and economic accounting for fisheries* (SEEAF) (United Nations, 2004). The SEEA central framework states that where possible, asset values of natural resources should be based on market transactions. Since most of New Zealand’s commercial fish resources are available for trading under the quota management system (QMS), it provides a robust market value for fish resources.

Asset values are derived from average values per tonne for transactions occurring during the fishing year. These transactions are for the transfer of individual commercial fisheries quota or annual catch entitlement managed under QMS. The values are in market prices (current prices).

The fishing year for most fisheries is from 1 October to 30 September. However, the fishing year for rock lobster and southern blue whiting, as well as some other minor stocks, is from 1 April to 30 March. The fishing year for Lake Ellesmere eels is from 1 February to 31 January (Ministry for Primary Industries, 2017). For the purpose of this account, all fisheries quota transactions ending in the same calendar year are aggregated into the total for that year ended September. For example, the fishing year ended 2002 includes fisheries quota for the years ended 31 January 2002 (one QMA only), 31 March 2002, and 30 September 2002. To see a list of all species and QMAs, including year ended and year first added, managed under the QMS as at September 2016, refer to the fish monetary stock Excel tables.

For ease of comparison between fisheries years, all export revenue figures, by weight and value, are given in September years.

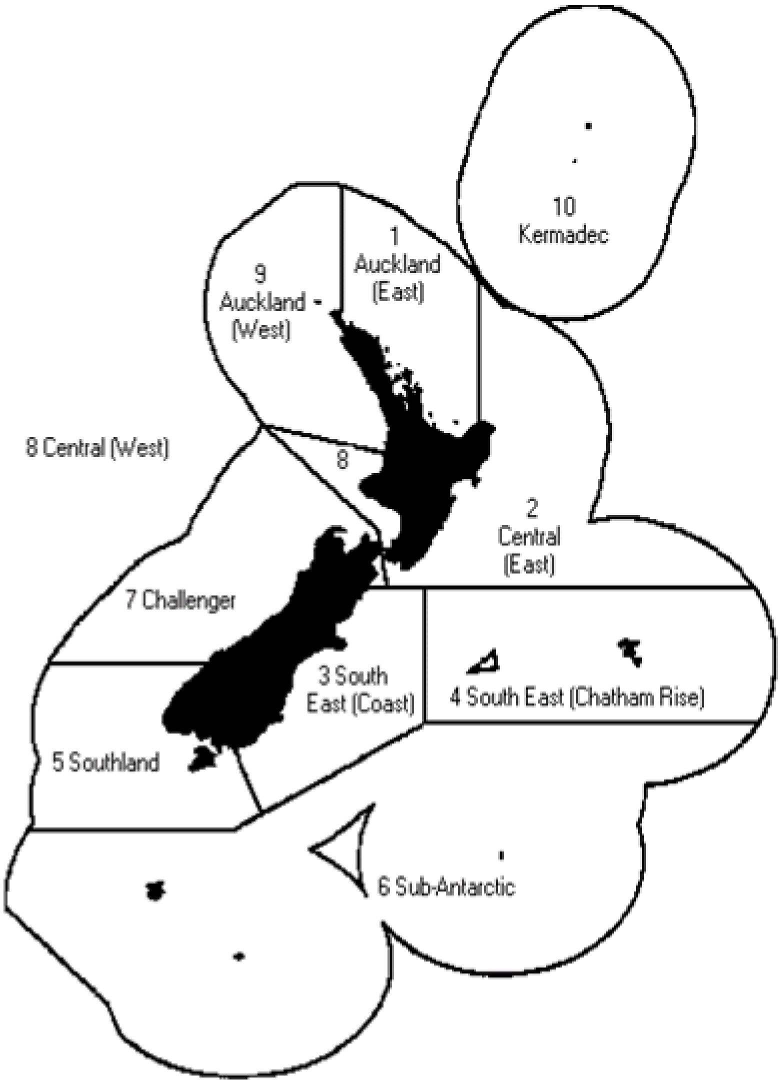
Quota management system

The QMS divides New Zealand's exclusive economic zone into 10 fisheries management areas (FMAs) (figure 4). For each quota management species, fish stocks are identified to provide for more effective management. Each fish stock is defined by a quota management area (QMA). This QMA may be the same as an FMA or a grouping of FMAs, depending on the geographical distribution of that fish stock. For example, the species john dory has one fish stock called JDO3 that incorporates FMAs 3, 4, 5, and 6, while snapper has a fish stock called SNA1 that matches FMA1.

Under the QMS, commercial catch limits (in tonnes) are set annually for each fish stock by the Minister of Fisheries as total allowable commercial catch. The catch limits are based on advice from the Ministry of Primary Industries and submissions from the fishing industry and other interested groups. TACC may be altered from the previous year if assessments of stock numbers show change.

Figure 3

New Zealand fisheries management areas



Note: Management areas may vary between species.

Source: Clement and associates (2016)

Individual transferable quota

Commercial fishers own individual transferable quota (ITQ). Quota is the property right representing the shares owned in a fish stock which can be bought and sold. Quota itself cannot be fished against.

Annual catch entitlement (ACE) is the catching right generated each year from the share of the TACC the quota holding represents. Therefore, a person or enterprise that owns quota cannot fish for that quota unless they hold ACE; but a person or enterprise that holds ACE may fish for that stock regardless of whether they hold, or own, quota. Quota for fish stocks are expressed as shares in whole numbers. The sum of that quota is always 100,000,000 shares for each stock. The value of one share is equal to one hundred-millionth of the total quota shares for that fish stock.

On the first day of every fishing year that person's or enterprise's quota shares generate an ACE, which is expressed in kilograms. On allocation, the quota and ACE separate so the ACE can be traded independently of quota. All quota and ACE transfers must be registered with FishServe. ACE can be transferred up to 15 days after the end of a fishing year, to allow for transfers to take place to balance catches.

As an example:

JMA7 has 100 million quota shares.

▼

J Fisher owns 10,000 quota shares or 0.01 percent of the JMA7 fish stock.

▼

On 1 October, J Fisher's shares generate ACE.

▼

The TACC for JMA7 is set at 50,000 tonnes (50 million kg), therefore 1 share = 0.5kg.

▼

J Fisher's 10,000 quota shares generate 5,000kg of ACE.

▼

J Fisher can catch 5 tonnes of JMA7 in that year.

Before 1 October 2001, under the Fisheries Act 1983, quota could be leased by the quota owner to another party. For these transfers the term 'lease' is used. These leases could be for varying periods, as determined by the two parties to the transaction. After 1 October 2001, under the Fisheries Act 1996, the quota holdings split into two property rights. It is now the ACE that can be purchased by a second party for the term of the fishing year. When referring to transactions that occurred during or after the fishing year ended September 2002, the term 'ACE transfer' is used to describe the transfer of catch entitlement between two parties. ACE can be on-sold multiple times before it is actually fished.

Under the current QMS system, only New Zealand residents can own quota (unless permission is granted by the Minister of Finance and the Minister of Fisheries). However, quota owners can contract overseas fishing vessels to harvest fish. However, the foreign-owned fishing vessels operating in New Zealand waters must be reflagged to New Zealand and comply with relevant New Zealand regulations.

Methodology

Scope

The fish account presents an asset value of New Zealand's commercial fish resources. The account values non-produced assets (wild stocks) and does not include produced assets (aquaculture). In theory, market prices for the sale of produced assets (aquaculture) are available and can be used to estimate the value of live fish owned by an establishment (United Nations, 2014b, para 5.441). In practice, the value of the fish resources is not readily separated from the capital involved in the industry. As such, the asset value of aquaculture stocks is not able to be calculated at this time but is an area for future development.

The asset value of the fish stock is taken as equal to the value of those species managed under QMS. This assumption is made on the basis that non-ITQ species will have zero rent and hence, zero asset value for the commercial fishing industry. Over time, more species have been brought into QMS resulting in an increase in the monetary valuation of the fish stock – effectively fish with zero rent value now acquires a non-zero value as their harvest is now restricted. In practice, this is not a major issue, as species comprising 95 percent of the total commercial catch, by weight, are managed under QMS (Clement & associates, 2016) although this proportion was lower in the earlier years of the series. Of about 130 commercial species, 100 are managed under QMS in the year ended September 2016 (MPI, 2017).

Previous method used

Fish monetary stock account: 1996–2003 used a quota valuation methodology which is explained in this section. Subsequent releases of the fish monetary stock account altered the initial methodology used in the account to incorporate the values for ACE transfers in the calculation of asset values.

When the fish monetary stock account 1996–2003 was produced for the first time, calculating the asset value of fish resources was relatively straightforward, using a quota valuation method. This approach followed the SEEA guidelines (United Nations, 2004), which states that an asset value for fish stocks can be produced through the value of licences and quotas where realistic market values are available.

The asset value based on quota valuations methodology is equal to the average value of the traded quota ($/tonne) multiplied by the total allowable commercial catch. Previously, for any individual quota where no quota trades were available, modelled figures were generated by using the average values of that quota's trades in the previous year. Where these were unavailable, quota trade information from the following year was used.

SEEA has since been revised and passed into statistical standard. The revised version is the SEEA central framework (United Nations, 2014b). The revision of the central framework has not resulted in any change to the methodology used in this account.

Declining quota trades

The amount of modelling within the valuation increased over time from less than 5 percent (on average for the period 1996–2001) to over 50 percent (had the valuation been produced in the same manner in 2004).

From 1996 the number of quota trades has generally declined. The number of quota trades used in this account averaged approximately 2,000 a year over the period 1996–2001, but this dropped to an average of around 900 transfers a year over 2002–16. At the same time the number of ACE transfers steadily increased. Newell et al (2005) found an average of 9,300 lease transactions a year for the period 1986–2000; subsequently, the average number of total ACE transfers a year has been around 69,000. In Newell's analysis and any work done before October 2001, 'lease' would be an appropriate term as quota could be leased for a period determined by the two parties to the transaction. After this, quota holdings split into two property rights; it is ACE that can be purchased by a second party for the term of the fishing year. When not referring to pre-2001 transactions, the terms 'ACE transactions' or 'transfers' are used. ACE can be sold multiple times before it is actually fished.

Since QMS was introduced in 1986, operators with higher overheads may have disposed of their quota for those who can most efficiently use it. It may also be a sign of a maturing market that operators are choosing to maximise their capital gain over time, by retaining ownership of their asset while extracting an economic return from that asset.

Current approach

SEEA states that where quota trade information is not available, another method to produce the asset value is to base the value on the net present value (NPV) of the resource rent of the fish stock.

This method led to the adoption of a supplementary method using the value of ACE transfers. ACE is the catching right generated each year from the share of total allowable commercial catch that the quota holding represents. Before 2001 there was no ACE; the quota itself could be leased, and lease periods were often varied. ACE was first used from October 2001. Because lease transactions before 2001 may have been for variable periods, this account uses only ACE transactions from the year ended September 2002 onwards in calculating the asset value for fisheries.

The NPV method uses the value of ACE transfers as an approximation of the asset's resource rent for the year, and discounts the sum of the future net income stream (or rent) in order to express its value at the present time. This approach requires assumptions to be made, including the choice of discount rate. The quota value represents the NPV of the owner's expected income using the quota over its period of validity. If the fishery is managed with such quotas and the quotas are valid in perpetuity, the value of all quotas, at the market price, should be equal to the value of the use of the fish stock. If the quotas are valid for a single year only, the total should give an approximation of the resource rent for the year (United Nations, 2014b).

Two approaches are now used in this account. Where quota trade figures exist, the quota valuation method is preferred. Where quota trade information is unavailable, then the NPV method, using ACE transaction values, is used in order to avoid reliance on modelled figures.

Before 1 October 2001, QMS had not created the property and harvest rights of quota shares and ACE. Previously, quota holders could lease their quota holding directly. These leases may have varied in duration and are therefore excluded from the analysis. ACE transaction figures (which are effectively a one-year lease) are used for the 2002–16 years only.

A small amount of modelling was still required (averaging less than 0.35 percent of total value between 2002 and 2016). Missing quota trade information is modelled using the subsequent year's information first, and then information from the previous year.

Using net present value method to incorporate ACE transfers into the valuation

The fish account assumes that under QMS management, fish stocks have stabilised at current levels and that the current rent will continue into the future. Although the assumptions may not hold true for individual fish stocks on a year-to-year basis, they are made because the sustainable use of the fisheries resource is a major objective of QMS. Under the assumptions, the NPV formula becomes the resource rent divided by the discount rate. The expanded formula is given below.

The NPV method discounts the sum of the future net income stream (or rent) to express its value at the present time. The general formula for calculating the asset value of a resource is described below.

At the beginning of period 0, the value V_0 is:

$$V_0 = \sum_{t=0}^{T_0} \frac{p_t Q_t}{(1+r)t}$$

$$p_t = \frac{R_t}{Q_t}$$

$$T_0 = \frac{S_0}{Q_0}$$

where:

V_t value of the asset at time t

p_t unit rent price of fish at time t

Q_t quantity of fish catch during time t

r the discount rate

R_t total resource rent at time t

T_0 the remaining lifespan of the resource computed at time 0

S_t volume of stock at the end of the accounting period t.

In the case of a renewable resource like fisheries, which is being harvested at a constant and sustainable rate, the lifetime is infinite and the formula reduces to:

$$V_0 = \frac{p_t Q_t}{r}$$

A note on assuming sustainability

As stated above, this account assumes that, under QMS management, fish stocks have stabilised at current levels and that the current rent will continue in the future. This assumption may not hold for all species, in all management areas, all the time. However, sufficient evidence shows fish stocks within New Zealand are currently being managed at an acceptable level, with management programmes in place to rebuild fisheries identified as being below target level.

MPI uses three performance measures to assess fish stocks: a soft biomass limit (below which a stock rebuilding plan is required), a hard biomass limit (below which closing a fishery should be considered), and an overfishing threshold (above which the rate of extraction exceeds the optimal extraction rate).

MPI reports on fish stock status every year. Stats NZ's environmental reporting team assesses the quality of the reports for inclusion in the marine domain indicators, which are published under the environmental reporting series produced by the Ministry for the Environment and Stats NZ. State of fish stocks for the 2015 fishing year is one of these indicators.

NIWA is the main provider of fisheries resource surveys, catch monitoring, and stock assessment research for New Zealand fisheries. See fisheries services for further information on NIWA's work in this area.

An example of a physical asset (stock) account table for aquatic resources is shown in the SEEA central framework manual (table 5.22). The table shows additions and reductions in stock with opening and closing values in physical terms, which would then have a corresponding monetary value in the monetary asset (stock) account. Compilation of a physical stock account for natural (non-cultivated) aquatic resources would require extensive modelling and would likely be compiled for the more economically important QMS species only. However, this is still an area for future development.

The central framework states that unless those setting the total level of the quotas do so based on knowledge of the maximum catch consistent with preserving stocks, earnings from the catch will not correspond to the level of income that maintains the aquatic resource intact. A total permissible catch resulting in earnings higher than this level will mean that some of those earnings should be regarded as depletion of the aquatic resources and not as income (United Nations, 2014b).

Choice of discount rate

A discount rate is a time preference for money, reflecting the fact that income received in the future is not as valuable as income received today. It also reflects the owner's attitude to risk. In general, individuals and enterprises will have higher rates of time preference than society; that is, they will tend to demand a quicker return from ownership of an asset than will the society as a whole. Higher rates of time preference translate into higher discount rates (United Nations, 2014b).

By discounting future income so that it is comparable with income earned today, an asset's value, based on future income, can be estimated. The choice of the discount to be used in estimating an asset's value is a pivotal variable and is often the subject of considerable debate. Applying the general concept of a discount rate to economic issues has generated much discussion (as yet unresolved) by many economists (Arrow, Nordhaus, and Stiglitz, among others). Choosing a discount rate has become a focus of discussion in environmental economics because of the impact this choice will have on models of economic outcomes over long periods of time. The choice of a discount rate and the nature of the assumed preferences may be perceived as having ethics-related underpinnings.

The *Integrated Environmental and Economic Accounting for Fisheries* (United Nations, 2004) lists the discount rates used in different economies when preparing their fisheries asset values. The rates varied from a low of 3.5 percent in Norway to a high of 10 percent in Namibia. Previous versions of this account used a fixed discount rate of 9 percent, which was chosen because it was consistent with the return on similar assets in the New Zealand economy over the period measured. The existence of both quota and ACE trade values for part of the stocks across the 2002–09 period meant that the choice of discount rate could be tested, which supported the use of a discount rate in the range of 8 to 9 percent. Work done at that time also supported the adjustment of the rate in line with changes in real market rates.

StatsNZ released provisional tables for the fish monetary stock account in August 2017. This release did not make the recommended adjustment and for consistency used a 9 percent rate in all years after 2002 when NPV methods were adopted.

After the August provisional release, Stats NZ consulted with Treasury and with colleagues from other national statistics agencies to get feedback on adopting a moving discount rate.

Discount rates are essential for converting present values into future discounted values. Higher discount rates imply that individuals attach greater weight to costs and benefits accruing in the immediate period (ie, myopic time preference as they are heavily discounting the future). Conversely, a lower discount rate implies that individuals attach greater weight to benefits and costs accruing in future periods.

Implications of either a variable or a fixed discount rate

A fixed discount rate is assumed to hold every year. This is the previous approach with the rate set at 9 per cent. The alternative is to vary the rate every year, using an appropriate method, to account for changing time preferences.

A fixed approach, where it is easy to verify the assumed value is valid, is advantageous in that it is easy to implement and does not require judgement of statistical models. However, the fixed approach means that when the 'true' discount rate is different from the assumed rate then the estimate of the asset value will be biased.

The variable approach, on the other hand, needs to be based on an empirical method, using reliable data and sound economic and statistical assumptions. Assumptions include the extent to which previous and future profit flows are important in determining the current periods' decision. Variable approaches can also be computationally more complex. However, the variable approach can account for changing time preferences and produce more accurate estimates of the fish monetary stock.

Discount rate estimates derived from comparisons of quota and ACE values

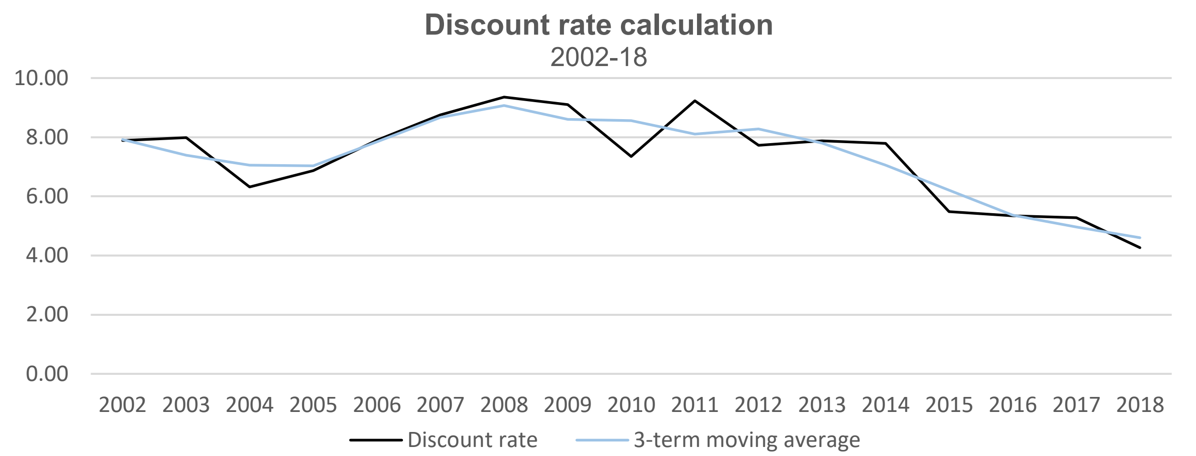
Where there are incidences for any fish species where we have an average quota sale value (the right to access the fishery in perpetuity and receive a share of the total allowable catch set each year) and average annual catch entitlement (ACE) transaction data available, we can examine the implied or endogenous discount rate.

Previous work by Newell (2007) analysed quota prices and quota leases for the period 1986–2000 and found that the implied discount rate fell by about half, from 14 percent to 7 percent, which approximately matched a similar fall in market rates (as measured by New Zealand Treasury bills).

Undertaking a similar exercise comparing ACE prices with quota prices for the period 2002–07 indicated an implied discount rate of 8–9 percent. These studies suggest that while the original rate of 9 percent used in this account appeared reasonable at the time, there may be a good case: (1) to lower the rate over time, to reflect the progressive increase in certainty as the QMS matures, property rights become entrenched, and more knowledge on fish populations and sustainable total allowable commercial catch is acquired; and (2) to allow the rate to fluctuate in line with changes in real market interest rates.

The derived discount rate and its three-year moving average rate is shown in figure 5. We prefer the moving-average approach to account for adaptive and forward-looking expectations, as well as reducing volatility.

Figure 4



Source: Stats NZ

In addition, we looked at business lending rates (nominal) available from the Reserve Bank (see Retail interest rates on lending and deposits) and compared them to the derived rate. Broadly, they tracked quite closely although the three-year moving average rate appeared slower to adjust after the 2008 global financial crisis. This may be because quota had been purchased in the years up until September 2008, with an expectation around subsequent ACE prices. We found that after 2008, ACE transfer prices continued to increase while new quota purchase transactions did not recover to the same average price per tonne until 2013.

Due to the variation in the available data and in the type, location, and equipment used in the fisheries covered, the variable discount rate is not appropriate for every species in every management area or year as was the case for the fixed rate. For this reason, we have looked closely at the estimates produced for the most important species (in monetary terms) and also the deep-water species (removed from the influence of recreational or customary access). The variable rate does appear to be producing realistic results for these fish.

Where we have sufficient data we have also looked at the movement over time of total allowable commercial catch limits and actual recorded catch in relation to the derived rates. There is some evidence that caution or concern about sustainability may be driving a shift towards a lower rate over time. However, the extent to which this is occurring cannot be distinguished from market conditions that have led the interest rate to decline. Although the New Zealand government set total catch limits based on stock assessments, capture-fish harvest rights in New Zealand are freely traded and owned entirely by private individuals and organisations. For this reason, the use of a social discount rate has not been considered.

Data quality

Estimates are based on quota and ACE trade values, but in some years the trading of individual quota is low or even non-existent, so that some species receive no asset value. Trades (quota and ACE) for nominal amounts, possibly between economically related parties, are not uncommon and are removed by the data supplier. In addition, we did not use a few ACE values (2 percent over the 2002–06 period) supplied by FishServe. We replaced them with imputed figures as they were unreasonably high and would have resulted in severe distortions to the estimated asset values and trends. It is likely that these trades contained other assets or did so for periods of more than one year.

All quota and ACE transfers must be registered with FishServe, and the total price of any transfer is collected on quota and ACE share transfer forms. Even after removing unreasonably high or low values, as described above, there is still some variation in transfer information (particularly ACE transfer information) that is difficult to explain. To capture any data revisions, we requested a re-supply of FishServe data for catch 2002–16, quota 2008–16, and ACE 2008–16. No outliers were identified or removed from this updated series.

Further variation may be caused by using the NPV method to produce an asset value estimate for a species quota management area, in any year where quota trade information is absent, and using the quota valuation method in the subsequent or previous year. The NPV method discounts future resource rent (ACE values) to express its value at the present time. Therefore, where the value of the asset equals the resource rent divided by the discount rate, then the discount rate can be given by dividing the resource rent by the asset value of the fishery. The 9 percent discount rate used in previous accounts was appropriate on average across the fish stocks and the 2002–09 period, but for some stocks ACE values are lower or higher than would be expected in relation to quota transfer values. This may be because the prices recorded against ACE transactions are determined by other considerations, such as transfers between related parties.

Every effort was made to evaluate the accuracy of the time series estimates included in the report. While trends in the figures are indicative, the use of absolute figures requires care.

Missing values

The previous section noted that some species may have no price information in one or more of their QMAs. Quota or ACE transfer information may be absent for many reasons. Some of these reasons are for example, when the Ministry of Fisheries allocates quota directly to the industry, or when the industry perceives the deemed values for that quota to be low enough that they do not need to secure ACE. When a fisher does not hold sufficient ACE, they incur a financial cost for taking the fish, and they are required to pay a deemed value. The system of deemed values is designed to encourage fishers to cover all their catch of QMS fish stocks with ACE. See Deemed values for more information.

Quota or ACE transfer information may also be absent when the fishery is not economically significant at the time. Most unvalued QMAs have a TACC of less than 10 tonnes and recorded catch is often only a small proportion of TACC, or in many cases, zero. When some unvalued species are economically significant, we use an alternative method to estimate an asset value.

Scampi, a high-value low-volume fishery (MPI, 2016), is one example of an unvalued, economically significant species. Since scampi entered QMS on 1 October 2004, there has been no information on quota trades. In 2005, there were ACE trades in 10 scampi QMAs, giving it an asset value of $148 million (the ninth most-valuable species the year). In 2006, 2007, and 2008 there were ACE trades in the main scampi QMAs but after 2008 there were no available ACE trade information until 2015 – this made the fishery effectively impossible to value with existing methodology. Fish monetary stock account: 1996–2008 modelled the asset value for scampi from the average asset values for the previous three years. When the fish monetary stock account was updated in 2009, the continued lack of quota and ACE transfer information resulted in a revision of scampi asset values using a new methodology based on the movement in the $/tonne export price for scampi. This methodology was expected to be a temporary measure. For the *Fish monetary stock account: 1996–2016,* we decided to use deemed values rather than export prices as they are likely to give a better indication of ACE pricing.

Interim deemed values are used because these are the prices that are in place during the fishing season and are more likely to be similar to prices paid for ACE during the fishing season. Note that deemed values effectively place a ceiling on ACE values (Townsend, 2010; Holland, nd) and may result in a higher asset value than would have been estimated if ACE transfer information was available. If final (annual) deemed values were used rather than interim values, the effect would have increased, as overfishing is controlled by graduated administrative incentives based on the payment of deemed values (Ministry of Fisheries, 2005).

Where fishers are unable or unwilling to obtain ACE they are required to purchase sufficient deemed values to cover their catch. For this reason, where ACE is unavailable for scampi and a few more economically significant species, the net present value methodology is repeated with interim deemed values substituted for ACE. The discount rate is the same as that used for ACE calculations, but catch volumes are substituted for TACC to better reflect the actual level of importance of the fishery in economic terms. For the *Fish monetary stock account: 1996–2016*, deemed values methodology was used, in the absence of other prices, for hake, oreos, scampi and southern blue whiting. For the *Fish monetary stock account: 1996–2018* update, this was extended to also include freshwater eels (South Island), ling, long-finned freshwater eel, orange roughy, pāua, rock lobster, short-finned freshwater eel, and snapper.

Stats NZ has taken all possible reasonable steps to ensure the quality of the data. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The fish account presents an asset value of New Zealand’s commercial fish resources. The estimates include all species as managed under the New Zealand quota management system, which captures most commercial fishing as non-QMS species account for less than 5 percent of catch (Clement & associates, 2016). Asset values for aquaculture, recreational, and customary fishing are not included and are an area for future work.

Accuracy

Key sources of uncertainty are the use of a discount rate to discount the sum of the future net income stream (or rent) in order to express its value at the present time. A further source of uncertainty is the assumption of sustainability.

Timeliness

Data are consistent with the latest available administrative data from FishServe at the time of compiling results and where possible with the valuation of other assets contained in the report.

Coherence/consistency

The methodology used here is consistent with guidance in SEEA. Time-series consistency has been ensured. Data are available from 1996. The resource rent and asset values are based on fisheries years. The fishing year for most fisheries is from 1 October to 30 September. However, the fishing year for rock lobster and southern blue whiting, as well as some other minor stocks, is from 1 April to 30 March and the fishing year for Lake Ellesmere eels is from 1 February to 31 January. For the purpose of this account, all fisheries quota ending in the same calendar year are aggregated into the total for that year ended September.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data are available in CSV format with the report.

Interpretability

The report contains the appropriate information to interpret these estimates. Renewable assets should be placed in context with non-renewable and other environmental assets to fully understand their relative value.

Forestry and timber

Accounts for forestry and timber include the extent of forested land, the amount of timber resources available and not available for use, and the value of the timber stock:

1. The physical asset account for timber resources records the stock and changes in stock of the volume of timber in New Zealand forests.
2. The carbon account for timber resources (experimental) records the stock and changes in stock of carbon stored in New Zealand forests.
3. The monetary asset account for timber resources records the monetary value of New Zealand's cultivated forests.
4. The physical *asset account for forested land* record the area and changes in area of New Zealand forests.

We also estimate the resource rent for the forestry and logging industry, using the residual value method, to supplement the monetary asset account and other natural capital valuations. The renewable energy chapter contains further detail on the resource rent calculation used.

In the timber accounts, a distinction is made between cultivated forests and natural forests. Cultivated forests are those which have been planted, primarily for production purposes. These forests are made up primarily of exotic species. Natural forests are those which occur naturally in New Zealand. These are made up primarily of indigenous forests (around 6.4 million hectares; Ministry for Primary Industries, 2019), although there are also some naturally occurring exotic forests.

It is currently assumed that all the cultivated forests in New Zealand are made up of exotic species. There is no estimate made for planted indigenous forests as a cultivated timber resource. This is due to limitations in data availability and as indigenous plantations are thought to make up a small proportion of all cultivated forests. Although there may be afforestation of indigenous forests, these tend to be left to regenerate naturally, and would thus be considered natural forests.

Forest land is defined using the same thresholds as the Framework Convention on Climate Change and the Kyoto Protocol. These thresholds include:

- Cover a minimum area of 1 hectare.
- Have a crown cover of at least 30 per cent.
- Reach a minimum height of 5 metres at maturity.

Data sources

The forestry and timber accounts utilise a number of data sources to construct estimates of New Zealand's total timber stocks and associated values. These are described in table 9.

Table 9

Data sources used in the forestry and timber accounts				
	Asset accounts for forests	Physical asset account for timber resources	Carbon account for timber resources	Monetary asset account for timber resources
National Exotic Forest Description (NEFD)	✓	✓		✓
Land-use carbon analysis system (LUCAS)	✓	✓	✓	
Roundwood removal data		✓		
Forestry company annual reports				✓
Annual enterprise survey				✓

Cultivated forest or natural forest are classified in each account according to the key data sources used to create them. These comprise the National Exotic Forestry Description (NEFD) and the Land Use Carbon Analysis System (LUCAS) land use classifications. The data source used to define cultivated or natural forest for each account are outlined in table 10.

Table 10

Data sources used to define cultivated forestry or natural forest			
	Forest type	National Exotic Forest Description (NEFD)	Land-use carbon analysis system (LUCAS) land use map
Asset accounts for forests	Cultivated forest	✓	
	Natural forest		✓
Physical asset account for timber resources	Cultivated forest	✓	
	Natural forest		✓
Carbon account for timber resources	Cultivated forest		✓
	Natural forest		✓
Monetary asset account for timber resources	Cultivated forest	✓	
	Natural forest		

National Exotic Forest Description

The National Exotic Forest Description (NEFD) is an annual publication produced by the Ministry of Primary Industries (MPI). It is based on an annual survey of commercial forest companies, administered by MPI. This survey covers all planted exotic commercial forests in New Zealand. Indigenous forest plantations are not included. The NEFD is usually available 12 months after the reference period. The NEFD is used to derive estimates of timber volume and net stocked area for planted forests.

Stock data collected in the NEFD survey includes information on the total volume, area and age of forests, broken down by species type. Stock data is reported as point data for a particular period (as at 1 April). The survey also collects stock change data. This includes changes in area from new plantings, restocking, and harvesting, and changes in volume from harvesting and natural growth. The stock change data covers a full year.

MPI derives two annual volume estimates of exotic forest growth from its NEFD survey. The Recoverable Annual Increment (RAI) is an estimate of the recoverable volume of tree growth within New Zealand's exotic forests. The Current Annual Increment (CAI) is an estimate of the total volume of tree growth within New Zealand's forests. The CAI is currently used to estimate Natural growth for cultivated timber resources available for wood supply.

The NEFD is used to define cultivated forests in the asset account for forests, and the physical and monetary asset accounts for timber resources. The NEFD reports on New Zealand's planted production forest estate, defined as exotic forest planted with the primary intention of producing wood or wood fibre.

Volume estimates from the NEFD do not include information from forests smaller than 40 hectares in size. The area estimates in the NEFD are adjusted using imputations, to and account for forests smaller than 40 hectares. This means that the area and volume estimates for cultivated forests do not completely align.

The area estimate for cultivated forests in the NEFD differs slightly from that used in the LUCAS land use map. The NEFD reports to a net stocked area a standard – this includes net stocked area of trees. The LUCAS land use classification reports a gross stocked area standard – which includes forest tracks, skid sites and unstocked areas. Work to improve the alignment of these two sources is an area for future development.

Data from the NEFD is converted from March years to calendar years for *the asset account for forests* and *the physical asset account for timber* resource, to align with data on natural forests and the carbon account. NEFD data remains in March years for the *monetary asset account for timber resources*

Land Use Carbon Analysis System

Data from the land use carbon analysis system (LUCAS) are produced by the Ministry for the Environment (MfE). Its primary purpose is to measure the net changes in carbon emissions for the land use, land-use change and forestry sector (LULUCF) as part of the greenhouse gas inventory annual reporting.

The LUCAS land use classifications are used to define natural forests in the asset accounts for forests, the physical asset account for timber resources, and both natural and cultivated forest in the carbon account for timber resources.

These classifications are slightly adapted, as the SEEA does not partition between pre-1990 and post-1989 forest land. Further information on these classifications can be found in Ministry for the Environment (2012). 'Planted forest' in the LUCAS land use classification are referred to as 'cultivated forest' in this release. The classification used for this release comprise:

Natural forests, defined to include:

- tall indigenous forest
- self-sown exotic trees, such as wilding pines and grey willows
- broadleaved hardwood shrubland, mānuka–kānuka (*Leptospermum scoparium–Kunzea* spp.) shrubland and other woody shrubland (≥30 per cent cover, with potential to reach ≥5 metres at maturity in situ under current land management within 30–40 years)
- areas of bare ground of any size that were previously forested but, due to natural disturbances (eg, erosion, storms, fire), have temporarily lost vegetation cover
- areas that were planted forest at 1990 but are subsequently managed to regenerate with natural species that will meet the forest definition
- roads and tracks less than 30 metres in width and other temporarily unstocked areas associated with a forest land use.

Cultivated forests, defined to include:

- radiata pine (*Pinus radiata*), douglas fir *(Pseudotsuga menziesii*), eucalypts (Eucalyptus spp.) or other planted species (with potential to reach ≥5 metre height at maturity in situ)
- exotic forest species that were planted on land that was natural forest
- riparian or erosion control plantings that meet the forest definition
- harvested areas which are assumed to be replanted
- roads, tracks, skid sites, and other temporarily unstocked areas less than 30 metres in width associated with a forest land use
- areas of bare ground of any size that were previously forested but, but have lost vegetation cover, due to natural disturbances (eg, erosion, storms, fire).

Data from LUCAS is used to derive:

- area of natural forests (including afforestation and deforestation) for each year
- standing volume of natural forests year, including the closing stock, additions from natural growth and losses to deforestation
- carbon stock and net change in carbon each year for cultivated and natural forests.

Roundwood removal data

The roundwood removal data is used as an estimate of the harvesting volume of timber from natural indigenous forests. This data is gathered by MPI, survey wood processors across New Zealand on an annual and quarterly basis. Each survey represents about 180 timber, panel, and pulp mills throughout New Zealand. As this only refers natural indigenous timber, harvesting of natural exotic forests are not included.

Roundwood removal data is converted to calendar years.

The incorporation of roundwood removal data as an estimate of harvesting volume from exotic cultivated forests is being considered as a potential future development of the account.

Forestry company annual reports

Many forestry company annual reports are available publicly through the New Zealand Companies Register. Using these reports, we collected data on the total hectares of forestry planted, and their estimates of the net present value of their timber stocks.

Annual enterprise survey

AES is an annual survey with a population of all active businesses, which collects information on a firm's financial performance and financial position. The survey sent to firms in the forestry industry also collects data on hectares of planted forest owned/leased and closing book values of growing tree stocks.

Physical asset account for forested land

The physical *asset account for forested land* records the area and changes in area of natural and cultivated forests in New Zealand. It records the opening and closing stock for each year, along with any additions as a result of new planting, or reductions due to deforestation and natural losses (ie, forest fires). For cultivated forests, the area of harvesting and restocking for a given period is also reported.

The asset account for forests is designed to complement the asset accounts for timber resources, so that any changes in area (due to afforestation or deforestation) should be reflected in the changes in the physical, monetary or carbon stocks.

The physical asset account for forested land differs from the physical asset account for timber resources differ, in that the latter does not include estimates for cultivated forests less than 40 hectares in area. This is due to differences in the NEFD survey. Forests smaller than 40 hectares are not included in the survey, and are thus excluded from the volume estimate, whereas imputations are made to estimate the area for forests smaller than 40 hectares.

Methods

The area of forest used for cultivated timber resources are taken from the NEFD. The area of natural forest is taken from the LUCAS land use map. More information on natural forest land can be found in the land use, land use change and forestry section of the New Zealand Greenhouse Gas Inventory report (Ministry for the Environment, 2019).

The balancing item enables the account to balance, so that the difference between the opening and closing stock equates up to the sum of the associated changes. It has been assumed that the opening and closing stock totals are correct, and the balancing item has been used to reconcile the differences. This item is needed for several reasons, including accounting for inconsistencies in the NEFD and LUCAS land use map, to account for natural losses which may occur from fire or extreme weather events, and to allow for expected margins of measurement error in the data.

Asset account for timber resources

The timber physical asset account estimates the annual stock of timber in New Zealand in cubic meters. It reports the opening and closing stock for each year, along with contributing factors to additions and reductions to the stock within this period.

Understanding changes in timber resources over time can be useful to indicate the sustainability of land and resource management and inform on issues of policy interest such as carbon sequestration.

The asset account for timber resources follows the structure recommended in the SEEA central framework, section 5.8. The account provides information opening stocks, additions to stock, reductions to stock, and closing stock. Cells that currently contain no information indicate areas that are too difficult to measure, are not significant enough to identify separately, or do not apply.

The balancing item enables the account to balance, so that the difference between the opening and closing stock equates up to the sum of the associated changes. It has been assumed that the opening and closing stock totals are correct, and the balancing item has been used to reconcile the differences. This item is needed for several reasons, including accounting for inconsistencies in the NEFD and LUCAS datasets, to allow for natural losses which may occur from fire or extreme weather events to be accounted for, and to allow for expected margins of measurement error in the data.

A key purpose of the accounts is to identify timber available for wood supply. All cultivated forests are assumed to be available for wood supply. There is currently no estimate for the availability of wood supply in natural forests. Timber may be available for wood supply in areas of natural forest which are comprised of naturally occurring exotic species, or indigenous forests for which harvesting permits have been granted. Incorporating these estimates of timber available for wood in natural forests is an area of future development in the account.

Methods

Cultivated timber resources

The volume of cultivated timber resources available for wood supply are taken from the NEFD. This includes estimates the closing stock, additions from natural growth, and removals from harvesting and thinning operations.

Approximately 15 percent of the timber volume removed from harvesting and thinning operations is considered to be non-recoverable (Visser, 2018). The remaining 85 percent is considered to be recoverable timber volume and is provided in the data from NEFD. To determine 15 percent of the total volume, the recoverable volume is multiplied by 0.1765 (15% / 85%). This percent is applied to the recoverable harvesting and thinning volume estimates provided by NEFD. (non-recoverable volume = recoverable volume x 0.1765).

It is assumed that all exotic timber recorded in the NEFD are available for wood supply. It is possible that some planted forests purpose may be to serve other functions such as erosion control or as riparian margins, and thus not considered to be available for wood supply. However, these forests likely make up a make-up small proportion of the total forest area and are not considered significant enough to be estimated separately.

Forests smaller than 40 hectares in size are not included in the estimates of timber volume in the NEFD. Future development work is being considered as to how to best incorporate estimates of these smaller forests into the timber stock accounts.

Natural timber resources

The volume of natural timber resources was derived from LUCAS data for natural forests. This includes estimates of the closing stock, additions from natural growth and removals from deforestation.

The volume of timber in natural forests was derived from the carbon pool of above ground biomass (ABG; t C). Above ground biomass (t C) was converted to volume using data from an analysis of the natural forest plot data set (Beets et al, 2009). A linear model was used to predict the relationship between tonnes of carbon in above ground biomass (ABG) and stem volume (m^3). The coefficient from the model was then applied to the closing stock, additions, and removals of the LUCAS ABG carbon pool.

Removal of volumes from harvesting were taken from the roundwood removals data for indigenous forests. Thus, any estimates of the harvesting of natural exotic forests are not included in this account.

The non-recoverable volume from the harvesting of indigenous timber is currently unknown, and thus not calculated.

Carbon account for timber resources (experimental)

The carbon account for timber resources estimates the stock and net change in stock of carbon in New Zealand forests. It includes breakdowns of carbon in soil and biomass for both natural and cultivated forests.

The account currently reports the net change in carbon stocks for each year, that is the net change in carbon after any additions and removals have been applied. Future developments of the account will look to include breakdowns of both additions and reduction of carbon stock, and of the separate the biomass carbon pools (above ground, below ground, dead wood and litter).

Methods

Data on forest carbon is the from the LUCAS; it is consistent with the input data used to determine emissions from the Land Use, Land Use Change and Forestry (LULUCF) sector in the New Zealand Greenhouse Gas Inventory (Ministry for the Environment, 2019).

Monetary asset account for timber resources

The monetary asset account for timber resources provides information on the monetary stock of commercial forestry resources in New Zealand.

Under the SEEA, only timber resources available for wood supply are in scope of the timber monetary stock account as they are commercially viable (in contrast, timber resources unavailable for supply are out of scope as they are not commercially viable).

The timber monetary asset for account currently only values cultivated timber from plantations of exotic tree species (using data from the NEFD). The inclusion of valuations for indigenous cultivated forests or natural forests which are available for wood supply is an area for future development.

Methods

The monetary asset account for timber resources estimates are calculated by multiplying the volume of cultivated timber (exotic) in cubic metres by the price of timber per cubic metre, for a given period.

The volume of timber stocks is taken from the NEFD. Prices are estimated using a variety of sources, including a sample of forestry companies' annual reports and AES data. Sample data collected include hectares of planted forest owned by each company and an estimate of their net present value. The hectares planted data are totalled and then converted into cubic metres of timber stock using NEFD data on total hectares and total cubic metres planted. This allows for calculation of the price per cubic metre of timber stock by dividing the total of the sample of prices by the total sample of timber stock.

This methodology therefore relies on the net present value estimates reported by the forestry companies in their reports and completed surveys. Different forest owners may have quite different valuation approaches. Some companies may estimate future timber prices in their valuation estimates, while others extend current timber values out to the future.

Timber data from the NEFD is reports in March years.

Data quality

Stats NZ has taken all possible reasonable steps to ensure the quality of the data in the timber accounts. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The timber physical stock accounts provide a complete picture of key drivers of change over time. This enables analysis of the relationship between these drivers and key variables of interest, such as gross domestic product and carbon sequestration.

Accuracy

In the timber physical stock account, cultivated timber statistics are sourced primarily from the NEFD. The NEFD survey was originally designed to assist in forecasting exotic forestry production. The harvesting cycle of pine forests in New Zealand is fairly consistent, with most pine trees ready for harvesting after 25–30 years.

Discrepancies between the differences in opening and closing stocks and stock change variables (change over the period is the sum of new planting plus restocking less the area clear felled) can arise. This can occur mainly because of new planting carried out by small landowners and private investors. While the larger forestry companies usually provide accurate stocking statistics, smaller private landowners tend to be more variable in their reporting accuracy. Independent information is difficult to obtain, even from satellite imagery, as plantations younger than about five years of age cannot be detected with any degree of accuracy. It should be noted that MPI is aware of this issue and adjusts the NEFD figure for reported new planting accordingly.

In addition, discrepancies in the hectare data can occur when forestry companies revise their estimates of forest area without revising their stock change information, therefore causing inconsistencies in the survey data. Finally, the only stock change data collected in the NEFD are for new planting, restocking, and area felled. Data on other types of stock change, such as losses due to fire and wind throw, are not collected, but are picked up in the stock-level data. The forest company would presumably report a smaller-sized forest after a large fire, but not in stock change data. MPI is aware of these issues but many of them cannot be dealt with simply by changing the survey. MPI is investigating ways of using other data sources, such as spatial information, to improve the accuracy of the survey.

For the purposes of the forestry account it is necessary to find a method to deal with these inconsistencies. Future options include adjusting the stock level or adjusting the stock change variables. However, due to the fact that it is not always clear which combination of adjustments would be correct, the discrepancies have at this stage been recorded in the tables as a balancing item. When new stock change variables are introduced from sources other than the NEFD, such as fires, the balancing item is adjusted again. In other words, the balancing item records all the discrepancies between the stock change and stock-level data.

Cultivated timber stock totals are estimated using NEFD data alone, while natural timber stock totals are estimated using data from the LUCAS. It is of note that the LUCAS land use map provides a different total area of cultivated forest land compared to the NEFD. The NEFD reports to a net stocked area a standard – this includes net stocked area of trees. The LUCAS land use classification reports a gross stocked area standard – which includes forest tracks, skid sites and unstocked areas. Work to make these two sources more aligned is an area for future development.

Timber monetary stocks use prices collected from AES and forestry companies' annual reports. It should be noted that because the estimates use prices from a sample of companies these estimates will be affected by sample error of unknown size. These accounts and the methodology underlying them are an area for future development.

Timeliness

The asset account for forests and the asset accounts for timber resources data are available to 2017.

Coherence/consistency

The methodology and table format used in the timber physical stock accounts is consistent with guidance in SEEA. Time-series consistency has been ensured. Data are available from 1995.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data are available in CSV format with the report.

Interpretability

The report contains the appropriate information to interpret these estimates. See the SEEA manuals on the United Nations' methodology page for additional information on SEEA's classification and underlying concepts.

Greenhouse gas emissions

Stats NZ produces estimates of greenhouse gases on a production basis, at both the national and regional levels, and on a consumption basis (national level only). These are all compiled using the residency principle, which allocates emissions to New Zealand residents regardless of where the emission occurs.

The SEEA central framework calls this an air emissions account because all air pollutants are in scope. However, we have only measured greenhouse gases on an SEEA basis, so we refer to this account in publications as 'greenhouse gases by industry and household'.

Greenhouse gas emissions by industry and household

The greenhouse gas emissions by industry and household (production) account converts sector-based emissions, as defined in the Greenhouse Gas Inventory, to emissions by industry as defined by the Australian and New Zealand Standard Industrial Classification 2006. It records emissions produced by New Zealand's industry and household sectors regardless of where they occur. It uses the same industrial classification used for other economic statistics, so that changes in greenhouse gases can be compared with other economic data. This enables us to assess:

- whether emissions have decoupled from economic growth
- whether structural change in the economy has affected our emissions profile
- where there are opportunities for targeted policies on emissions reduction while maintaining economic growth.

Data sources

The Ministry for the Environment publishes New Zealand's Greenhouse Gas Inventory (the inventory) in April each year. The inventory is the official report of all human-induced emissions and removals of greenhouse gases in New Zealand. It measures New Zealand's progress against obligations under the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

The inventory reports on New Zealand's emissions and removals of the following greenhouse gases:

- carbon dioxide
- methane
- nitrous oxide
- hydrofluorocarbons
- perfluorocarbons
- sulphur hexafluoride.

The indirect greenhouse gases, carbon monoxide, sulphur dioxide, oxides of nitrogen, and non-methane volatile organic compounds are also included.

The gases are reported under five sectors:

- energy
- industrial processes and product use (IPPU)
- agriculture

- land use, land-use change, and forestry (LULUCF)
- waste.

These sectors represent the source of emissions from a process perspective. The emissions included in the inventory are those over New Zealand's territory. Gross emissions are those from anthropogenic sources (ie, energy, IPPU, agriculture, and waste) and net emissions are anthropogenic emissions less the LULUCF sector.

The inventory presents emissions data in a common reporting format (CRF), that is, a series of standardised data tables containing mainly quantitative information, which contains a set of standard emissions classes (common reporting format classes).

The inventory compiles data from the Ministry of Business, Innovation, and Employment (MBIE), Ministry for Primary Industries (MPI), Environmental Protection Agency (EPA), Stats NZ, and businesses. It contains extensive detail on the data sources for the activity data and emissions factors used and the quality of these revisions and improvements.

Stats NZ uses the Inventory and additional data sources to allocate emissions to industry. MBIE provides disaggregated data for fuel combustion categories aggregated across industries in the inventory. MPI provides emissions factors and benchmarks that we allocate to agricultural sub-industries using data from the agricultural production survey. The Ministry for the Environment also provides data to split waste sector emissions across relevant industries and households. Data from Stats NZ's national accounts and other economic data are also used to allocate emissions to industry. National accounts data and company data are also used for adjusting for economic residence.

Coverage

Sectors

The greenhouse gas emissions by industry and household account records the gross emissions of greenhouse gases for the energy, IPPU, agriculture, and waste sectors, but excludes LULUCF. The exclusion of LULUCF follows Eurostat (2015) guidance. LULUCF may be included in future releases pending further international developments.

The greenhouse gas by industry and household account aggregates emissions based on the source of economic production rather than type of process. This has two implications.

1. Similar terms in the inventory and the greenhouse gas emissions by industry and household account may refer to different emissions. For example, agriculture in the inventory refers to all livestock, manure management, cropping, and fertiliser emissions. In the greenhouse gas emissions by industry and household account agriculture refers to emissions by firms allocated to the agriculture industry.
2. Only emissions relating to New Zealand's economic production are included. Emissions by economic residents abroad are to be included, while emissions from non-residents over New Zealand's territory are to be excluded. This is to enable comparisons with other economic statistics, such as GDP.

Greenhouse gases

The greenhouse gas emissions by industry and household account currently includes estimates for carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride, and carbon dioxide equivalent emissions. We have not yet included indirect gases.

Carbon dioxide emissions from biomass are currently excluded. In the SEEA framework, these emissions are recommended to be recorded separately.

Residuals included in the SEEA central framework include all atmospheric emissions and air pollutants (ie, non-greenhouse gases) such as particulate matter, carbon monoxide, and sulphur dioxide. We will investigate the potential for including further emissions and pollutants over time.

Industry coverage

Estimates are available for 114 industries. This level of detail is broadly consistent with level 4 of the New Zealand Standard Industry Output Categories (NZSIOC). Industries are aggregated for reporting purposes, as shown in table 11, but additional industry detail is available in the corresponding CSV file. Household emissions are disaggregated by source.

Table 11

Industries included in the greenhouse gas emissions by industry and household account
Total industry
Primary industries
Agriculture, forestry, and fishing
Agriculture
Horticulture and fruit growing
Sheep, beef cattle, and grain farming
Dairy cattle farming
Poultry, deer, and other livestock farming
Forestry and logging
Fishing, aquaculture and agriculture, forestry and fishing support services
Mining
Goods-producing industries
Manufacturing
Food, beverage, and tobacco product manufacturing
Textile, leather, clothing. and footwear manufacturing
Wood and paper products manufacturing and printing
Petroleum, chemical, polymer, and rubber product manufacturing
Non-metallic mineral product manufacturing
Metal product manufacturing
Transport equipment, machinery, and equipment manufacturing
Furniture and other manufacturing
Electricity, gas, water, and waste services
Electricity and gas supply
Water, sewerage, drainage, and waste services
Construction
Service industries

Industries included in the greenhouse gas emissions by industry and household account
Wholesale trade
Retail trade
Accommodation and food services
Transport, postal, and warehousing
Road transport
Rail, water, air, and other transport
Postal, courier transport support, and warehousing services
Telecommunications, financial, professional, rental, and administrative services
Government and defence
Education and training
Health care and social assistance
Arts, recreation, and other services
Households
Transport
Heating/cooling
Other

Time series

The greenhouse gas emissions by industry and household account is available from 2007 onwards. While the inventory is available from 1990, the data needed to allocate emissions to industry and to adjust for economic residence is only available from 2007. Chain volume value added (which is used to derive emissions intensity) is also available from this point.

The Greenhouse Gas Inventory is compiled on a calendar-year basis. Other statistics used in the greenhouse gas emissions by industry and household account that are based on a March year are converted to a December year to align with the emissions data. The Greenhouse Gas Inventory is published approximately 15 months after the latest reference period.

Concepts and principles

The greenhouse gas emissions by industry and household account is compiled using the definitions, concepts, and standards presented in the SEEA framework.

To be able to integrate greenhouse gas emissions with economic data, such as GDP, the same principles of SNA need to be applied to the emissions data. These include:

- **production boundary** – includes only emissions relating to New Zealand's economic residents, for example, tourists' emissions are excluded; this differs from the 'territorial' approach used in the inventory
- **consistent industrial classification** – uses a classification system that aligns with economic data
- **timing of recording** – aligns other input and comparison data to calendar years for consistency.

Estimates of greenhouse gases compiled under the SEEA framework differ from those in the inventory due to the production boundary principle. The bridging table, presented along with the emissions data, shows how the inventory and greenhouse gas emissions by industry and household account compare. Table 12 provides further detail on the bridging table as defined in Eurostat (Euorostat, 2015) and its application to New Zealand.

Table 12

Sources of differences between the SEEA and inventory approaches to measuring greenhouse gases.	
Bridging item	**Significance for NZ and methods**
Greenhouse gas emissions by industry and household accounts total	
Less national residents abroad	Adjustments made relating to transport. No adjustments are made for fuel purchased overseas by fishing vessels to return to New Zealand, as this is considered to be small.
Plus non-residents on the territory	Adjustments for international tourists use of road transport vehicles are made. Fuel expenditure data from the Tourism Satellite Account is used to allocate emissions to tourists. Some foreign units operate on the domestic territory but information on the extent to which activity involves combustion of fuels is not available.
Plus/minus other adjustments and statistical discrepancy	Minor, only includes emissions from Tokelau.
Equals total emissions as reported to UNFCCC (excluding LULUCF)	

The greenhouse gas emissions by industry and household account and greenhouse gas inventory are compiled using standard international frameworks. Using either data source depends on why the information is required. The greenhouse gas inventory, New Zealand's official measure of greenhouse gases, provides the source information for understanding New Zealand's position under the Kyoto Protocol and for achieving the targets in the Paris Agreement. The greenhouse gas emissions by industry and household account is the source information for understanding the economic context of greenhouse gas emissions and for showing how they are changing in relation to economic activity.

Allocating emissions to industry

Industries are defined according to the Australian and New Zealand Standard Industrial Classification (ANZSIC) 2006 and compiled at the NZSIOC level. Emissions are allocated to industry in two ways:

- one-to-one matches when the common-reporting-format class aligns solely to an industry
- one-to-many matches when the common-reporting-format class is attributable to multiple industries and additional data or methods are used to split across industries.

Most common-reporting-format classes can be allocated directly to an industry (ie, a one-to-one match) at a high level. To allocate a common reporting-format class to an industry, an assessment is made on which producers (firms) are engaged in the process-based emissions and where those firms were allocated to in the industry classification system. Additional information is used if common-reporting format classes need to be allocated to a finer industry level.

Agriculture

The agriculture sector, as defined in the inventory, includes biological emissions from livestock, manure management, cropping, fertiliser, and other agricultural land management practices. Emissions are based on the source process, regardless of the industry the livestock, and other activities, are allocated to.

In the greenhouse gas emissions by industry and household account, agriculture refers to emissions by firms whose primary activities relate to agriculture and are allocated to the agriculture industry. Using an industrial classification means allocating all emissions occurring in the production process to a firm and then allocating them to industry based on their primary activities (known as the principle of dominant economic activity). This means emissions from the agriculture industry include those from livestock and manure management, cropping, fertilisers, open burning, direct energy use (eg, stationary and mobile emissions for operating the farm, but excluding heat processing involved in milk production), and waste in farm fills.

This can lead to a difference in, for example, emissions from what is commonly referred to as the beef and lamb sector, covering emissions only from beef and lamb, as opposed to the sheep, beef cattle, and grain farming industry which may include emissions from sheep, beef, other livestock, or even dairy cattle.

Livestock and manure management, cropping, and fertiliser emissions are allocated to the following industries:

- horticulture and fruit growing
- sheep, beef cattle, and grain farming
- dairy cattle farming
- poultry, deer, and other livestock farming
- forestry.

Data from the agricultural production survey was used to allocate livestock and manure management, cropping, and fertiliser emissions to their dominant industry. Emissions factors were supplied by the Ministry for Primary Industries. Data from the Fertiliser Association of New Zealand was used as benchmarks for allocating fertiliser emissions.

Energy and waste sector emissions associated with agricultural practices are also allocated to the agriculture industry, leading to a further difference with the inventory's definition of agricultural emissions.

Energy

Energy sector emissions are allocated to industry based on one-to-one matches for most inventory classes at a high level, as shown in table 13, and allocated to lower level industries using additional data sources as required.

Table 13

Allocation of energy emissions to industry	
Fuel combustion – sectoral approach	
1.A.1 Energy industries	
1.A.1.a Public electricity and heat production	Electricity and gas supply
1.A.1.b Petroleum refining	Petroleum, chemical, polymer, and rubber product manufacturing
1.A.1.c Manufacture of solid fuels and other energy industries	Mining
1.A.2 Manufacturing industries and construction	
1.A.2.a Iron and steel	Metal product manufacturing
1.A.2.b Non-ferrous metals	Metal product manufacturing
1.A.2.c Chemicals	Petroleum, chemical, polymer, and rubber product manufacturing
1.A.2.d Pulp, paper, and print	Wood and paper products manufacturing and printing
1.A.2.e Food processing, beverages, and tobacco	Food, beverage, and tobacco product manufacturing
1.A.2.f Non-metallic minerals	Non-metallic mineral product manufacturing
1.A.2.g.i Manufacturing of machinery	Transport equipment, machinery and equipment manufacturing
1.A.2.g.viii Other (please specify)	Furniture and other manufacturing
1.A.2.g.vi Textile and leather	Textile, leather, clothing, and footwear manufacturing
1.A.3.a Domestic aviation	Rail, water, air, and other transport
1.A.3.c Railways	Rail, water, air, and other transport
1.A.3.d Domestic navigation	Rail, water, air, and other transport
1.A.3.e Other transportation	Rail, water, air, and other transport
1.A.4 Other sectors	
1.A.4.a Commercial/institutional	Services excluding transport, postal, and warehousing
1.A.4.b Residential	Households
1.B Fugitive emissions from fuels	
1.B.1 Solid fuels	Mining
1.B.2 Oil and natural gas and other emissions from energy production	
1.B.1 Solid fuels	Mining
1.B.2.a.1 Exploration	Mining
1.B.2.a.2 Production	Mining
1.B.2.a.4 Refining / storage	Petroleum, chemical, polymer, and rubber product manufacturing
1.B.2.b.1 Exploration	Mining

Allocation of energy emissions to industry	
Fuel combustion – sectoral approach	
1.A.1 Energy industries	
1.B.2.b.2 Production	Mining
1.B.2.b.3 Processing	Electricity and gas supply
1.B.2.b.4 Transmission and storage	Electricity and gas supply
1.B.2.b.5 Distribution	Electricity and gas supply
1.B.2.c Venting and flaring	Mining
1.B.2.d Other (please specify)	Electricity and gas supply

MBIE provides additional industry-level data to allocate emissions to industry for the following common reporting format CRF codes:

- 1.A.4.c agriculture/forestry/fishing
- 1.A.2.g.v mining and construction.

Road transport

The most challenging allocation of emissions to industry from the inventory is for road transport. Eurostat (2018) provides guidance on measuring road transport emissions by industry. This manual combines the elements of methods for allocating road transport emissions into three categories:

- A: very good, best practice suitable as model for others
- B: sufficient, acceptable
- C: insufficient, not acceptable.

The approach developed by Stats NZ meets most of the elements in category B. Recommendations on measuring road transport by industry have been incorporated to the extent to which available data allows.

Road transport emissions are split by main vehicle type in the inventory without reference to an industry or sector. Emissions data are available for the following vehicle types:

- cars
- light duty trucks
- heavy duty trucks and buses
- motorcycles.

A modelling approach was used to allocate to industry, using information from Stats NZ's national accounts supply-and-use tables and tourism satellite account. The combined datasets allow for a time series of proportions of fuel use, at the required level of industry disaggregation, to be compiled and applied to the greenhouse gas inventory data. Industry proportions of fuel use are applied to the inventory road transport data to ensure consistency with the inventory, with adjustments made depending on whether the industry utilises multiple types of capital that may use that fuel type. Liquified petroleum gases, other liquid fuels, and other fossil fuels are aggregated into other fuels as national accounts data is not available at this level. This approach is used for cars, light duty trucks, and heavy trucks and buses.

Motorcycles are completely allocated to households. This is considered acceptable as motorcycles account for less than 1 percent of road transport emissions.

Industrial processes and product use

The industrial processes and product use classes from the inventory are allocated to industry as shown in table 14. Following Eurostat (2017), the allocation of emissions for product use distinguishes between emissions from manufacturing, stocks, and disposal. Emissions from manufacturing were made following an assessment of which manufacturing industry was most likely to be undertaking the activity of manufacturing the technology. Stocks were allocated by identifying ‘candidate industries’ (ie, those most likely to be using the technology) and then apportioned based on a relevant economic variable as is done in a number of countries. All emissions from disposal are allocated to the waste services industry.

Table 14

Industrial process and product use by industry		
Greenhouse gas inventory		**Industry**
2.A	Mineral industry	Non-metallic mineral product manufacturing
2.B	Chemical industry	Petroleum, chemical, polymer, and rubber product manufacturing
2.C	Metal industry	Metal product manufacturing
2.D.1	Lubricant use	All industries and households based on proportion of road transport emissions
2.D.2	Paraffin wax use	Households
2.D.3	Urea catalyst in road transport	Road transport
2.F.1.a	Commercial refrigeration	Retail trade, wholesale trade, and accommodation industries
2.F.1.b	Domestic refrigeration	Households
2.F.1.c	Industrial refrigeration	Food, beverage, and tobacco product manufacturing industries
2.F.1.d	Transport refrigeration	Retail trade, wholesale trade, accommodation, and transport industries
2.F.1.e	Mobile air-conditioning	All industries and households based on proportion of road transport emissions
2.F.1.f	Stationary air - conditioning	Relevant service industries
2.F.2	Closed cells	All industries and households
2.F.3	Fire protection	Government and defence
2.F.4.a	Metered dose inhalers	Households
2.G.1	Electrical equipment	Electricity and gas supply
2.G.2.e	Medical and other product use	Health care and social assistance
2.G.3.a	Medical applications	Health care and social assistance

Waste

Allocation of waste sector emissions involves both one-to-one matches and apportionment of common-reporting format classes across industries.

The following inventory classes are allocated directly to the water, sewerage, drainage, and waste services industry:

- managed waste disposal sites
- uncategorised waste disposal sites
- non-municipal solid waste
- composting.

Emissions from industrial wastewater, unmanaged waste disposal sites, and domestic wastewater are allocated to industry based on data provided by the Ministry for the Environment for the specific purpose of compiling the greenhouse gas emissions by industry and household account.

Industrial wastewater

Emissions for industrial wastewater are split between food, beverage, and tobacco product manufacturing; textile, leather, clothing, and footwear manufacturing; and wood and paper products manufacturing. Only data for methane and nitrous oxide are available.

Unmanaged waste disposal sites

Emissions from farm fills are allocated across the four agriculture sub-industries. Emissions from non-municipal solid waste are allocated to the waste industry.

Domestic wastewater

Domestic wastewater emissions are split between households and electricity, gas, water, and waste services. The household component consists of the approximate 10 percent of the population connected to septic tanks.

Open burning

Emissions from open burning are allocated across the four agriculture sub-industries in proportion to emissions from farm fills.

Table 15 summarises the allocation of inventory waste categories to industry.

Table 15

Allocation of inventory waste categories to industry	
Greenhouse gas inventory	**Industry**
Managed waste disposal sites	Water, sewerage, drainage, and waste services
Uncategorised waste disposal sites	
Non-municipal solid waste	
Composting	
Industrial wastewater	Food, beverage, and tobacco product manufacturing
	Textile, leather, clothing, and footwear manufacturing
	Wood and paper products manufacturing
Farm fills and open burning	Horticulture and fruit growing
	Sheep, beef cattle, and grain farming
	Dairy cattle farming
	Poultry, deer, and other livestock farming
Domestic wastewater	Electricity, gas, water, and waste services
	Households
Incineration	Health care and social assistance

Summary of allocations

Table 16 summarises the main sources of emissions by industry. Sources of emissions listed below are not exhaustive.

Table 16

Sources of emissions by industry	
Industry	**Emissions sources(1)**
Agriculture	Energy, agricultural processes, waste (including farm fills and open burning)
Forestry	Energy, livestock
Fishing	Energy
Mining	Energy (manufacture of solid fuels and other energy industries, mining (excluding fuels) and quarrying), fugitive emissions from solid fuels, natural gas venting and flaring, exploration and production of oil and natural gas
Food, beverage, and tobacco product manufacturing	Energy, waste, industrial refrigeration
Textile, leather, clothing, and footwear manufacturing	Energy, waste
Wood and paper products manufacturing and printing	Energy, waste

Sources of emissions by industry	
Industry	**Emissions sources(1)**
Petroleum, chemical, polymer, and rubber product manufacturing	Petroleum refining energy, chemical manufacturing, oil refining and storage, chemical industry industrial processes
Non-metallic mineral product manufacturing	Non-metallic minerals energy, mineral industry industrial processes (including cement, lime, and glass production)
Metal product manufacturing	Iron and steel and non-ferrous energy, metal industry industrial processes (including iron and steel, aluminium, lead, and zinc production)
Transport equipment, machinery and equipment manufacturing	Manufacturing of machinery and transport equipment energy
Furniture and other manufacturing	Energy
Electricity, gas, water, and waste services	Public electricity and heat production, transmission and storage and distribution of natural gas, geothermal, electrical equipment, managed waste disposal sites, uncategorised waste disposal sites, disposal of industrial products
Construction	Energy
Services excluding transport, postal, and warehousing	Commercial/institutional stationary energy emissions, commercial refrigeration, medical and other product use, medical applications
Transport, postal, and warehousing	Domestic aviation, railways, domestic navigation, pipeline transportation, residence adjustments
Households	Residential energy, domestic refrigeration, domestic wastewater
Note: Road transport is allocated across all industries and households.	

Tourism-related emissions

Emissions from tourism are not readily identifiable in the inventory or greenhouse gases by industry and households account. As the inventory covers all sources of emissions on the domestic territory, regardless of the resident of the emitter, emissions from tourism within New Zealand count towards its emissions reported to the UNFCCC. In addition, as tourism is a cross-cutting industry its contribution to emissions is not readily identifiable in Stats NZ's greenhouse gas emissions by industry and household series.

Emissions attributable to tourism are derived by linking the SEEA industry estimates to the tourism satellite account data using a common industry classification and an appropriate apportioning variable. These estimates include emissions on the domestic territory only from both domestic and international tourism. Methodological guidance on estimating tourism emissions is based on United Nations World Tourism Organisation (2019).

Apportioning industry emissions between tourism and non-tourism activity is based on the share of economic output. Output shares reflect the direct tourism sales as a proportion of total output (eg, share of sales) and are compiled on an industry basis. Using output ratios assumes that the generation of emissions by a producing unit does not depend on the origin of the consumer of the good or service. The use of output ratios also reflects that emissions arise due to the combination of capital, labour, and intermediate inputs, that is, that there may be multiple emissions processes for an industry. The output ratios do not distinguish between domestic and international tourists.

Tourism output is the value of goods and services purchased by tourists, excluding imports sold directly to tourists, and comprises:

- tourism intermediate consumption – the goods and services used in the process of production of products sold to tourists
- tourism value added – the 'value' a producer adds to the raw material goods and services and/or transformed goods it purchases in the process of production.

The output share approach allocates emissions where a financial transaction occurs between the tourism operator and the tourist. For waste, an alternative approach is used to reflect the contribution of tourist activity. Emissions from landfill attributable to tourism are estimated using the average number of tourists in New Zealand per day and assumptions around waste generated per visitor. Emissions from domestic wastewater attributable to tourism are based on the average number of tourists in New Zealand per day.

The approach used to estimate tourism emissions is top-down. In theory, data on environmental flows related to visitors may be collected directly in cases where tourism and non-tourism businesses can provide information on the different environmental flows as they relate to visitors and non-visitors. While some detailed information may be available in some cases, such data are unlikely to be available on a regular basis for official statistics.

Tourism scope

Tourism represents an individual purchasing goods and services outside their usual environmental, resulting in a positive economic impact for that destination. This benefit would not have occurred without tourism. This is the basis of tourism expenditure and is the reason a Tourism Satellite Account (TSA) excludes expenditure by outbound New Zealand travellers on foreign-produced goods and services. In other words, the economic benefits that accrue from these travellers do not benefit New Zealand.

However, expenditure by outbound tourists on services produced by domestic units (for example, international flights on New Zealand carriers, New Zealand travel agents' booking fees, or travel insurance for outbound trips) is included within the TSA because it is a form of tourism and provides economic benefit to the New Zealand economy.

In New Zealand, for a tourist to be outside their usual environment they must, subject to previously stated exclusions, satisfy at least one of the following conditions:

- travel by a scheduled flight or inter-island ferry service
- travel more than 40 kilometres from their residence (one way) and outside the area they commute to for work or visit daily
- travel as an international tourist.

Industry coverage

Tourism-related emissions are compiled at the NZSIOC level and aggregated to the same level as the TSA for publication. These industries can be classified as either tourism-characteristic industries, or tourism-related industries.

A **tourism-characteristic** industry is one where either:

- at least 25 percent of the industry's output is purchased by tourists, or
- the industry's output includes a tourism-characteristic product. For example, less than 25 percent of the water transport industry's output is consumed by tourists, but its characteristic outputs are water freight transport and water passenger transport. Water passenger transport is a tourism-characteristic product, so the water transport industry is classified as a tourism-characteristic industry, and a direct physical contact occurs between the industry and the tourist buying its products.

Tourism-characteristic industries are therefore:

- accommodation
- air and space transport
- arts and recreation services
- food and beverage services
- rental and hiring services
- road, rail, and water transport
- other transport, transport support, and travel and tour services.

A **tourism-related** industry is one where:

- the industry is not a tourism-characteristic industry
- between 5 and 25 percent of the industry's output is purchased by tourists
- a direct physical contact occurs between the industry and the tourist buying its products.

Education and training and retail trade are therefore tourism-related industries.

A non-tourism-specific industry is any industry that is not a tourism-characteristic industry or a tourism-related industry. However, a non-tourism-specific industry may still sell some of its products to tourists. Examples include manufacturing and wholesale trade.

In addition to emissions attributable to tourism from direct industry production, emissions are directly produced from domestic tourists from road transport. These direct emissions by domestic tourists are also in scope and are added to the tourism industry emissions. Direct emissions by international tourists are only included in the territory-based estimate and recorded in the bridging table.

Interpretation

The methodology used to estimate tourism-related emissions is designed to link emissions to the production boundary of the TSA. This means the tourism emissions estimates relate to all tourism on the domestic territory (domestic and international visitors) from New Zealand-resident producers and emissions from resident operators engaged in transporting passengers to or from New Zealand.

As this scope excludes non-resident units operating on the territory, bridging tables are provided to show the link between emissions attributable to tourism on residency and territory bases. Emissions attributable to tourism occurring on the territory can be derived as the SEEA estimates less emissions attributable to tourism by resident operators overseas, plus emissions attributable to tourism by non-resident operators. The estimate can be compared to economic data from the TSA while the territory estimate can be compared to total emissions from the inventory.

Emissions from New Zealanders' tourism activities overseas is not included in the tourism-related emissions estimates. Emissions from New Zealand tourists overseas may be of interest but cannot be estimated and integrated with the TSA given the scope and boundary of the TSA.

Cruise ships are also excluded on the basis that they are operated by non-residents.

Regional emissions

Greenhouse gas emissions by industry and households are available for the following regions:

- Auckland
- Bay of Plenty
- Canterbury
- Gisborne
- Hawke's Bay
- Manawatū-Whanganui
- Marlborough
- Northland
- Otago
- Southland
- Taranaki
- Tasman/Nelson
- Waikato
- Wellington
- West Coast.

Emissions from the Chatham Islands are included within the Canterbury region. This approach is in line with regional GDP statistics.

Industry coverage

Estimates are published for the following aggregated industries by region:

- primary industries
  - agriculture
  - forestry, fishing, and mining
- goods-producing industries
  - manufacturing
  - electricity, gas, water and waste services
  - construction
- service industries
  - transport, postal, and warehousing

- services excluding transport, postal, and warehousing[1]

Direct household emissions are available by region. These estimates include emissions from road transport, heating and cooling, and other direct sources.

Estimates are compiled at NZSIOC level 4 but are released at this level for consistency with regional GDP and for confidentiality purposes.

Exclusions

Emissions from non-residents operating on the domestic territory (eg, tourists use of private vehicles) are excluded, consistent with the SEEA approach to measuring emissions on an economic residence basis. Emissions from resident units operating overseas (eg, international flights) have not yet been allocated to regions but are included in national SEEA estimates.

Methods

The general approach to measuring greenhouse gas emissions applies an emissions factor to activity data. The emissions factors and global warming potentials are consistent with the greenhouse gas (GHG) inventory and Stats NZ's greenhouse gases by industry and household series. Activity data that relates to the process, stock, or economic activity that the emissions result from is obtained from various datasets and used to distribute emissions across regions.

To estimate emissions by region, the principles, concepts, and definitions from the SEEA were applied to allocate industry emissions to regions. The allocation of emissions depends on the following central principles:

- As emissions are due to either an output from an industrial activity or direct emissions by households, the regional allocation mechanism is to reflect its source and economic unit.
- Unless it can otherwise be ascertained, the production technology for a given industry is the same across regions.
- To link to economic and population statistics, the residency principle is to be applied.
- To avoid double counting, only direct emissions in a defined regional boundary are to be measured.

Allocation principles

Residency

Regional GHG estimates were compiled to be consistent with the published national (SEEA) estimates, with the intention of enabling the sum of the regions to equal national-level estimates. The SEEA uses the residency principle in order to maintain consistency with the national accounts.

In national accounts, value-added (ie, GDP) is allocated to the region in which the firm or branch is resident, based on the physical and legal existence of a unit in that region. To maintain compatibility

[1] Includes: wholesale trade; retail trade; accommodation and food services; transport, postal, and warehousing; information media and telecommunications; financial and insurance services; rental, hiring, and real estate services; professional, scientific, and technical services; administrative and support services; public administration and safety; education and training; health care and social assistance; arts and recreation services; and other services.

with the SEEA and national accounts, this same principle was applied to estimating emissions on a regional level.

The residency principle is one of several system boundaries that can be applied to measuring emissions for a region. The residency principle allocates the activity to where the unit undertaking the activity is based, even though that activity may happen in a region other than where they are resident or even overseas, while the territory principle allocates to the territory where the activity takes place. Ultimately, the choice of principle depends on the purpose for which emissions are being measured and the framework that these estimates will be incorporated into.

As an illustration of the difference between the two principles, if a family who live in Wellington take a vacation by car to Hawke's Bay, the residency principle would allocate the fuel purchases (and emissions) associated with the trip to Wellington (whether the fuel was purchased in Wellington, Hawke's Bay, or elsewhere on route). In principle, the territory principle would allocate the emissions to the region where the fuel was burnt (eg, distance travelled within each region) which may or may not be where it was purchased. However, in practice (due to data availability), the emissions may be allocated based on fuel sales assuming the fuel was burnt where it was purchased.

The rationale for the residency principle is to maintain consistency with the national accounts. To determine whether a unit is resident, it is assessed as to whether it has a 'centre of economic interest' in New Zealand.[2] Movement of freight by road, for example, may entail activities and expenditures in regions other than where the freight company is usually resident.

Allocating to the operator

The SEEA approach allocates emissions to the operator, the unit that exerts control over the production process used to generate emissions. The notion of the operator is also significant for distinguishing emissions from production or embodied emissions in the consumption of goods and services. The operator should also be distinguished from the owner of the capital. If capital is leased, then emissions are allocated to the lessee who utilises the capital. For regional emissions, this has the implication of excluding international tourists who operate vehicles as they are non-resident.

Implementation

Issues in implementing the residency principle can arise where a unit undertakes some sustained activity in another region. In practice, it is generally accepted that units present in an area for less than 12 months are not resident. Notional units are sometimes established (in both the regional economic and emissions accounts) to reflect a unit's centre of interest in a region where otherwise it might not be considered resident, for example where no legal unit exists.

[2] The following is from the System of National Accounts 1993 (SNA 1993) with 'region' substituting for 'country':

"An institutional unit is said to have a centre of economic interest within a region when there exists some location – dwelling, place of production, or other premises – within the economic territory of the region on, or from, which it engages, and intends to continue to engage, in economic activities and transactions on a significant scale, either indefinitely or over a finite but long period of time. The location need not be fixed so long as it remains within the economic territory." (14.12)

Allocations based on residency and territory principles differ when:

- there are no actual producer units in the region in which the activity takes place
- an activity spans many regions.

Examples of the first situation include mobile labour (travelling salespersons), mobile capital (aeroplanes, rail), and capital assets located separately from their production units. For mobile capital, we define there being a notional unit in a region if it contains a point of origin or destination.

Examples of the second situation include infrastructure assets. These situations pose issues which are difficult to resolve whichever concept is adopted. As an example, large capital assets such as buildings or dams may not always be recorded in business registers. When a significant unit is identified in an area and data is available, a notional unit may be created for regional GDP or emissions compilation purposes. In this case the allocation will be the same under the residence and territory approaches.

In the case of energy, where emissions can be from stationary or mobile sources, emissions measured using the residency principle or geographic/territorial principle may differ substantially. This is observable in the national level production based SEEA estimates where total emissions are greater than those of the GHG inventory (which is based on the territory principle), because emissions by residents overseas are greater than non-residents on the territory. At a regional level, this situation may arise due to firms purchasing fuel in other regions, or fuel being purchased in a region by international tourists.

Emissions from agriculture, the industrial processes and product use (IPPU), and waste sectors are largely from stationary sources, given the fixed nature of capital used in their generation. Emissions from these sectors measured under either a residence or territory approach may be broadly similar (except if due to methodological differences or differences in source data).

Allocation methods

National industry emissions are allocated to region directly if emissions are known to only be produced in that region or allocated proportionally using the most relevant and available region by industry datasets. The overall approach prioritises direct allocations (ie, where the allocation to region can be made using a data source that is broadly consistent with the national level approach) with imputations made for remaining emissions to ensure full national coverage is obtained.

Note that the proportions that can be used to allocate to region do not need to be in physical quantities of the same unit used in calculating national level emissions. Rather, a proportion which reflects the relative share of emissions (ie, relative activity) is appropriate. Monetary data can also be used to form proportions and are equal to physical ratios where prices are similar across regions.

Data sources

Several sources of regional activity data are used to split emissions by industry and household to region, including regional GDP, agricultural production survey, electricity generation data, flight movements and other transport data, retail fuel sales, direct allocations from the Inventory, and population statistics.

Bottom-up data sources (those that contain unit record data, which includes regional GDP) are preferred because they reflect a specific activity driving the emissions in a region. Top-down data sources are either aggregated or proxy measures that entail assumptions in their application. Note that bottom-up sources are still reconciled with GHG inventory totals for consistency.

Industry emissions

Allocating emissions using economic activity data

Data on regional economic activity is used when there is an absence of data to make a direct allocation of emissions to regions. The ability to use these data sources is a benefit of the conceptual alignment between the SEEA framework and the national accounts. Underpinning this method is the assumption that firms within the same industry will have the same production function (ie, the same processes are used to convert inputs to outputs).

The allocation from industry to region is made for 114 industries. This level of granularity improves the accuracy of the regional emissions estimates by allowing the form of the production function to vary across detailed industries (the alternative is to assume aggregate production functions which do not account for specialisations within regions). Regional economic data for 16 regions is used in the compilation process, with Nelson and Tasman aggregated for publication.

This production function assumption does not hold when:

- the industries underlying the industry level of compilation differ in terms of their emissions profile (eg, sub-industries within electricity and gas supply include hydro, other renewables, and fossil fuel generation) and are not evenly distributed spatially
- output includes both domestic and international activities that are not distributed across regions, but emissions data only relates to domestic emissions (eg, international flights)
- a region possesses a different technology to other regions that affects emissions per unit of output (eg, electric buses in Wellington or differences across regions in the electrification of rail).

In these cases, alternative methods and sources are utilised.

When using economic activity data, we use gross output to allocate to regions. Value added reflects the industries' contribution to the economy. It is calculated as gross output less intermediate consumption (ie, consumables 'used up' in the production process). Gross output is preferable for allocating emissions to regions as:

- it gives an indication of the regions' level of production that is comparable across regions and more robust when there are changes of behaviour from output or input price changes (and as a result estimates are less volatile)
- it captures the use of capital, labour, energy, materials, and services in production, rather than just capital and labour which is important in the context of emissions measurement
- it reflects the whole of industry production approach that aligns to the approach of measuring emissions by industry, which collates emissions by inventory sector. This means imputations, using gross output, can be made for an industry whether its emissions come from the agriculture, energy, industrial processes and products use, or waste sectors
- value added can be negative while emissions are still occurring, while gross output is positive and better represents the extent to which production is occurring.

Gross output data are compiled as part of the annual regional GDP statistics. The national accounts (industry production and investment) series is produced from reconciled goods and service flows that are an outcome of the annual balancing process that ensures consistency between the production, expenditure, and income approaches to measuring GDP. These statistics form the basis of the industry dimension used in regional GDP. For most industries, regionalisation is implemented using geographical information from Stats NZ's Business Frame, the annual enterprise survey, and Linked Employer-Employee Data (LEED).

While the use of economic data for allocating emissions from economic sources aligns the emissions to the underlying units, this top-down nature of the approach entails an assumption of equal production functions for an industry across regions. This may not account for efficiency gains from an agglomeration of economies. Further consideration of this may be warranted in time, but no clear approach for accounting for this is currently known.

Regional GDP statistics are published annually in March with a one-year lag (eg, data published in March 2019 was to the year ended March 2018). Regional emissions are produced on a December-year basis. Additional work will explore the potential to disaggregate the level of industry detail further. However, this will be limited due to the use of confidential regional GDP data.

Allocation by industry

Agriculture

We use agriculture production survey/census data to apportion livestock and manure management, crops, fertiliser emissions, and emissions from farm fills and rural waste by industry. This approach is consistent with the activity data for agriculture industries at the national level and uses data consistent with the GHG inventory. Livestock and manure management emissions are split based on livestock numbers, crops by tonnes of crop produced, and fertiliser emissions by fertiliser use.

We calculated agriculture emissions at a national scale, then apportioned them to regions based on data from the agricultural production survey. Regional-level agriculture estimates do not account for differences between regions in other factors that also affect emissions, such as agricultural productivity (eg, production per animal or hectare), emission factors, or feed characteristics.

Emissions from farm fills and rural waste are split based on land area to reflect the relative intensity with which a region undertakes agricultural activities.

Energy emissions from agriculture industries are apportioned using gross output.

Forestry, fishing, and mining

Gross output is used to allocate emissions to the forestry, fishing, and mining industries.

Manufacturing

Manufacturing emissions are estimated using direct allocations from the GHG inventory, gross output, and supplementary information on the distribution and use of fuels by region.

Electricity, gas, water and waste services

We use electricity generation data from the Electricity Authority, which includes information on generation type and electricity output by plant, to regionalise emissions from public electricity and heat production. The electricity generation industry economic data includes the outputs from renewable energy, which (except for geothermal) are assumed to have zero emissions. Therefore, electricity generation data is more appropriate to estimate emissions at a regional level.

Emissions from landfill sites are based on a combination of economic activity and landfill data. Adjustments are made for recovery rates by region based on advice from the Ministry for the Environment (MfE).

Gross output and population statistics are also used to allocate waste industry emissions to regions.

Construction

Gross output is used to allocate emissions to the construction industry.

Service industries

Air transport

For domestic aviation, we use the number of flights by airport and aircraft type from Airways Corporation, emissions factors from MfE's voluntary guidance for greenhouse gas reporting by aircraft type, and the distances between airports. The estimates are benchmarked to the domestic aviation series from the GHG inventory.

Rail transport

Points of origin and destination are used to define centres of economic interest for rail freight which allows for notional units to be established and a regional allocation to be made.

Ministry of Transport produces rail freight information from origin to destination in tonne kilometres as part of the freight information gathering system. These are combined with emissions factors per tonne kilometre from MfE's voluntary guidance for GHG reporting. Rail transport estimates need further work but are a very small component of total emissions, so uncertainty present in these allocations is not expected to have a significant impact on results.

Water transport

Data from the Ministry of Transport on coastal shipping, emissions factors from MfE's voluntary reporting guidance, and regional GDP statistics were used to allocate to region. Water transport estimates need further work but are a very small component of total emissions, so uncertainty present in these allocations is not expected to have a significant impact on results.

Services excluding transport, postal, and warehousing

Gross output is used to allocate emissions to service industries (eg, retail trade, wholesale trade, government, health, education) excluding transport, postal, and warehousing.

Household emissions

Retail fuel sales, population statistics, and rural population estimates by region are used to allocate emissions by households. Direct emissions from households include those from road transport, heating and cooling, and other sources.

Road transport

Emissions by a households' use of vehicles is the most complex allocation in the regional estimates. Using population statistics to apportion emissions is the most straightforward option but would assume equal vehicle use and efficiency across the country. This assumption may not hold due to differences across regions in:

- the availability and accessibility of public transport, taxis and ride-sharing schemes, and other modes of travel (eg, pedestrian/cycle-friendly routes)
- the share of the population in rural or urban areas (ie, regions with more rural populations may be more reliant on private car use)
- differences in fuel prices which may influence model choice
- urban design, terrain, and transport infrastructure.

Many of these issues will be evident in differences in regions in fuel expenditure per capita. Retail fuel sales data, which is available by region, shows differences in fuel use by region but includes fuel purchases by industry, tourists, New Zealand residents from other regions (ie, domestic tourism and fuel hopping) as well as households within the region.

Retail fuel sales data (which consists of a price per unit of fuel and quantity of fuel sold) includes expenditures by households, businesses, and tourists. While tourism expenditures can be subtracted (using data from MBIE), the relative contributions from households and industry cannot. However, other variables were able to be constructed that could approximate fuel sales by households and industry. As these variables were in different units, however, a modelling approach was needed. A regression model was developed to determine the relative contributions of industry and households to fuel sales, after accounting for tourism, price differences across regions, and industry use. The predicted effect of population on fuel sales was used to form a ratio for allocating national level road transport emissions (for non-tourism purposes) to households by region.

Road transport emissions from household tourism

Household emissions from road transport due to tourism were apportioned based on relative income and population size. The approach taken reflected that increased emissions from road transport used for tourism depends not just on the population size of a region but the likelihood of the region to be engaging in tourism, which is a function of household income. Allocation of household emissions from road transport is based on population statistics and relative median income from Stats NZ's experimental income series.

Population connected to septic tanks

Regional proportions of populations in rural settlements were used to allocate these emissions to regions.

Heating and cooling and other emissions

Regional population proportions were used to allocate these emissions to region. Differences across regions may also depend on (deviations from) average temperatures and available heating sources (eg, wealthier regions may have more efficient heating and cooling technologies) and income levels (eg, energy poverty). It is not known what the relative significance of these other drivers is, how to account for them, or whether such an adjustment would have a quantitative impact.

Consumption-based emissions

The consumption approach associates a 'carbon footprint' to the consumption of final goods and services, such as household consumption, government expenditure, and investment in physical assets. This is done by measuring the emissions 'embodied' in a good or service throughout the entire supply chain required to produce that good or service for final use. This approach accounts for the role of trade through accounting for emissions embodied in imports and exports.

Table 17 illustrates the relationship between the inventory, greenhouse gas emissions by industry and household accounts, and consumption-based emissions. The consumption-based estimates use the SEEA greenhouse gas by industry and household accounts in order to be able to integrate with import, export, and input-output tables, which are on a residency basis and use economic classifications. This is important, as embodied emissions cannot be observed, and therefore require the use of macroeconomic statistical infrastructure (classifications and concepts) to model the reallocation of production-based emissions to final users.[3]

Table 17

Derivation of consumption emissions from territorial production emissions		
Item	**Classification**	**Allocation principle**
Net emissions	Process	Territory
Less LULUCF		
Equals production of emissions on the territory (GHG inventory – excluding LULUCF)	Process	Territory
Plus resident emissions overseas		
Less non-residents on the domestic territory		
Plus/minus other differences		
Equals production of emissions by residents	Economic (industry)	Residency
Less emissions embodied in exports		
Plus emissions embodied in imports		
Equals consumption of emissions by residents	Economic (final user)	Residency
Source: Stats NZ		

To reallocate these emissions to the final user, use is made of the conceptual framing of the national accounts, particularly input-output tables. Underpinning the input-output tables is the accounting identity of supply and use where sources of supply are:

- gross output by industry
- imports

and the uses of this supply are:

- intermediate consumption of goods used in production
- household consumption expenditure
- government final consumption expenditure
- non-profit institutions serving households consumption expenditure
- gross fixed capital formation
- exports.

All forms of use except intermediate consumption are considered final use categories[4].

The input-output tables are used to allocate the emissions from production and imports through supply chains, via use in the form of intermediate consumption, to final use categories.

[3] To this end, consumption-based emissions are considered an analytical extension of the SEEA framework, rather than part of the central framework.

[4] Intermediate consumption, as a use by businesses in their production process, is associated with output which subsequently is used in another production process within a supply chain or consumed by final users. In calculating consumption-based emissions this intermediate use is represented by the technical coefficients matrix (A).

Exports are consumed by foreign economic units and are excluded from the estimate of New Zealand's consumption-based emissions.[5]

As a result of the above, a simplified representation of consumption-based emissions is:

Consumption = Production + imports – exports

where consumption-based emissions can be broken down by:

- household consumption expenditure
- government final consumption expenditure
- non-profit institutions serving households consumption expenditure
- gross fixed capital formation.

Methodology

Estimating consumption-based emissions first involves differentiating between domestic production-based emissions (SEEA air emissions account), and emissions embodied in imports to distinguish between emissions associated with the two forms of supply. Domestic production-based emissions are purely direct emissions resulting from the production process as estimated for the SEEA industry and household emissions accounts, whereas the emissions associated with imports are those embodied in other countries' exports (a final use category in their accounts). This means that imports will include the indirect emissions embodied in the goods and services throughout the supply chain to produce those exports. As a result, different methodologies are required for the two sources of supply.

While the domestic production-based emissions estimates can be readily obtained from the Stats NZ SEEA based air emissions accounts (described above), there is no observable value of the emission embodied in imports, and therefore this needs to be modelled, usually involving some significant assumptions (which are discussed below). The current methodology estimates emissions embodied in imports, E_f (foreign emissions intensity), for each year as:

$$E_f = e_d (I - A - M)^{-1} m$$

where

e_d =Domestic emissions intensity (1 x n)

I =Identity matrix (n x n)

A =Technical coefficient matrix (n x n)

M = Import use coefficient matrix (n x n)

m = Imports (n x 1)

where

n = number of industries

[5] Exports may be used in foreign production processes as an intermediate use, but National Accounting conventions treat them as a final use from the perspective of the domestic economy.

Emissions intensity is defined as:

e_d = Emissions/Gross output

The M matrix is calculated as:

$Imports_i/Output_i$

Where

$Imports_i$ = a (n x n) matrix of imports supply and use on an $industry_{foreign}$ to $industry_{domestic}$ basis

Adjusting the Leontief inverse by the M term accounts for the role of imports throughout global supply chains: foreign production, that ends up as New Zealand imports, will also use imports in its production, and these imports will also use imports, and so on.

The technical coefficient and import matrices are fixed over time and are based on the 2013 input-output tables.

Allocating emissions to final use categories

Domestic production-based emissions

New Zealand's production-based emissions are reallocated through the supply chains using the domestic emissions intensity, the Leontief inverse from the input-output tables, and expenditure by final use category. This is calculated as:

$$e_d (I - A)^{-1} Y$$

where

Y=final consumption (n x k)

k = final use categories

Emissions embodied in imports

Imports can either be used as an input to domestic production processes or by final consumers. Imports used as intermediate consumption are treated in the same way as domestic emissions, with an M matrix denoting the use of imports in each industry's production process. This gives us:

$$e_f M (I - A)^{-1} Y$$

where

$e_f = E_f/m$

The direct use of imports by final use categories is calculated as:

$$e_f m_{FUC}$$

where

m_{FUC} = expenditure on the direct use of imports by final use categories

The sum of these two components equals the initial calculation of emissions embodied in imports:

$$e_d (I - A - M)^{-1} m = e_f M (I - A)^{-1} Y + e_f m_{FUC}$$

Assumptions

Consumption-based emissions are estimated using a top-down approach, where economic activity data is used to estimate and reallocate emissions to final use categories. The assumptions discussed below affect both the calculation of total consumption-based emissions (particularly the calculation of emissions embodied in imports) and the reallocation to final use categories, influence the methodology and data needs for calculating consumption-based emissions, and have implications for the overall quality of the estimates.

As climate change mitigation policies will be explicitly aimed at changing technology and production processes, it will be important that the impact of these assumptions is reduced over time through the integration of additional data and the further development of methodology.

Constant economic structure assumption

The constant economic structure assumption arises from the use of a single set of technical coefficients for the calculation of the consumption-based emissions time series. This has implications for the quality of the resulting consumption-based emissions, as changes in the relationships between industries is not accounted for.

The use of the same technical coefficients for several years is usually justified on the basis that the domestic production structure remains relatively similar in the short to medium term. When these are not updated, changes in the mix of commodities used by industry in their production process may not be adequately captured over time.

Domestic technology assumption

The domestic technology assumption (DTA) refers to the assumption that New Zealand emission intensities are representative of those for the foreign production processes that produced the goods and services New Zealand has imported.

The DTA does not require additional data and results in a much-simplified methodology. The DTA will affect the total estimate of New Zealand's consumption-based emission through the estimate of the emissions embodied in imports. There are likely to be differences in emission intensities in industries such as agriculture and electricity generation due to a high level of renewable generation. Also, New Zealand may not have the same types and levels of manufacturing that are used overseas to produce our imports. This means that the New Zealand industry's emissions intensities may not always be representative. While the resulting estimates for emissions embodied in foreign output are unlikely to be perfectly representative, it is unclear what the impact on the consumption-based total will be until we start exploring the replacement of domestic emission intensities with country specific emission intensities.

Domestic production process assumption

The domestic production process assumption (DPPA) is the assumption that the New Zealand economic structure, commodities used and supply chains, is representative of other economies.

The DPPA implicitly assumes foreign production has the same production function and use of imports, and the same energy profile for its economy. These all affect the estimation of the emissions embodied in imports. The proportion of imports used in production will vary greatly by country, so the DPPA may over- or under-state the estimation of imports used, which influences the estimate of emissions embodied in imports. For most industries the assumption of the same production function will be approximately representative (the industry classification is built around this idea), even if the proportion of imports used is different. However, where New Zealand doesn't have a mature industry, it may not be representative of foreign production processes. When using the DTA, whether inputs to production are domestically or internationally sourced becomes less of an issue, as they are assumed to have the same emissions intensity.

Given the above assumptions, the minimum data requirements for compiling consumption-based emissions are: production-based emissions on a SEEA basis (as it is conceptually aligned with the SNA-based input-output tables), input-output tables, and supply and use data. Reducing the assumptions made will increase the data requirements, such as including the use of trade data by commodity and country, and emissions intensities by country.

Data quality

Relevance

Greenhouse gas emission statistics are compiled on an economic residence basis to facilitate comparisons with economic statistics. All major greenhouse gases are covered except for carbon dioxide from biomass.

Accuracy

Uncertainty in the emissions estimates can arise from both the activity data and emissions factors. These are described in detail in the inventory. The allocation of the one-to-one industry-inventory match is considered to be accurate. Greater uncertainty, which has not been quantified, exists in the allocation of road transport emissions and other emissions sources that are distributed across multiple industries and households.

Uncertainties, which also cannot be quantified, exist in the consumption-based emissions account due to the use of modelling assumptions.

Timeliness

The inventory is published with a 15-month lag from the latest reference period, and the greenhouse gas account is published approximately two months after the inventory.

Coherence and consistency

In principle, the greenhouse gas emissions by industry and household account is consistent with the estimate of gross emissions in the inventory from the energy, industrial processes and product use, agriculture, and waste sectors. The residence principle of air emissions accounting in the SEEA framework has been applied to those emissions sources that are of greatest significance in New Zealand.

The regional and consumption-based emissions estimates are consistent with the national level greenhouse gases by industry and household statistics.

Interpretability

Be cautious in comparing the change in emissions over time with the change in GDP when the levels of emissions are low. A large percentage change in emissions could still reflect a small change in absolute terms. As decoupling indicators are based on indexes, this volatility could overemphasise the significance of emissions change in relation to GDP.

The industries cannot be interpreted in the same manner as the sectors in the inventory even if the name is the same (eg, agriculture and waste) as they are compiled using different perspectives.

Accessibility

All industry-level data are available via Excel and CSV format.

Land cover

The land cover account presents national and regional estimates of New Zealand's land cover in hectares.

We use the land cover database (LCDB) and a classification consistent with SEEA to present estimated land cover in an accounting format. To assist with international comparisons, we also use the SEEA land cover classification to separate land cover from land use. In the future this will allow us to assess how land is used according to the dominant land cover in the area.

The land cover account, currently experimental as we seek feedback on the classifications we use, provides a valuable basis for developing ecosystem accounting.

Structure of account

The land cover account is presented as a stock account with estimates of opening stock, additions, reductions, and closing stocks. The accounting format allows for net change, which is commonly reported to be decomposed into additions and reductions in stock. A small net change in stock may mask significant changes in land cover parcels if total additions are close to reductions. Stocks, and additions and reductions, are calculated in hectares. As the polygons in the LCDB are similar over time, additions and reductions are calculated by comparing the land cover in one period to another. We are not yet able to determine whether the additions or reductions to stock are due to economic or natural processes.

Data source

LCDB is a national classification of land cover mapped using satellite imagery. It covers mainland New Zealand and the nearshore islands but not the Chatham Islands.

LCDB has four major versions (1–4) correlating to the four summer survey periods – 1996/97, 2001/02, 2008/09, and 2012/13. The land cover classification was developed over the first three versions. We use version 4.1 consistently so that changes over time do not reflect classification changes.

Classification

The SEEA classification for land cover is preliminary within the SEEA central framework, but classifies land cover into these categories:

- artificial surfaces
- herbaceous crops
- woody crops
- multiple or layered crops
- grassland
- tree-covered areas
- mangroves
- shrub-covered areas
- shrubs and/or herbaceous vegetation, aquatic or regularly flooded

- sparsely natural vegetated areas
- terrestrial barren land
- permanent snow and glaciers
- inland water bodies
- coastal water bodies and intertidal areas.

LCDB contains 33 lower-order classes which map to the 14 SEEA classes listed above. A concordance between the SEEA classification and LCDB classes is presented in table 18. The SEEA classification of land cover maps closely to the LCDB classes making it viable to produce a land cover account. Multiple or layered crops and sparsely natural vegetated areas are not significant features of New Zealand's land cover and are not included in the land cover account. The SEEA land cover account does not distinguish between natural and managed areas. SEEA notes:

> Current land cover is a function of natural changes in the environment and of previous and current land use, particularly in agricultural and forestry areas. Although characteristics of vegetation (such as whether it is natural or cultivated) influence the land cover within an area, they are not inherent features of the land cover. Thus, a clear and systematic description of classes of land cover allows the land cover classification to be compared with that for types of land use, while maintaining pure land cover criteria. The FAO LCCS [Food and Agriculture Office Land Cover Classification System] provides a theoretical basis for this approach (United Nations, 2014b, para 5.259).

The SEEA classification differs from that used in environmental reporting published by Stats NZ and the Ministry for the Environment. The SEEA approach to land cover accounts focuses solely on the cover, while the environmental reporting approach includes some aspects of land use in the land cover classification.

Table 18

SEEA classes and lower-order LCDB classes	
SEEA class	**Detailed LCDB class**
Artificial surfaces	Transport infrastructure Surface mine or dump Built-up area (settlement) Urban parkland/open space
Coastal water bodies and intertidal areas	Estuarine open water
Grassland	Alpine grass/herbfield Depleted grassland High-producing exotic grassland Low-producing grassland Tall tussock grassland
Herbaceous crops	Short-rotation cropland

SEEA classes and lower-order LCDB classes	
Inland water bodies	Lake or pond
	River
Mangroves	Mangrove
Permanent snow and glaciers	Permanent snow and ice
Shrub covered areas	Gorse and/or broom
	Mixed exotic shrubland
	Manuka and/or kanuka
	Matagouri or grey scrub
	Fernland
	Sub-alpine shrubland
Shrubs and/or herbaceous vegetation, aquatic or regularly flooded	Flaxland
	Herbaceous freshwater vegetation
	Herbaceous saline vegetation
Terrestrial barren land	Sand or gravel
	Landslide
	Gravel or rock
Tree- covered areas	Forest – harvested
	Deciduous hardwoods
	Exotic forest
	Indigenous forest
	Broadleaved indigenous hardwoods
Woody crops	Orchard, vineyard, or other perennial crop

Data quality

The land cover account is currently experimental as the SEEA land cover classification undergoes further testing and research. Future updates may include reallocations of detailed land cover classes.

Stats NZ has taken all possible reasonable steps to ensure the quality of the data. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The estimates cover all of New Zealand's territorial area, excluding the Chatham Islands.

Accuracy

Data have been checked for accuracy, duplication, and anomalies by Landcare Research. While care has been made to allocate LCDB classes to the SEEA classification, the experimental nature of the SEEA classification means some uncertainty may be present in these allocations.

Timeliness

The land cover database is available for four summer survey periods – 1996/97, 2001/02, 2008/09, and 2012/13. It is not yet known when the next land cover database will be available.

Coherence/consistency

Version 4.1 of the land cover database has been used for all survey periods. The land cover classification is consistent with that in the SEEA, which is currently experimental.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data are available in CSV format with the report.

Interpretability

The report contains the appropriate information to interpret these estimates.

Marine economy

The marine economy is a satellite account, which cuts across traditional industry definitions by grouping common activities to increase the understanding of and provide analysis for specific sectors or functional activities within the national economy. The marine economy is not described in the SEEA but is produced as part of Stats NZ's environmental-economic accounts to help assess the impacts and dependencies of the marine economy on marine environmental assets.

The marine economy is a function of both industry and geography. It is the sum of the economic activities that take place in or use the marine environment, or that produce goods and services necessary for those activities and make a direct contribution to the national economy.

The marine economy does not attempt to value natural capital, nor does it distinguish between marine-based activities that are extractive or non-extractive, use or non-use, or that enhance or degrade the marine environment.

Blue and green economies

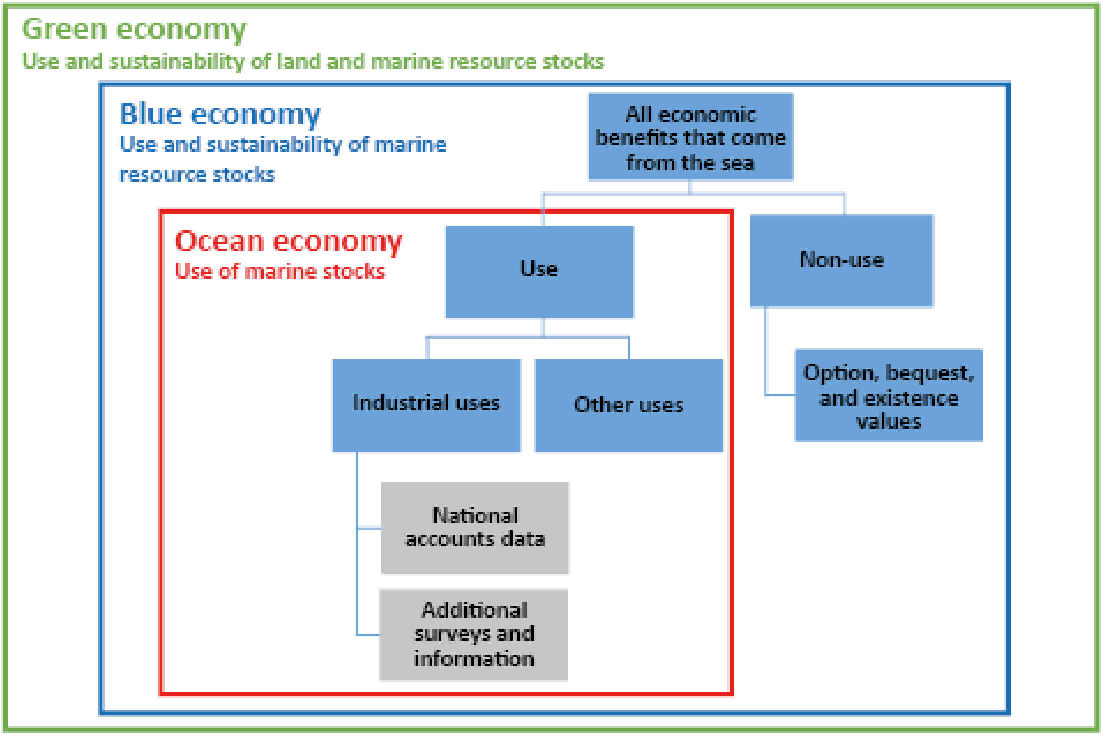
Studies similar in scope to New Zealand's marine economy sometimes use the terms 'ocean economy' or 'maritime economy' – these terms are broadly equivalent. The United Nations Environment Programme (UNEP) launched the Green Economy Initiative in 2008. The working definition of a green economy is one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, nd).

Recently, the importance of measuring the blue economy (within a sustainable environmental framework) has been emphasised in Asia-Pacific developing economies, although the measurement and use of these studies is still in development. This emphasis has come from the social and environmental impact of economic development.

The concept of the ocean (or marine) economy within a blue or a green economy using a sustainable development framework is shown in figure 5. Where the ocean economy has minimal environmental or equity considerations, the blue economy – encompassing the red – adds principles of sustainability and equity. An OECD report (2019) noted that Stats NZ's work, along with those in Portugal and the United States of America, are good examples of national-level efforts to develop ocean economy satellite accounts.

Figure 5

How the ocean economy fits within the blue and green economy frameworks



Source: Adapted from McIlgorm, 2016

About the marine economy

The marine economy is calculated using internationally accepted methodology and the following Stats NZ data:

- annual enterprise survey (AES) and national accounts to derive value added
- overseas merchandise trade, construction statistics, and linked employer-employee data for complementary information on exports, consents related to marine construction, and the number of wage and salary earners and earnings in marine-related industries.

Methods

To produce an estimate of the marine economy, we compiled data on those industries identified as engaged in marine-based economic activities according to the definition of the marine economy accepted for this study. After identifying and categorising the industries of interest, we identified the industrial classifications that contained these industries based on ANZSIC06.

Reports by Colgan (2003), Kildow and McIlgorm (2010), and Surís-Regueiro et al (2013) highlight the four principles for developing a methodology:

- comparability across industries and space
- comparability across time
- theoretical and accounting consistency
- ability to be replicated.

We met these principles by using ongoing Stats NZ economic and labour market collections and associated accounting rules and classifications.

Direct value added

Direct economic impacts result from the flow of money between an organisation and its stakeholders. This also describes the direct contribution to the economy when this flow of money is estimated at industry level.

We estimated direct value added by using data from Stats NZ's AES and from the annual national accounts. It is preferable to use national accounts estimates where possible, as these include conceptual adjustments. However, the national accounts are not compiled at the level of industry detail sufficient to provide data on the marine economy. Therefore, we used detailed AES data to provide ratios to split the national accounts data into the categories of interest.

In this way we are able to provide a dataset consistent with and directly comparable with the national accounts annual GDP series while using, where possible, the individual ANZSIC06 classes that fall within the scope of the marine economy. We aggregated these classes to category level and summed them to produce an overall estimate of the New Zealand marine economy and its contribution to national GDP.

AES is New Zealand's most comprehensive source of financial statistics. It provides annual information on the financial performance and financial position for industry and sector groups operating within New Zealand, and is the primary source data for GDP, which is used to calculate detailed annual national accounts.

Value added is calculated as the value of output (the value of goods and services produced) less the value of intermediate consumption (the value of goods and services used to produce that output). Marine economy estimates are in current prices (or the prices current at the time the production takes place), so changes in estimates for a particular activity may come from:

- movements in prices or volumes of goods and services produced
- movements in prices or volumes of goods and services used in production.

Indirect value added

Indirect marine economy value added is derived as a residual item. We calculated the total value added of the marine economy by using the table of industry-by-industry total requirements from national account's input-output tables for the March 2013 year (the most-recent total requirements table available) and the direct value-added estimates. We then calculated indirect estimates as the total less direct marine economy value added. This approach is consistent with that used in the tourism satellite account. (An input-output table shows how much extra output is required from every industry if a particular industry is to produce more of its own output, defined as direct requirements. These contributing industries would then need further input into their own production processes or indirect requirements. The table shows total (direct and indirect requirements). For more information about these tables, see National accounts input-output tables: Year ended March 2013.

The input-output method used to estimate indirect effects assumes the inter-industry coefficients are stable over time. It captures the first round of indirect supply but does not account for contributions further down the value chain.

An alternative approach is to use a computable general equilibrium (CGE) model to allow for input constraints, changes in prices, and reallocation of input resources across sectors. CGE models can be used to identify the economy-wide impacts of a shock to marine sectors, distinguishing direct from indirect impacts.

Contribution to GDP

It is important to note the difference between gross value added (GVA) and gross domestic product (GDP). GVA is defined as the value of output less the value of intermediate consumption and is a measure of the contribution to GDP made by an individual producer, industry, or sector. The GDP of a country, viewed as an aggregate measure of production, is equal to the sum of the GVA of all resident institutional units engaged in production (plus any taxes and minus any subsidies on products not included in the value of their outputs). As taxes less subsidies will generally be positive, any industry breakdown compared with GDP will be a lower percentage than the same breakdown compared with GVA.

For the offshore minerals, fisheries and aquaculture, shipping, marine tourism and recreation, and marine services classifications, value added information is derived from AES and the national accounts as described above. For these groups, the calculation of value added is gross output minus intermediate consumption. The government and defence group, while still consistent with the national accounts, is derived from the local authority census and the calculation of value added is the sum of costs: compensation of employees, depreciation, and taxes on production less subsidies.

Employment and earnings

Information on wage and salary earners and earnings is from linked employer-employee data (LEED). LEED uses existing administrative data from the taxation system together with business data from Stats NZ's Business Frame to provide statistics on filled jobs, job flows, worker flows, mean and median earnings for continuing jobs and new hires, and total earnings. This information gives an insight into the operation of New Zealand's labour market.

Previously we reported on jobs where the term 'jobs' refers to a unique employer-employee pair present on an Employer Monthly Schedule in the reference quarter. For the revised tables released in 2019 we have replaced the jobs measure with wage and salary earners. The values presented are total earnings (before tax) paid in the reference quarter. LEED information is presented for March years. Note that self-employed individuals are not included in these figures.

The reasoning for replacing jobs with wage and salary earners is to improve the interpretability of the data. A job is defined as an employee-employer relationship where employer is a geographical location (or workplace). Some of these jobs held by an individual person could be for the same employer at a different address or for the same employer at different times during the year as well as for different employers within the same industry. For this reason, the LEED job and earning figures presented created confusion when used to calculate average annual earnings, particularly for the fishing industry. Given that the reference period is the tax year (or the year ending March) It's more appropriate to report counts of people if the reference period is annual. Job counts tend to correspond to short reference periods such as quarterly and monthly.

For the report we calculate LEED data on a kind-of-activity unit (KAU) basis to be consistent with the collection unit used for AES. This means there may be some differences in comparing these LEED estimates with published LEED series, which use the geographic unit (GEO) structure. By definition, a KAU is engaged in predominantly one activity for which a single set of accounting records is available. The Business Frame is a database of all known individual private and public sector businesses and organisations engaged in producing goods and services in New Zealand that meet significant criteria. The structure of each business on the Business Frame consists of an enterprise, a KAU, and a geographic unit. Collectively, they are referred to as statistical units. Larger or more complex businesses may have a number of statistical units. We give each statistical unit an industry classification based on its predominant activity. Different divisions of a company may be spread across several industries, depending on how the company is structured. See Linked employer-employee data for more information.

Coverage

We classified all marine activities included in the report into nine categories, following international studies in other Asia-Pacific Economic Cooperation economies (McIlgorm, 2004, 2016; Kildow & McIlgorm, 2010). The nine categories are the same as those used in New Zealand's Marine Economy 1997–2002. We placed industries or sectors in the appropriate category following international best practice and with regard to New Zealand's economic structure. However, some marine studies have grouped their marine sectors differently or use different terminology (eg, Australian Institute of Marine Science, 2014; Morrissey & O'Donoghue, 2012). There is a recent European proposal to use a similar breakdown, but with a living and non-living resources breakdown in a framework that groups activities as completely marine based, mainly marine, and partially marine. This proposal (Surís-Regueiro et al, 2013) was developed for use by European Union economies using the Statistical Classification of Economic Activities in the European Community (NACE). An initial examination of this proposal showed it will not easily concord with ANZSIC06.

Using national accounts data reduces the risk of double-counting any economic activity. However, the industrial classifications used by Stats NZ to produce the national accounts were not designed to separate marine from land-based economic activity.

See the appendix for a list of the industrial classifications we used to measure the marine economy and those that we excluded.

The nine categories are:

- offshore minerals
- fisheries and aquaculture
- shipping
- government and defence
- marine tourism and recreation
- marine services
- research and education
- manufacturing
- marine construction.

Although the limitations of using national accounts data in these valuations are well known, it is essential in reducing the risk of double-counting, and it aids comparability (McIlgorm, 2016).

Excluded activities

GDP is measured as the value added from production by industry, where GDP equals the sum of value added for all producers, plus taxes on production and imports. To isolate the marine component of GDP, the report cuts across traditional industry boundaries and uses information from industries that specifically use the marine environment. This leads to an estimate of the marine economy's direct contribution to New Zealand's economy. Note that the methodology we used could not capture some activities that take place in the marine environment. Because some activities could not be included, the value of the marine economy and its contribution to the total economy is understated.

Although some marine categories in the report are underestimated and others are partly represented, the final figure for the New Zealand marine economy is deemed to be a good but conservative estimate. Because the marine economy crosses a broad range of 'conventional' industries, problems arise when attempting to isolate the marine component of industries without a clear land/marine split. For example, fish retailing could not be included as it is covered in an industrial classification that also includes fresh meat and poultry retailing (G412100). Overall, we anticipate that except for government and defence and marine tourism and recreation, the industries not measured would not have made up a major component of the marine economy.

Marine tourism

Marine tourism is difficult to measure. Although Stats NZ produces a tourism satellite account that measures the sector's contribution to the economy, no attempt has yet been made to estimate the marine component of tourism.

Government and defence

New Zealand's marine economy 1997–2002 included partial estimates for the government and defence category, which were not updated for the 2007–13 report. These estimates were based on data provided directly from a selected group of units, but this approach was not directly comparable with the official estimates in the national accounts. Due to changes in industrial classification from ANZSIC96 to ANZSIC06, government-owned units have moved from ANZSIC96 division M government administration and defence to one that records the type of service delivered. ANZSIC06 prioritises a production function concept, where ownership is not a criterion for classification; therefore, only units engaged in providing public administration and safety (some of which are private sector units) are recorded in ANZSIC06 division O public administration and safety.

Central government administration, which includes units whose primary activities are policy and administration, is recorded in a separate ANZSIC06 (O751000); defence is recorded in O760000. However, it is not possible to separate the marine component from the non-marine component of these activities with any precision. For example, armed forces are included within O760000 but includes naval as well as ground and other support forces. The primary source of information for the government sector accounts is the Crown's Financial Information System, which is not set up to classify expenditure in terms of activities.

The latest estimates include a partial measure of government and defence, which uses local government information (from city, district, and regional councils) from the local authority census, which recorded expenditure under the activity code for marine safety. Data availability for the local authority census is from 2009.

Data quality

We made every effort to evaluate the accuracy of the time series; however, trends are considered to be indicative and using absolute figures requires care. We have erred on the side of caution when activity boundaries are blurred. In most cases, where the marine component of an activity could not be isolated from its non-marine component, we excluded that activity from the analysis.

Sample errors

Estimates of the economic contribution of the offshore minerals, fisheries and aquaculture, and shipping categories are deemed to be relatively robust due to the availability of data and the relative ease of deriving the marine component of that data. The marine tourism and recreation and the marine services categories are only partly represented and the sample errors for these categories are above 50 percent for all years. Be cautious when interpreting these estimates.

Sample design

A sample redesign of the annual enterprise survey (AES) in 2009 had an impact on some industries' time-series figures published for the 2008 financial year compared with the 2009 financial year. Marine services and marine tourism and recreation are published below the AES sample design level, so the time-series break had a significant impact. For this reason, 2007 and 2008 values are suppressed for these categories. A further series of AES sample redesign since 2015 has increased the proportion of Inland Revenue's IR10 data used, resulting in decreased respondent burden and full coverage for several industries. This has had a significant effect on marine tourism and recreation. When analysing this category, 2017 results should be considered a break in the series.

Renewable energy

An energy monetary asset account is a balance sheet for an energy resource. The balance sheet shows a resource's opening stocks at the beginning of a year, changes in its stock over a year, and closing stocks at the end of a year.

The opening and closing stocks are calculated as the net present value (NPV) of anticipated resource rent. The difference between opening and closing stocks is a residual that implicitly accounts for other changes affecting asset levels and values, including changes in the capacity to use renewable energy resources.

Definition of renewables

A renewable resource, or 'renewable', is a resource that after being used, can return to previous stock levels by natural processes of growth.

The SEEA central framework (United Nations, 2014b, p45) recognises the following renewable sources of energy.

- solar
- hydro
- wind
- wave and tidal
- geothermal
- other electricity and heat.

The United Nations is developing the SEEA-Energy, an SEEA 'sub-system', to provide compilers and analysts with agreed concepts, definitions, classifications, tables, and accounts for energy and energy-related air-emission accounts. SEEA-Energy elaborates and expands the guidance on accounting included in the International Recommendations for Energy Statistics (IRES) and is fully coherent with the broader SEEA. According to IRES, heat from renewable resources is considered renewable but heat from chemical processes is considered non-renewable. Electricity data supplied by MBIE includes electricity generated from waste heat, which includes heat from chemical processes (eg, the fertiliser industry). For this reason, we exclude electricity generated from waste heat in the report.

Method

The resource rent from the electricity generation industry is first calculated: gross operating surplus less user cost of produced capital, all sourced from the national accounts (see Industry coverage for the subgroups under the electricity generation industry). No appropriate taxes or subsidies on extraction are applicable to this industry, so nothing is added back to gross operating surplus.

The resource rent from electricity generation using renewables is then calculated by applying the proportion of total electricity production from MBIE to the national accounts data. Quarterly MBIE data is converted to March years for consistency with the economic data.

User cost and rate of return of produced capital

User cost is derived using the method used in productivity statistics. This is computed as the price index of the asset multiplied by the sum of the rate of economic depreciation and rate of return, all multiplied by the productive capital stock (derived using the perpetual inventory method). Stats NZ adopted a 4 percent real rate of return for capital assets in the compilation of productive capital stock and productivity estimates for all industries and all years. See MacGibbon (2010) for more information on this approach to user cost.

Asset lifespan

For the asset value computations to work, we assume that the lifespan of the resource is infinite (ie, there will always be a minimum sufficient flow). The longevity of the fixed asset used to generate electricity (ie, the dams) are accounted for in calculating user cost.

Discount rate

The asset value for natural capital assets used for generating electricity is calculated as resource rent divided by the discount rate (due to the assumption of infinite lifespan). The discount rate is 6 percent to be consistent with Treasury recommendations for undertaking cost-benefit analyses for water and energy assets (see current discount rates).

In setting the discount rate, we first considered the purpose for which it is needed. When considering the value of water for hydroelectric plants, a commercial rate is more appropriate than a lower social rate of time preference to ensure that the valuation is aligned to the general concept of market prices. For national accounting purposes, the focus is on average value to production in current uses rather than marginal value of choices between uses. It is necessary to assume that consenting conditions on hydro-generation internalise the externalities (including environmental) – although in practice that may be inconsistently done.

The NPV approach invokes assumptions on the real rate of return and real discount rate (assumed to be constant at 4 percent and 6 percent, respectively). Annual distortions from these rates may lead to some bias in the trend, while systematic differences will affect the confidence in the level.

Under the NPV approach, renewable monetary assets are estimates of the net discounted income stream from the resource. The estimate is not a measure, for example, of the value of the stock of water in dams at that particular point in time. In fact, a hydro dam may be dry at the time of the balance date but is still valued on the basis of the expected future availability of water.

Coverage

Industry coverage

ANZSIC06 groups firms based on similar production functions (see table 19 for the structure of the electricity, gas, water, and waste services industry).

The starting point for estimating the asset value of renewables used for electricity generation was the national accounts benchmarks for electricity generation and on-selling industries. To estimate resource rents from electricity generation, we excluded units engaged in on-selling electricity and electricity market operation. We used data from the AES to exclude these units from the national accounts totals. This provides the baseline for computing the resource rent from electricity generation. Units engaged in electricity transmission, electricity distribution, water supply, sewerage, and drainage services are included in the electricity, gas, water, and waste services industry but are not included in the asset values.

The resource rents for electricity generators used national accounts data at the working-industry level (electricity generation and on-selling combined). This level of information is considered to be robust. AES had complete coverage of firms in the electricity and gas supply industry (division level). This means sample errors are zero.

The top-down approach we used involves using national accounting aggregates and supplementary information to estimate the resource rent from renewables. This contrasts with a bottom-up approach which would be based on firm-level data.

We explored a bottom-up approach using firm-level data from AES, but classification issues at the ANZSIC level mean the validity of this approach could not be ensured. The top-down approach is also not subject to confidentiality issues – aside from excluding on-selling electricity and electricity market operation, it is based on publicly available data. However, using national aggregates affects the potential to produce disaggregated estimates, for example, by region.

The use of supplementary information, in this case electricity production by generation type from MBIE, results in an assumption that resource rents will be similar for all electricity producers. This may not be the case for all producers, but due to the small number of large companies involved and their structure (ie, where a company may operate stations using several types of fuel) this assumption is necessary to present information for all types of renewables used in electricity generation.

Table 19

Industrial classification structure of the electricity, gas, water, and waste services industry ANZSIC06		
Subdivision	Group	Class
Electricity supply		
	Electricity generation	
		Fossil fuel electricity generation
		Hydroelectricity generation
		Other electricity generation
	Electricity transmission	
	Electricity distribution	
	On-selling electricity and electricity market operation	
Gas supply		
Water supply, sewerage, and drainage services		
	Water supply, sewerage, and drainage services	
		Water supply

Industrial classification structure of the electricity, gas, water, and waste services industry ANZSIC06		
		Sewerage and drainage services
Waste collection, treatment, and disposal services		
	Waste collection services	
		Solid waste collection services
		Other waste collection services
	Waste treatment, disposal, and remediation services	
		Waste treatment and disposal services
		Waste remediation and materials recovery services

Asset coverage

The asset value of and resource rent from electricity generation reflects the role of land form in generating electricity. For example, the land's slope under a river and the land used for operating a dam are essential to production. However, the role of land in generating hydroelectricity cannot be readily extracted from these estimates. Similarly, land that generates gross operating surplus may also be attributed to other renewable energy assets, such as an exposed or sunny position for wind and solar generation, respectively. Although we cannot separate the contribution from land form we expect its influence to be small.

Data quality

Stats NZ has taken all possible reasonable steps to ensure the quality of the data. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The estimates include all significant natural capitals used in generating electricity at the national level.

Accuracy

Key sources of uncertainty are the use of a fixed discount rate and rate of return on produced assets. The use of generation proportions may not capture the relative value of carbon to non-carbon using assets. Resource rents may be higher for renewable assets given they are substantially carbon free.

Timeliness

Data are consistent with the latest available national accounts release. The report covers data until the year ended March consistent with the latest period available from the national accounts at the time we compiled the latest SEEA report.

Future updates will incorporate any national accounts revisions to any year in the series.

Coherence/consistency

The methodology used here is consistent with guidance in the SEEA. Time-series consistency has been ensured. Data is available from 2007. National accounts data is available from 1987, but for user costs there is greater uncertainty in the earlier part of the time series given the use of constant price rather chain volume productive capital stock in the calculations. For future work we will endeavour to estimate values back to 1996 to enable comparability with the water physical stock account, and to balance these values against data quality.

The resource rent and asset values are based on March years, so we recommend caution when comparing these with other environmental information, such as river flow or rainfall which may be in June or calendar years.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data is available in CSV format with the report.

Interpretability

The report contains the appropriate information to interpret these estimates. Interpretability can be enhanced by comparing these estimates with river flow and climate data. However, the lack of regional estimates affects the ability for these comparisons to be made. Renewable assets should be placed in context with non-renewable and other environmental assets to fully understand their relative value.

Water physical stocks

The water physical stock account describes how stocks of fresh water are affected by water flows within the hydrological system during accounting periods. The structure of the account is defined by the SEEA handbook, and the system of environmental-economic accounting for water (SEEAW) (United Nations, 2007). These frameworks describe a system of stock or asset accounts, with opening and closing stocks of water resources and the flows that affect these stocks.

In the New Zealand water physical stock account, total opening and closing stocks are not quantified. Instead, the account is presented in terms of inflows, outflows, and changes in storage levels.

The water physical stock account brings together a variety of hydrological data, including precipitation, evapotranspiration, outflows, and changes in stored water, at both the national and regional level. The account currently contains limited information on water abstraction.

The components of inflows we report on are:

- precipitation
- inflows from other regions (regional scale only).

The components for outflows are:

- evapotranspiration
- abstraction for hydroelectricity generation
- discharge from hydroelectricity generation
- outflows to sea and net abstraction
- outflows to other regions (regional scale only).

The changes in storage components are:

- net change in lakes and reservoirs
- net change in soil moisture
- net change in snow storage
- net change in ice storage
- changes to groundwater volume.

We also provide estimates of livestock drinking-water at the national level.

The account currently covers the years ended June, from 1995 to 2014. Each accounting period represents the 12 months from 1 July to 30 June, inclusive. The year ended June 1995, for example, ends on 30 June 1995. The period 1 July–30 June has been selected as the water physical stock account accounting year because:

- June/July is generally a period when storage has been replenished and water levels are stable
- periods of low flows or drought are of interest and usually occur entirely within a June year
- each June year contains a whole irrigation season.

The unit of measurement used is millions of cubic metres. One million cubic metres is equivalent to one gigalitre, which is one billion litres.

Data sources

Surface water components of the water physical stock account (precipitation, inflows from other regions, evapotranspiration, abstractions for and discharges from hydroelectricity generation, outflows to sea and other regions, and net change in lakes, reservoirs, soil moisture, snow and ice storage) are sourced from NIWA. The data are consistent with those in used in environmental reporting (Ministry for the Environment & Stats NZ, 2015). Further information on the data sourced from NIWA can be found in (NIWA 2015 and NIWA 2011).

Changes in groundwater volumes are provided by GNS Science. The data are consistent with those used in environmental reporting (Ministry for the Environment & Stats NZ, 2017).

Stats NZ's agricultural production survey provides the annual livestock numbers for drinking-water and dairy-shed requirement calculations. If data are not available for all livestock types for all years, livestock numbers are estimated using imputation and linear interpolation techniques. We acknowledge that this introduces a level of uncertainty to some values within the time series. However, this approach is considered appropriate for providing high-level estimates that are fit for purpose.

Horizons Regional Council's 2007 report, Reasonable Stock Water Requirements: Guidelines for Resource Consent Applications, provided the basis for the livestock drinking-water estimations. The report was selected after a literature search of relevant publications, including documentation from regional councils, Ministry of Agriculture and Forestry Biosecurity New Zealand, and Lincoln University. The search revealed a range of possible values for each livestock type, and some level of broad agreement, but no universally approved values. Therefore, we approached Fonterra and a number of industry organisations for further advice. We appreciate the advice provided by:

- Fonterra
- AgResearch
- Beef and Lamb New Zealand
- New Zealand Pork Industry Board
- Deer Industry New Zealand
- New Zealand Equine Research Foundation
- Poultry Industry Association of New Zealand
- New Zealand Dairy Goat Breeders Association
- Dairy Goat Co-operative (NZ).

Methods

Precipitation

Precipitation is any form of water that falls to Earth's surface, such as rain, snow, sleet, and hail. It is the source of all inflows to the inland part of the hydrological system at the national level.

Daily measurements are obtained from rain gauges around the country and a detailed national rainfall dataset that was developed using spatial interpolation modelling. Rain gauges have a typical measurement uncertainty of 10 percent. Most rain gauges have a tendency to catch less rain than actually falls, especially at windy sites. On average, the standard 300mm-diameter rain gauges used in New Zealand catch about 7 percent less than the rainfall on the ground. Adjustments have not been made for this effect because the adjustment depends on wind speed, which is not known at most rainfall measurement sites. Rain gauges are extremely sparse in remote areas that have high, changeable rainfall. The national rainfall dataset obtained has been calibrated against river flow measurements to reduce the effects of rain measurement error, especially in high rainfall areas where most rainfall leaves as river flow (NIWA, 2011). The derived rainfall dataset is used as an input into a hydrological model and compiled into regional volumes.

Inflows from other regions

In general, regions in New Zealand are bounded by catchment boundaries. Most rivers do not flow from one region to another, but, there are exceptions. The major transfers between regions and rivers are shown in table 20.

Table 20

Surface water transfers between regions

River	**From this region**	**To this region**
Motu, Waioeka (and others)	Gisborne	Bay of Plenty
Wairoa (and others)	Gisborne	Hawke's Bay
Whanganui (and others)	Manawatu-Wanganui	Waikato (by diversion)
Clarence	Marlborough	Canterbury
Wairoa	Nelson	Tasman
Waitaki (south bank)	Otago	Canterbury
Mokoreta	Otago	Southland
Kaiwera stream	Southland	Otago
Buller	Tasman	West Coast
Mangatawhiri (and others)	Auckland	Waikato

Source: NIWA (2011)

Total inflows

Total inflows is the sum of precipitation and inflow from other regions. At the national level, there are no inflows from other regions or countries. Regional inflows and outflows, when summed across all regions, balance each other out.

Evapotranspiration

Evapotranspiration is the loss of water by evaporation from the soil and transpiration from plants. It is one of the main freshwater components of the hydrological system in New Zealand, accounting for about 20 percent of outflows at the national level.

Evapotranspiration is calculated by the Topnet hydrological model, which calculates daily actual evapotranspiration using measurements of temperature, wind speed, and solar radiation. The model reports daily values and annual summaries for each catchment, and catchment volumes are then summed into regional and national totals.

Outflows to other regions

Outflows to other regions is a measure of the total quantity of surface water that leaves a region and flows to another region during an accounting period. It is calculated by hydrological modelling on the basis that no abstraction is occurring. At the national level, the outflow across regional boundaries balances the inflow across regional boundaries.

Abstraction for hydroelectricity generation

Abstraction for hydroelectricity generation is a measure of the total volume of water abstracted from surface water by hydro-generation companies during an accounting period. Volumes are presented in the accounts at the national level only. Figures are additive, meaning that water abstracted for use in a power station is often abstracted (and counted) several more times by downstream power stations. Most abstraction by volume occurs in Canterbury, Waikato, and Otago. Water that is stored behind hydro dams is accounted for in changes in lakes and reservoirs.

Discharge from hydroelectricity generation

Water abstracted for hydroelectricity generation is also discharged back into the hydrological system. One hydroelectricity power station in Southland returns water direct to the sea, which prevents others from reusing the fresh water. This could be defined as consumptive. The consented weekly allocation for this take is 308 million cubic metres per week, over 40 percent of the total national weekly consumptive allocation (Aqualinc Research, 2010). However, SEEAW treats all discharges from hydroelectricity generation as non-consumptive abstraction, regardless of where in the environment or economy the water is discharged.

Outflows to sea and net abstraction

Outflows to sea and net abstraction accounted for about 80 percent of outflows of fresh water from New Zealand over the 1995–2010 period. Outflow to sea and net abstraction include both the total volume of water that flows to the sea from rivers and a residual net abstraction figure. The net abstraction figure is determined by adding total inflow to a region and subtracting outflows to other regions, evapotranspiration, and changes in water storage.

Outflows of water to the sea includes outflows of groundwater and surface water. Groundwater is slow-moving, while surface water may spend just a day or two in New Zealand’s network of small catchments and fast-flowing rivers before reaching the sea.

Detailed breakdowns for this component are not available because there is insufficient data for net abstraction volumes and little data or estimation methodology suitable for measuring the volumes for private industrial abstraction at a national level.

Total outflows

Total outflows are the sum of evapotranspiration, outflows to other regions, and outflows to sea and net abstraction (which includes changes in storage). At the national level there are no outflows to other regions or countries. Regional inflows and outflows, when summed across all regions, balance each other out. Water that enters New Zealand’s inland part of the hydrological system and that has not left by the end of the June year is dealt with in the storage components below.

Changes in soil moisture

Soil moisture refers to water stored in land and soil – in the rooting zone (typically the top 1 metre, depending on soil and vegetation type). The amount of moisture varies according to rainfall, soil type, land use, and evapotranspiration. In turn, evapotranspiration varies according to air temperature, day length, and vegetation. Soil moisture can vary markedly during the year, with summer levels often being low while winter levels are high. Changes in soil moisture are calculated using the Topnet hydrological model.

Changes in lakes and reservoirs

New Zealand has more than 50,000 lakes (NIWA, 2011). Of these, 3,820 are over 1 hectare in size with 229 lakes being over 50 hectares (MfE, 2007).

Lakes and reservoirs store water for irrigation, town supply, and hydroelectricity generation. They are also used for flood control, wildlife, recreation, and transportation. At least 16 artificial lakes have been created for hydro-power stations. The South Island's Lake Benmore, at 7,500 hectares, is the largest of these (MfE, 1997).

The lakes and reservoirs in New Zealand that are monitored and for which data are available are mostly hydroelectricity reservoirs and major lakes. Due to the very large sizes of these monitored lakes, the monitored lake-level data covers approximately 80 percent of the surface area of all lakes and reservoirs in New Zealand. For the water physical stock accounts, it is assumed that those lakes and reservoirs for which data are unavailable will have the same changes in levels as those that are monitored.

The net change in storage for each measured lake or reservoir is the difference in the level of water between the start and end of each accounting period, multiplied by the area of the lake or reservoir. Changes in lake and reservoir levels in the water physical stock account are point-to-point movements from the end of one June year to another and can depend on rainfall in the last few days or weeks of each June.

Changes in groundwater

Groundwater is the water contained in the saturated zone within pores and fractures of rock formations (Fetter, 1994). The saturated rock formations through which groundwater moves are called aquifers. Aquifers yield water in usable quantities and can be classified as unconfined, semi-confined, or confined. Unconfined aquifers are estimated to contain about 96 percent of New Zealand's groundwater, with the Canterbury region having the largest groundwater storage.

Water enters aquifers from precipitation or by seepage from rivers, lakes, and reservoirs. Groundwater in aquifers eventually flows naturally to the surface through springs and seeps, or it can be extracted through wells for agricultural, municipal, and industrial use. Most groundwater replenishment occurs between autumn and spring, when evapotranspiration is low, and soils are moist and unable to absorb much additional water.

Data for groundwater volumes were provided by GNS. The volumes are for water in aquifers that is currently used or potentially available for use. There has been no change to the methodology used in estimating groundwater volumes for the water physical stock accounts. The current water physical stock account uses the 15 well series in Update of national groundwater volume stock account 2017 rather than the 37 well series. This is to maintain a long term and comparable time series. Further consideration of moving to the 37 well series will be made in the future. In addition, the indicator wells are the same as those used in the previous water physical stock accounts except for two indicator wells: well 2970710 Takaka marble aquifer, and well 951 Mamaku Ignimbrite aquifer. These wells have replaced well WWD6713 and the Waikato indicator well. Further explanation of the methodology used in estimating groundwater volume can be found in *Update of national groundwater volume stock account* (Moreau & Bekele, 2017).

Changes in snow

The change in the quantity of water stored as snow is calculated using a component of the Topnet model, similar to the SnowSim model used previously. Both are temperature index models that include factors to simulate the effects of snow ageing and rain on snow events. Snow-water equivalent was accumulated within every Topnet model catchment.

Mountain-fed rivers in the South Island usually have their lowest flows in winter, due to snow-pack accumulation in the mountains. Melting snow in spring and summer raises river flows and, if stored in lakes, can be used later in the year to generate electricity for meeting winter demand.

Changes in ice

The change in the quantity of water stored in ice is measured indirectly in New Zealand, through annual monitoring of the areas and end of summer snowline altitudes of 49 index glaciers. This permits the estimation of changes in the mass of the index glaciers, and a spatial mapping technique is then used to extend this to the 3,144 glaciers in the New Zealand glacier inventory.

A glacier is a body of ice at least one hectare in area that has persisted over the last two decades (NIWA, 2011). The data reported in the water physical stock account are for changes in glacier volume over a glacier accounting year, which ends at the end of summer (March or April). This is so that the glaciers can be observed separately from temporary snow.

Total change in storage

Storage can be viewed as a balancing set of components. If inflows of water to the inland part of the hydrological system exceed outflows then the excess must be going into storage. Conversely, if the total storage volume reduces from one year to the next, then outflows will be higher than inflows. Volumes of water held in storage can fluctuate throughout the year but it is the volumes at the end of each June year that affects the water physical stock accounts. Storage levels are point-to-point movements and are influenced by short-term changes in weather, such as storms and longer-term weather cycles including the El Niño-Southern Oscillation and Interdecadal Pacific Oscillation.

Changes in storage are a relatively minor part of the water physical stock accounts. The total volume of water stored in aquifers, lakes, and reservoirs; and as soil moisture, snow, and ice, is large but the annual changes are relatively small.

Livestock water requirements

Estimates of livestock drinking-water requirements are provided for the following livestock types:

- dairy cattle
- beef cattle
- sheep

- deer
- pigs
- poultry (includes chickens, ducks, and turkeys)
- horses
- goats.

Estimates of dairy-shed water requirements are provided for the following livestock types:

- dairy cattle
- dairy goats.

Livestock drinking-water requirements

Livestock drinking-water requirements are estimates of the amount of drinking water required for New Zealand's livestock. Consumption of drinking water is highly dependent on many factors, including the size of the animal, milk yield, quantity of dry matter consumed, temperature and relative humidity of the environment, temperature of the water, quality of the feed, and moisture content of the feed (Looper & Waldner, 2002). Where possible, estimates of drinking-water requirements have been applied to the age, sex, and lactation state of each livestock type. The per-head-per-day litre values are estimates based on average daily demand.

The livestock drinking-water volumes provide an estimate of how much water animals actually consume. It does not account for losses due to pipe leakage, spills, and evaporation. Consequently, the amount of water abstracted from surface and groundwater will be higher than the amount actually used.

Livestock dairy-shed water requirements

Livestock dairy-shed water requirements are estimates of the water required to operate New Zealand's dairy (or milking) sheds. Estimates of dairy-shed requirements include water used for cleaning plant and equipment, washing down milking areas, and cooling of milk. The per-head-per-day litre values are based on average daily demand. Estimates are provided for dairy cattle and milking goats but exclude water requirements for yard wash-down and cleaning for other livestock types, such as cleaning horse stables or chicken pens.

The dairy-shed water requirements provide an estimate of how much water is required. It does not account for losses due to pipe leakage. Consequently, the amount of water abstracted from surface and groundwater will be higher than the amount actually used.

Coverage

Fresh water

The water physical stock account deals with the inland water components of the hydrological system. The scope is broad and includes all freshwater (as opposed to seawater) resources whether above, on, or below ground that provide both direct-use and non-use benefits. Direct-use benefits include water that can be extracted in the current period and water that may be used in the future. Non-use benefits (such as those for recreational benefit) arise simply by having the resource in existence.

The water physical stock account measures, where possible, interactions between the hydrological cycle and the economy. The exchange of water between the environment and the economy is partly represented by net abstraction in the ‘outflows to sea and net abstraction’ component of the stock account. Estimates of water abstraction and discharges includes: water use for livestock drinking and dairy-shed requirements; and abstraction and discharge for hydroelectricity generation.

The stock classification for freshwater resources reflects those components of the hydrological system that are available for water abstraction and that provide direct inputs into the economy. Soil moisture, glaciers, and permanent snow are not specifically classified as a ‘stock’ as water is not abstracted directly from these sources. However, they are important components of the hydrological system and are included in this account.

Regional and national figures

The water physical stock account is compiled on a regional and national basis. Although New Zealand is a relatively small country, there is considerable variation in precipitation and water availability among regions, especially in the South Island. For example, droughts may occur in Canterbury at the same time as heavy rainfall occurs on the West Coast. Accounts at the regional level allow more meaningful analysis. Such extremes tend to average out at the national level.

Exclusions

Opening and closing stocks

Opening and closing stocks are excluded because of difficulties in measuring volumes, particularly for rivers. SEEA includes opening and closing stocks in the water asset or stock account and suggests that the stock of water in a river can be measured by the volume of the riverbed. However, many South Island rivers are braided and have riverbeds that are constantly shifting. Data are not available for riverbed volumes in New Zealand. The absence of opening and closing stocks for rivers means that total opening and closing stocks cannot be calculated. The water physical stock accounts therefore, are presented in the form of a water balance, where inflows equal outflows plus changes in stored volumes.

Water abstraction

Currently, there is insufficient data to quantify the actual volumes of water abstracted for irrigation, industrial use, municipal and domestic use, livestock use, and geothermal electricity production.

Outflows to sea and net abstraction are estimated as a residual volume, calculated as the inflow minus other outflow and change in storage. Net abstraction is the difference between abstraction and discharges. It is not specifically calculated because there is insufficient data on abstraction and discharges back into the environment.

As robust and comparable data becomes available, it is ideal that a physical flow account for water will be developed which will show sources, uses, and return flows of abstracted water. The physical flow account could then be linked to the stock account to show what water is available and how it is used. Example tables for physical supply-and-use tables for water are shown in the SEEA central framework manual (see table 3.6).

Estimates for these components will be included in future water physical stock accounts as robust and comparable data becomes available.

Water quality

Water quality is outside the scope of the water physical stock account. Development of ecosystem accounts may provide a means for integrating water quality and stock information.

Data quality

Stats NZ has taken all possible reasonable steps to ensure the quality of the data. An assessment against the six data-quality criteria for official statistics is presented below.

Relevance

The water physical stock account is based on a water balance approach by region, showing the inflows, outflows and changes in storage. Stock information is not available for many components. The account does not yet contain information on key sources of abstraction, such as irrigation.

Accuracy

Customised reports from NIWA (2011, 2015) and GNS (Moreau & Bekele, 2017) provide more detail on the accuracy of the data and models used in this account.

Timeliness

The water physical stock account is currently published with a significant lag. It is a significant undertaking for the input data to be produced and climate-related changes are likely to occur over a longer timeframe, therefore this account will be updated approximately every five years.

Coherence/consistency

The methodology used here is consistent with guidance in SEEA. Time-series consistency has been ensured.

Accessibility

All assumptions and explanations of the impact of these assumptions have been made. Data are available in CSV format and Excel tables.

Interpretability

Customised reports from NIWA (2011) and GNS (Moreau & Bekele, 2017) provide more detail on the components used in this account.

Glossary

annual catch entitlement (ACE): Under the Fisheries Act 1996, the annual catch entitlement system was introduced in October 2001. This system separates the property right of the quota from the harvesting right. On the first day of each fishing year, individual transferable quota (ITQ) generates a harvesting right – ACE. Ownership of ACE provides the harvesting right, and this can be traded separately from quota during the fishing year. For example, if a fisher owns 1,000 quota shares, having the quota weight equivalent of 10 tonnes of ITQ, those quota shares will generate 10 tonnes of ACE at the beginning of each new fishing year. The ITQ may be traded separately at any time during the fishing year but has no fishing rights attached to it (new fishing rights will be generated by the ITQ at the beginning of each fishing year). During each year, ACE can be used to balance catch, or satisfy or obtain a remission of deemed value liability.

asset value: The asset value of a natural resource is conceptually the market value of the asset if it was sold. However, in practice market values will not always be available. Where market prices do not exist the asset value is estimated as the net present value of discounted resource rent.

carbon sequestration: A natural or artificial process by which carbon dioxide is removed from the atmosphere and held in solid or liquid form

cultivated timber: Tree resources whose natural growth and regeneration are under direct control, responsibility, and management of an institutional unit. Currently, in the timber account all exotic timber is assumed to be cultivated timber.

deemed value: If a fisher does not hold sufficient ACE, they incur a financial cost for taking the fish – being required to pay a deemed value. The deemed value is set at a rate that eliminates any financial benefit that the fisher may receive from landing the fish.

degradation: Refers to the loss in quality of the natural resource as a result of surrounding concentrations of pollutants or other activities and processes, such as improper land use, natural disasters, pests and disease.

discount rate: Annual percentage by which future income is discounted to give an equivalent value in the present period. The discount rate expresses a time preference for money now rather than in the future. A social discount rate or social rate of time preference reflects the time and risk preferences of society as a whole. It reflects the value that society attaches to present, as opposed to future consumption. A social discount rate will usually be applied by government in relation to its decision-making on behalf of a society.

El Niño Southern Oscillation (ENSO): Cyclical change in the movement of wind and warm equatorial water across the Pacific Ocean. An El Niño or La Niña phase of ENSO occurs every two to seven years and lasts around a year (NIWA, nd). In New Zealand, the impacts vary between individual phases, but over summer, an El Niño tends to lead to increased westerly winds, with more rain in the west and drought in the east (Salinger & Mullan, 1999). By comparison, a La Niña may lead to fewer westerly winds and more north-easterly winds in New Zealand. This tends to cause warmer temperatures around the country and more rain in the northeast of the North Island and less in the south and southwest of the South Island.

environmental assets: Naturally occurring living and non-living components of Earth, together constituting the biophysical environment, which may provide benefits to humanity.

exclusive economic zone (EEZ): Within its exclusive economic zone, which extends 200 nautical miles from the coast, New Zealand has sovereign rights over the management of the resources of the seabed and water column. New Zealand also has jurisdiction in respect of construction of artificial islands, marine scientific research, and protection and preservation of the marine environment, subject to the rights of other States including: freedom of navigation, overflight, and laying of submarine cables.

final consumption expenditure: Consists of expenditure incurred by resident institutional units on goods or services that are used for the direct satisfaction of individual needs or wants, or the collective needs of members of the community. Final consumption expenditure may take place on the domestic territory or abroad. Final consumption expenditure is incurred by households, non-profit institutions serving households and general government. Non-financial corporations, financial and insurance corporations do not have final consumption expenditure.

free on board (FOB): Value of export goods, including raw materials, processing, packaging, storage, and transportation up to the point where the goods are about to leave the country as exports. FOB does not include storage, export transport, or insurance cost to get the goods to the export market.

gigawatt hour (GWh): Unit of energy representing one billion (1,000,000,000) watt hours and is equivalent to one million kilowatt hours. Gigawatt hours are often used as a measure of the output of large electricity power stations. One GWh equals 0.0036 petajoules.

gross domestic product (GDP): Measure of the total economic activity of an economy occurring within the natural boundary of a country.

gross fixed capital formation: Measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realised by the productive activity of institutional units.

gross operating surplus: Surplus generated by operating activities after the labour input has been compensated.

harvesting (non-recoverable volume): Volume of timber removed that is not commercially viable for example, stumps and non-merchantable tops of stems.

harvesting (recoverable volume): Volume of timber removed that is commercially viable. The entire tree is removed.

individual transferable quota (ITQ): Individual transferable quota system divides the commercial catch among fishers. An ITQ permits the holder to catch a specified percentage of the total allowable commercial catch (TACC) for a particular stock. Fishing companies and independent fishers buy or sell their ITQs in the same way property is bought or sold. They are owned in perpetuity unless sold. In 1986 provisional quotas were allocated to fishers in proportion to their catch history. To reduce the provisional quotas, so the total quota issued equalled the desired TACC for each fish stock, the Government bought up provisional quotas from commercial fishers by a tender system. Initially, quotas were issued in tonnage, but in 1990 the Government moved to proportional quotas. Quotas are now a percentage of the TACC for each species. Foreign ownership of ITQs within New Zealand's exclusive economic zone (EEZ) is not allowed, unless granted by the Minister of Finance and the Minister of Fisheries.

Interdecadal Pacific Oscillation (IPO): Pattern of sea-surface temperature and sea-level pressure changes over the Pacific basin that occur over 20- to 30-year timescales. It affects the strength and frequency of ENSO (Salinger et al, 2001). In New Zealand, a positive IPO phase is linked to stronger west to southwest winds, more rain in the west, and drier conditions in the north and east. The opposite occurs in a negative phase. IPO was in a negative phase from 1999 to 2013, then switched to a positive phase.

lifespan: Estimated time for which an asset will continue to be in use and produce revenue.

megawatt: Unit for measuring power that is equivalent to one million watts. A megawatt hour (Mwh) is equal to 1,000 kilowatt hours (Kwh). It is equal to 1,000 kilowatts of electricity used continuously for one hour.

natural timber: Tree resources whose natural growth and regeneration are not under direct control, responsibility, and management of an institutional unit. Currently, in the timber account all indigenous forests are assumed to be natural timber.

net generation: Generation that excludes that used on-site for auxiliary services (eg, lighting, coal grinders) and internal losses. Net generation does not include transmission/distribution losses.

net operating surplus (NOS): Gross operating surplus, less consumption of fixed capital.

net present value (NPV): Value of an asset, based on the summed value of discounted future earnings from the use of the asset.

new planting: Planting of trees for the primary purpose of producing wood or wood fibre, on land that has not previously been used for growing planted production forests.

non-renewable energy: Exhaustible energy source that cannot be regenerated after use.

quota management system (QMS): System that has been in place since 1986. Catch limits for each stock are set by the Minister of Fisheries and the commercial allocation is provided to commercial fishers through the annual catch entitlements.

rate of return: Measures the ‘profitability’ of an asset. Often calculated by dividing the operating surplus by the capital stock. Stats NZ adopted a 4 percent real rate of return for capital assets in the compilation of productive capital stock and productivity estimates for all industries and all years.

removals: Total volume of timber resources removed from forest land, other wooded land, and other land areas during the accounting period.

renewable energy: Energy source that after exploitation can return to previous stock levels by natural processes of growth or replenishment, as long as the resource is managed adequately.

resource rent: The revenue generated from a resource, less all costs incurred in its extraction.

restocking: Replanting of planted production forest area that has been clear felled.

System of Environmental-Economic Accounts (SEEA): Developed by the United Nations Statistical Division as a satellite system to the System of National Accounts (SNA), to incorporate environmental concerns (costs, benefits, and assets) in the national accounts. SEEA is intended to be a system with global application and standards suitable for all countries and all aspects of the environment. SEEA is the international standard for measuring the links between the environment and the economy.

System of National Accounts (SNA): International accounting framework consisting of a coherent, consistent and integrated set of macro-economic accounts, balance sheets and tables. SNA is based on agreed concepts, definitions, classifications, and accounting rules. It provides a framework within which economic data can be compiled and presented for the purposes of economic analysis, and decision and policy making.

taxes on production and imports: Consist of taxes payable on goods and services when they are produced, delivered, sold, transferred, or otherwise disposed of by their producers plus taxes and duties on imports that become payable when goods enter the economic territory by crossing the frontier or when services are delivered to resident units by non-resident units; they also include other taxes on production, which consist mainly of taxes on the ownership or use of land, buildings or other assets used in production or on the labour employed, or compensation of employees paid.

thinning (non-recoverable volume): Additional timber lost when timber is extracted for commercial use. This is removed from the tree without removing the tree entirely.

thinning (recoverable volume): Extraction of timber for commercial use. This is removed from the tree without removing the tree entirely.

total allowable catch (TAC): Catch limit set each year by the Minister of Fisheries. It covers total removals from the stock including commercial, recreational, and Māori customary.

total allowable commercial catch (TACC): Total allowable commercial harvest of fish. This is set once each year by the Minister of Fisheries.

user cost of produced capital: Cost of using produced capital assets in a year. It accounts for the price change of the asset, an exogenous rate of return, depreciation, and the sum of all taxes-less-subsidies that the government levies on owning certain assets.

Appendix: Marine industry activity categories

Offshore minerals

ANZSIC classification: B07000 oil and gas extraction
Primary activities (ANZSIC06): natural gas extraction; oil shale mining; petroleum gas extraction

ANZSIC classification: B10110 petroleum exploration
Primary activities (ANZSIC06): natural gas and petroleum exploration

General comments: Does not include refining or blending materials into petroleum fuel or manufacturing fuel from liquefied petroleum gases. Oil and gas field support services, a primary activity or B10900 other mining support services, are not included.

Fisheries and aquaculture

ANZSIC classification: A04110 rock lobster and crab potting
Primary activities (ANZSIC06): crab fishing or potting; rock lobster fishing or potting; saltwater crayfish fishing

ANZSIC classification: A04120 prawn fishing
Primary activities (ANZSIC06): prawn fishing; scampi fishing

ANZSIC classification: A041300 line fishing
Primary activities (ANZSIC06): bottom long-line fishing; line fishing; ocean trolling; squid jigging; surface long-line fishing

ANZSIC classifications: A04140 fish trawling, seining and netting
Primary activities (ANZSIC06): beach seining, fishing; bottom gill netting, fishing; Danish seining, fishing; finfish trawling; pair trawling; purse seining, set netting, fishing; surface netting, fishing

ANZSIC classifications: A04190 other fishing
Primary activities (ANZSIC06): abalone/paua fishing; freshwater eel fishing; freshwater fishing nec; marine water fishery product gathering; oyster catching (except from cultivated oyster beds); pearling (except pearl oyster farming); seaweed harvesting; spat catching; turtle hunting

ANZSIC classifications: A02010 longline and rack (offshore) aquaculture
Primary activities (ANZSIC06): mussel farming (longline), offshore longline or rack aquaculture, oyster farming (rack), paua farming (longline or rack), pearl oyster farming (rack), seaweed farming (longline or rack)

ANZSIC classifications: A02020 caged (offshore) aquaculture
Primary activities (ANZSIC06): farming of caged finfish, salmon, trout, and tuna

ANZSIC classifications: C11200 seafood processing
Primary activities (as defined by ANZSIC 2006): crustaceans processed mfg (including cooked/frozen) nec; fish cleaning or filleting; fish fillet manufacturing; fish loaf or cake manufacturing; fish pate and paste manufacturing; dried, smoked, and canned fish manufacturing; molluscs processed mfg (incl shelled); oyster shelling, freezing, or bottling in brine; scallops preserved mfg; seafoods preserved and canned mfg; seafood canned manufacturing

ANZSIC classifications: F36040 fish and seafood wholesaling
Primary activities (ANZSIC06): crustaceans wholesaling (incl processed, except canned); fish wholesaling; molluscs wholesaling (incl processed, except canned); seafoods fresh or frozen wholesaling

General comments: A020300 onshore aquaculture is excluded as by definition these activities take place on land. All subdivision A041 fishing is included. Some units in A04190 other fishing may be involved in freshwater fishing (longfin and shortfin eels). However, this is a small-value fishery compared with commercial capture fisheries as a whole.

Shipping

ANZSIC classifications: C23910 shipbuilding and repair services
Primary activities (ANZSIC06): drydock operation, hull cleaning, ship repairing, ship wrecking, shipbuilding, submarine constructing

ANZSIC classifications: C23920 boatbuilding and repair services
Primary activities (ANZSIC06): boat repairing; boat building; canoe, dinghy, and inflatable boat manufacturing; jet boat building, motorboat, inboard, and outboard building; powerboat building; sailboat manufacturing; yacht construction

ANZSIC classifications: I48100 water freight transport
Primary activities (ANZSIC06): coastal sea freight transport service between domestic ports, freight ferry service; harbour freight transport service; international sea freight transport service between domestic and international ports; river freight transport service; ship freight management service (ie, operation of ships on behalf of owners); water (river, sea, and lake) freight transport service

ANZSIC classifications: I48200 water passenger transport
Primary activities (ANZSIC06): boat charter, lease or rental with crew for passenger transport; ferry operation including vehicular; passenger ferry service; passenger ship management service (ie, operation of ships on behalf of owners); ship charter, lease or rental, with crew, for passenger transport; water passenger transport service; water taxi service

ANZSIC classifications: I52110 stevedoring services
Primary activities (ANZSIC06): ship loading or unloading service (provision of labour), stevedoring service

ANZSIC classifications: I52120 port and water transport terminal operations
Primary activities (ANZSIC06): coal loader operation (water transport); container terminal operation (water transport); grain loader operation (water transport); port operation; ship mooring service; water freight terminal operation; water passenger terminal operation; wharf operation

General comments: C23920 boatbuilding and repair services excludes the manufacturing of boats from fibreglass (included in C19190 other polymer product manufacturing) and manufacturing of surfboards and sailboards (included in C25920 toy, sporting, and recreational product manufacturing). Sea freight forwarding services are included in C52920 freight forwarding services and not included in the report. Leasing, hiring, or chartering ships without crew are also excluded (a primary activity of C66190 other motor vehicle and transport equipment rental and hiring). The operating of charter fishing boats and whale-watching cruises are excluded as they could not be separated from I50100 scenic and sightseeing transport. Constructing and planning port facilities are not included in port and water transport terminal operations. Some activities may be operated on fresh water rather than the marine environment but is included as the majority of primary activities are marine based.

Marine tourism and recreation

ANZSIC classifications: G42450 marine equipment retailing.
Primary activities (ANZSIC06): boat retailing (including used); boat trailer retailing; marine accessories retailing nec; outboard motors retailing; sailing or nautical accessories retailing; yacht retailing

General comments: The scope of this section would be all units providing services to tourists and all retail products and services aimed to be used within the marine environment. It was not possible to identify tourism and recreation ANZSIC classes that primarily dealt with marine activity except marine equipment retailing. Retailing sailboards, canoes, or wetsuits are included in G42410 sport and camping equipment retailing. Hiring of pleasure craft (without crew) are not included as these activities are recorded in the rental, hiring, and real estate services industry.

Marine services

ANZSIC classifications: I52190 other water transport support services.
Primary activities (ANZSIC06): lighterage service; navigation service (water transport); pilotage service; salvage service, marine; ship registration and agency service; towboat and tugboat operation; water vessel towing service

General comments: Marine conservation. Many units whose activities include marine conservation will be included within ANZSIC S95500 other interest group services. Many of these will also be non-profit organisations.

Government and defence

The latest estimates for the 2007–16 years include a partial measure of government and defence, which uses local government information (from city, district, and regional councils) from the local authority census, which recorded expenditure under the activity code for marine safety.

Marine construction

General comments: The scope of this section would include construction of wharves and port facilities and also coastal defences and restoration. It was not possible to identify construction ANZSIC classes identified that primarily dealt with marine construction.

Marine manufacturing

General comments: The scope of this section would be all equipment used in the marine environment not already included within the shipping category and all marine manufactures, for example, medicines or health products not already covered within fisheries and aquaculture. It was not possible to identify manufacturing ANZSIC classes that primarily dealt with marine manufacturing.

Research and education

General comments: The scope of this section would be all research and education relevant to the marine environment. It was not possible to identify education and research ANZSIC classes that primarily dealt with marine manufacturing.

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