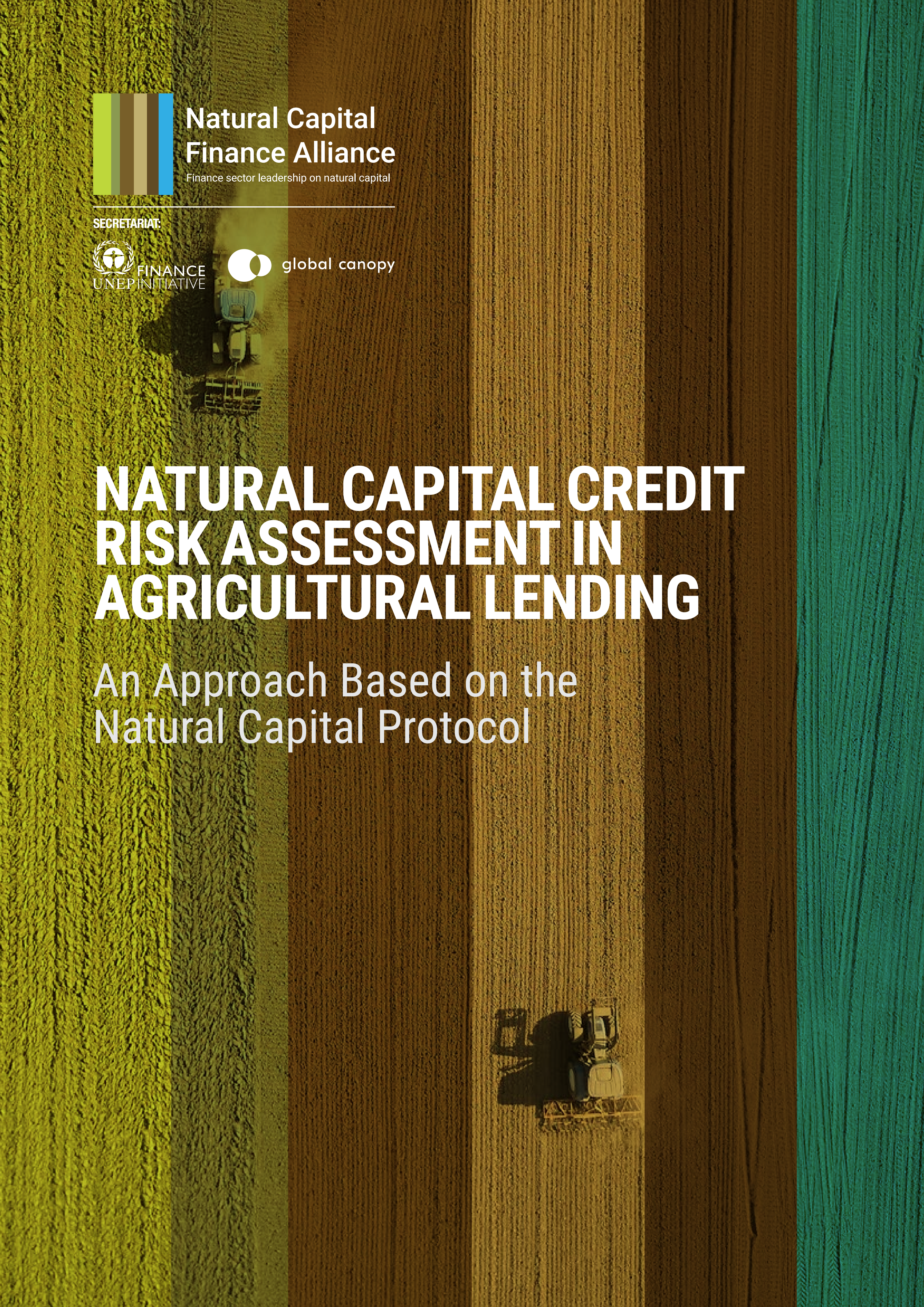

Natural Capital Finance Alliance

Finance sector leadership on natural capital

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NATURAL CAPITAL CREDIT RISK ASSESSMENT IN AGRICULTURAL LENDING

An Approach Based on the Natural Capital Protocol

ACKNOWLEDGEMENTS

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This document is based on research originally conducted under the Sense-T 'Sensing Natural Capital' project, funded by the Australian Commonwealth Department of Infrastructure and Rural Development (Ascui & Cojoianu 2017; Cojoianu & Ascui 2018). The authors thank the research team members, interviewees and the project's industry partners, National Australia Bank (NAB) and the Climate Disclosure Standards Board (CDSB) for their support.

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CITATION

Ascui, Francisco and Cojoianu, Theodor (2019) *Natural Capital Credit Risk Assessment in Agricultural Lending: An Approach Based on the Natural Capital Protocol*, Oxford: Natural Capital Finance Alliance.

CONTENTS

FIGURES

TABLES

FOREWORD

Agriculture is a high risk sector both in terms of its dependencies and impacts on natural capital. A confluence of pressures driven by consumption patterns and demographic changes, land degradation, water scarcity, pollution, loss of biodiversity and climate change combine to compromise our ability to continue current production patterns while satisfying increasing demand from population growth and changing diets.

We are seeing increasing incidents of droughts, floods, pollination failure and changing temperature patterns affecting yields and crop selection. Despite this, the finance sector has relatively little experience with assessing agricultural sustainability and its effect on long-term productivity in a systematic manner.

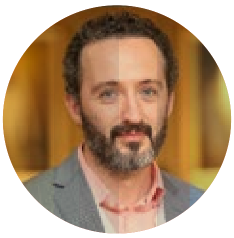
Supporting financial institutions' ability to analyse natural capital related risks and opportunities in agriculture requires the development of new decision support frameworks for different asset classes and financial products. Here we provide a framework for the inclusion of natural capital considerations into credit risk assessment for agricultural lending.

The framework is presented as a more detailed elaboration of the overarching framework for identifying, measuring and valuing natural capital impacts and dependencies set out in the Natural Capital Protocol (Natural Capital Coalition 2016) and the Connecting Finance and Natural Capital supplement to the Protocol (Natural Capital Coalition 2018). The work follows from the launch of the Natural Capital Finance Alliance's ENCORE (Exploring Natural Capital Risks, Opportunities and Exposure) tool in 2018, which systematically details the dependency link between nature and economy, developed in partnership with UNEP-WCMC. The first application of the ENCORE environmental risk framework, Integrating natural capital in risk assessments: A step-by-step guide for banks, was published in 2019 in partnership with PwC. This details an overarching approach to advanced environmental risk management by banks, with case studies covering mining, agriculture and infrastructure.

This report builds on previous work by presenting an in-depth approach to natural capital and credit risk in agriculture. This framework has been developed on the knowledge that agricultural enterprises have significant impacts and dependencies on natural capital, leading to risks (and opportunities) which are unlikely to have been fully evaluated by lenders in the past, leading to sub-optimal allocation of capital in current credit risk assessment processes. Evaluating these natural capital risks (and/or opportunities) would allow improved allocation of capital, with more flowing towards enterprises with better management of natural capital impacts and dependencies, resulting in enhanced financial outcomes for the lender, and greater value for society as a whole.

A process for natural capital assessment is incorporated in a generic model for credit risk assessment, which proposes that the overall risk is a product of the current risk level, the likely future trend over the relevant timescale(s), the probability of the risk being priced and the farmer's ability to mitigate the risk. The model is applied to wheat production in Australia, but can be adapted to other agricultural production systems in different regions.

This work is one of a growing number of examples of approaching natural capital risks and opportunities in the finance sector from a pricing perspective, which are available on the Natural Capital Finance Alliance website.



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INTRODUCTION

It is increasingly recognised that financial institutions have significant impacts and dependencies on natural capital – defined as the stock of the world's renewable and non-renewable natural resources and ecosystems that yield flows of environmental goods and services, which directly and indirectly underpin the global economy and human wellbeing. Historically, many of these impacts and dependencies have been overlooked. The value of goods and services that nature provides 'for free' has often been ignored, and resources have typically been priced at their cost of extraction, rather than the cost of their replacement or substitution, which would promote more sustainable long-term use. Despite its importance, natural capital rarely appears on the balance sheets of corporations and is seldom taken into account in financial decision-making. These practices can ultimately translate into unpriced material risks for financial institutions that may emerge at either local or systemic levels. For example, natural capital risks may result in higher loan defaults or lower returns on equity than are currently priced into loan interest rates or equity valuations.

The Natural Capital Finance Alliance (NCFA) is a finance-led initiative which seeks to address this gap by integrating natural capital considerations into decision-making for financial products and services. This requires the development of new decision support tools for different asset classes and financial products. Here we provide one such tool: a framework for the inclusion of natural capital considerations into credit risk assessment for agricultural lending.

Having such a framework for agricultural lending is important for two reasons. The first is that agriculture is a front-line sector in terms of both its dependencies and impacts on natural capital. Agriculture is a major driver of global land-use change, which is estimated to cause losses of ecosystem services worth US$4.3-20 trillion/year (Costanza et al. 2014). At the same time, agriculture is fundamentally dependent on a range of both renewable and non-renewable natural capital inputs, from soil and water to nutrients and pollination services. Despite this, the finance sector has relatively little experience with assessing agricultural sustainability and its effect on long-term productivity. A survey of 26 financial research providers conducted for the NCFA in 2015 (Cojoianu et al. 2015) found that only nine claimed to have any methodological expertise in assessing natural capital risks in agriculture. This expertise was limited to either whole-sector analysis (based on input-output modelling) or individual assessments for large listed or private companies. More granular assessment at the farm level, which is the relevant unit of analysis for agricultural lending, is not yet offered by financial research providers.

Secondly, secured lending—particularly at the relatively small scale typical of loans to farmers—is an asset class that has been relatively overlooked in the shift towards greater awareness of natural capital issues across the finance sector. Although banks started to take certain high-profile environmental risks into account from the 1980s (e.g. liability for contaminated land clean-up costs, driven by legislation such as the *Comprehensive Environmental Response, Compensation and Liability Act 1980* in the United States), this has generally not evolved into a more comprehensive approach to integrating natural capital impacts and dependencies into credit risk assessment. A survey of 36 financial institutions (mainly banks) in 2015 found that although 42% of respondents claimed to consider natural capital risks in their credit risk assessments, on closer questioning there was no evidence that this was done systematically (Cojoianu et al. 2015). The most widely applied environmental, social and governance (ESG) risk management framework for debt is the Equator Principles, which were launched in 2003 and have now been adopted by 92 financial institutions from 37 countries, covering the majority of project finance debt in developed and emerging markets.[1] However, the Equator Principles are targeted at project finance transactions over US$10 million, or project-related corporate loans over US$100 million, and are therefore not normally applied to the smaller-scale lending that is more typical in the agricultural sector. In addition, the Equator Principles focus mainly on environmental impacts, and provide minimal guidance for evaluating risks arising from natural capital dependencies (Equator Principles 2013).

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1 http://equator-principles.com/members-reporting/ (accessed 1 June 2018).

The lack of attention to natural capital in secured lending has multiple reasons, including lack of awareness, lack of suitable contextual methodologies, availability of data, budgets and capacity. The agricultural sector presents further challenges due to being highly **context-specific**, with impacts and dependencies that vary considerably between sectors and geographies, as well as between individual farms. This framework addresses some of the methodological challenges by providing a process and guidance for how natural capital risks (arising from both impacts and dependencies) could be addressed in lending to agriculture, with specific examples drawn from a case study based on lending to wheat farming businesses in Australia. The framework is intended for use within a bank or other lending institution, for example by a credit assessment officer evaluating an agricultural loan application. Typically such loans may be to purchase land or equipment, or smaller amounts to provide working capital, recognising that agricultural incomes and expenditures are often not well matched and/or uncertain. The framework could also be used by a farmer to evaluate whether they are doing the right things to improve their access to credit in future.

The framework is presented as a more detailed elaboration of the overarching framework for identifying, measuring and valuing natural capital impacts and dependencies set out in the Natural Capital Protocol (Natural Capital Coalition 2016) and the Connecting Finance and Natural Capital supplement to the Protocol (Natural Capital Coalition 2018). The latter (henceforth referred to as 'the Supplement') covers all financial asset classes and products, whereas the present framework is intended to apply to a specific asset class (secured lending) and sector (agriculture). To avoid duplication, we do not cover all steps in detail; the framework should therefore be read in conjunction with the Supplement. The framework, like the Protocol and Supplement, is divided into four stages covering 'why', 'what', 'how', and 'what next'.

The framework is a natural capital *risk assessment* framework as opposed to a natural capital *accounting* framework. Accounting frameworks are generally backward-looking and concerned with measurement and valuation, whereas risk assessment is forward-looking and concerned with risk evaluation.

Background to the examples: Wheat farming in Australia

Most of Australia's grain production is located on a narrow belt of land (in the east, south east and south west of the country), known as the Wheatbelt or Grainbelt, which benefits from a temperate climate, sufficient rainfall (on average 300-600mm/year) and relatively fertile soils (Land Commodities 2012). At 46 million hectares, the Wheatbelt comprises 6% of Australia's total land area (Land Commodities 2012). Despite the name, farmers in the Wheatbelt also run livestock and grow other crops in addition to wheat. Rotating between wheat, other crops and livestock can help manage pests and diseases, improve soil nutrition and mitigate the risk of crop failure through diversification. In 2014-15, wheat was grown on about 57% (13.8 million ha) of total Wheatbelt farmland (24.3 million ha) (Farrell 2015).

The majority of Australia's grain, including around 90% of wheat, is grown in a single winter growing season, with the precise harvesting period varying by region (Land Commodities 2012). Given relatively low levels of rainfall over much of the Wheatbelt, there is minimal water available for irrigation. Hence, almost all grain in Australia is produced under a dryland cropping system (i.e. crops are rain-fed, as opposed to irrigated).

Natural Capital Credit Risk Assessment Framework

1. FRAME STAGE: WHY?

The Frame Stage helps you establish **why** you would conduct a natural capital credit risk assessment. The Supplement provides extensive guidance on this, including clarification of key natural capital concepts and the merits of undertaking an assessment.

This framework has been developed on the assumption that agricultural enterprises may have significant impacts and dependencies on natural capital, leading to risks (and opportunities) which are unlikely to have been fully evaluated by lenders in the past, leading to sub-optimal allocation of capital in current credit risk assessment processes. Evaluating these natural capital risks (and/or opportunities) would allow improved allocation of capital, with more flowing towards enterprises with better management of natural capital impacts and dependencies, resulting in enhanced financial outcomes for the lender, and greater value for society as a whole.

Nevertheless, undertaking such an evaluation has a cost, which may be high relative to its benefits, therefore it is not suitable in all circumstances. It might make sense to start only with the largest loans in the highest-impact sectors, for example. It should also be recognised that while the initial costs of doing an assessment may be high, the unit cost should fall over time, as assessment processes become streamlined.

As this framework is primarily intended for use in bank lending, which is a particularly risk-averse form of financing, the focus is on risk rather than opportunity assessment. Nevertheless, it could be adapted to assess opportunities, such as those arising from the absence of certain risks, compared to alternatives. Likewise, the framework is mainly intended to be applied at individual loan level, but could be adapted for analysis of a portfolio of similar loans. For bottom-up portfolio analysis aggregation becomes an additional challenge.

2. SCOPE STAGE: WHAT?

The Scope Stage involves defining **what** should be included in an assessment.

An important and distinctive feature of the agricultural sector is that relevant natural capital impacts and dependencies vary considerably across geographies and agricultural sub-sectors (e.g. different crops and livestock production systems). For example, a soil condition that is beneficial for one crop type can be unfavourable for another, and even the same crop grown on the same soil under different climatic conditions can require very different inputs. Therefore, while in theory a comprehensive set of risk factors and indicators could be used to assess natural capital risks across all agricultural types and geographies, the reality is that such an assessment would be so broad as to be prohibitively resource-intensive for the evaluation of an individual loan. A two-stage approach is therefore recommended, in which the key potential risks are first scoped at sector/region level (e.g. for wheat farming in Australia – see Table 2 in Step 3.2 below) to establish a framework within which loan-specific assessments, for that sector and region, can then be made.

Definitions

Risk factor: This term has the same meaning as 'risk source' in ISO31000: an element which alone or in combination has the intrinsic potential to give rise to risk (ISO 2018).

Risk indicator: A risk indicator is something that can be measured, either qualitatively or quantitatively, in order to assess a risk factor.

Once the scope has been determined at sector/region level, it should not need to be repeated at that level unless new information about material risks comes to light; scheduling a regular review at a suitable interval can help to ensure any such changes are incorporated. Scoping at the individual loan level is mainly a process of checking whether the sector/region scope is appropriate for the particular circumstances, and considering whether any risks should be added or removed.

Example: scoping key risks at sector/region level:

The key risk factors for wheat farming in Australia are summarised in Table 2 (in Step 3.2 below), which has been derived from a detailed review of academic and industry publications, plus financial sector interviews (Ascui & Cojoianu 2017; Cojoianu & Ascui 2018). It will not, however, include *all* possible natural capital risks which may affect any particular wheat farm in Australia. For example, the sector-level assessment does not include waste as a key risk, as this was not identified as a common risk across the sector. Nevertheless, farming activities can produce various forms of waste, and in some cases (e.g. on-farm disposal of lead-acid batteries) this could result in significant impacts on natural capital. If this is the case, then the impact of these risks should also be evaluated: they should be included within the scope at the individual loan level, even if absent at the sector level. Similarly, it is likely that some of the sector-level risks will not be relevant to individual cases: for example, salinity is a problem in specific areas, but may not be applicable in other areas. Therefore the scope of the assessment, as determined at sector/region level, should always be checked and confirmed at the level of the individual loan.

STEP 2.1: DECIDE THE OBJECTIVE; **STEP 2.2:** IDENTIFY THE TARGET AUDIENCE

We assume that the **objective** of the assessment is to assess material risks to agricultural lending and the **target audience** is internal, e.g. a credit assessment officer or credit committee. However, the framework could be adapted for different objectives and audiences, and the Supplement provides guidance for clarifying these.

STEP 2.3: DEFINE THE SCOPE

The steps within this section are highly inter-related, and may therefore need to be considered as a whole.

Step 2.3.1: Decide the focus of the assessment; Step 2.3.2: Decide whether to focus on impacts and/or dependencies; Step 2.3.3: Specify value perspective

In this framework the **focus** is assumed to be the individual farm, and the assessment should cover **both impacts and dependencies**. We assume the relevant **value perspective** that the assessment should represent is that of the lender, but the framework could be adapted to reflect the perspective of the farmer, the community or society in general. The perspective chosen may affect the impacts and dependencies that are considered to be material, as well as how they are rated. A key difference between the lender's perspective and a societal perspective is that the former may exclude certain impacts or dependencies if they are considered unlikely ever to be material to the performance of a loan. However, even in such cases, the possibility of the lender being impacted in other ways, e.g. by reputation, should be considered.

Step 2.3.4: Define boundaries and/or scenarios

This step involves the definition of temporal and spatial boundaries and scenarios. The choice of **temporal boundary** or **time horizon** (step 2.3.4) is closely related to the previous question of value perspective. Certain impacts and dependencies are only material in the short- or long-term, and the interests of the stakeholder whose value perspective is being represented may also change with the time horizon (for example, the interests of future generations of society may be different to those of the current generation). More than one time horizon may be relevant to take into account: for example, it may be logical to focus on the term of the loan as the most immediately relevant time horizon; but a longer time-frame may also be considered, reflecting the long-term relevance of obtaining repeat business and the investments made in continuing customer relationships. The **spatial boundary** for the assessment also depends on the value perspective chosen, as well as the time horizon and the type of risk: for example, some impacts and dependencies are specific to the farm, while others are local, regional or even global in scale. Impacts and dependencies may also occur **upstream** or **downstream** in a supply chain.

Examples of spatial distribution of natural capital impacts and dependencies

Local: rain-fed wheat farming fundamentally depends on the local soil conditions and rainfall.

Regional: water pollution can affect entire watercourses. On-farm management of weeds, pests and diseases can affect the extent and severity of outbreaks at regional level.

Global: greenhouse gas emissions produce an impact that is global: climate change. Successful farming also depends upon a narrow range of favourable temperatures, which in turn is affected by global climate change.

Upstream: a farm may be exposed to rising energy costs or pricing of greenhouse gas emissions indirectly, for example via increased prices for fertiliser.

Downstream: agricultural products can have further impacts on natural capital through their consumption or disposal. For example, wheat that is used as cattle feed indirectly contributes to emissions of methane from enteric fermentation; food waste disposed to landfill also produces methane emissions.

Another useful way of thinking about boundaries is by using the concepts of **attributional** versus **consequential** analysis: an attributional analysis measures impacts according to a defined scope of responsibility, while a consequential analysis measures the total system-wide impacts resulting from a decision or action (Brander & Ascui 2015; Finnveden et al. 2009). The two approaches can yield quite different conclusions. For example, an attributional analysis of the conversion of wheat farming from food to biofuel might conclude that it reduces greenhouse gas emissions (due to the biofuel substituting consumption of conventional fossil fuels), whereas a consequential analysis would take into account the fact that additional land (e.g. former grasslands or forest) would need to be brought into production elsewhere in order to meet demand for wheat, which would produce offsetting greenhouse gas emissions. A consequential analysis of US ethanol production from corn found that, when taking these offsetting emissions into account, it produced more net greenhouse gas emissions than continued use of gasoline (Searchinger et al. 2008).

The Supplement recommends selecting a **baseline** and **alternative scenarios** for the assessment. For credit risk assessment purposes, a suitable baseline could be considered to be whatever best represents the 'current situation' or present level of risk for the relevant natural capital risk factors. In practice, an assessment of the 'current situation' may be based on either farm-specific or broader (e.g. regional) historical trends or average conditions. One or more **alternative scenarios** could be considered for the future level of risk. One possibility is to consider the 'best guess' or most realistic expected scenario for the future. Another is to consider a scenario that specifically represents what the loan is intended to achieve, where applicable, e.g. a loan for investments in new technology, in which case the condition before the intervention would be relevant to understand as the baseline, with the change in condition expected after the intervention being a likely source of risk and therefore the relevant scenario to consider. From a lender's risk-averse perspective, negative outcomes are likely more relevant to consider than positive outcomes, and practical considerations may constrain this exercise to considering a single scenario consisting of negative outcomes for each source of risk, as a form of 'stress-testing'. For example, a lender might wish to consider the impacts arising from occurrences or events which represent a certain percentile of negative outcomes for each risk (e.g. the 90th percentile, or outcomes which have a one in ten, or less, chance of occurring). Such scenarios could be established on the basis of historical data, projections from modelling such as that produced by the Intergovernmental

Panel on Climate Change (IPCC n.d.), or qualitatively. Alternatively, a central or 'best guess' scenario could be used in general (as this is most commonly available from analyst reports and other forecasts), with stress-testing only being conducted around certain key variables, such as costs (e.g. of fertiliser or carbon) or rates of change (e.g. the rate of increase in area affected by high salinity).

Step 2.3.5: Conduct materiality assessment

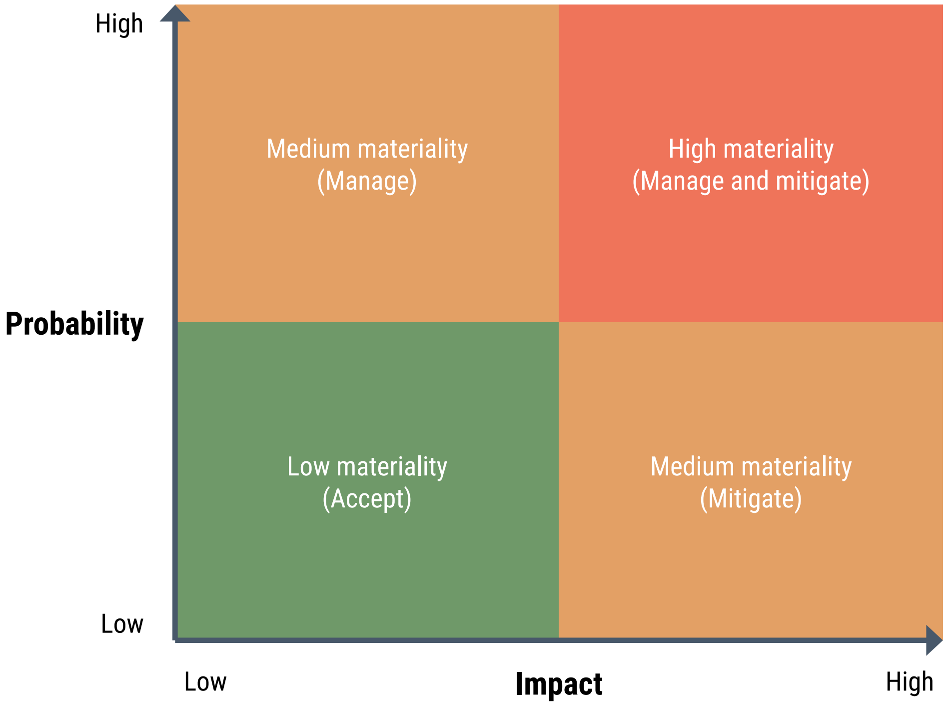
Materiality assessment is a screening step, intended to reduce the field of possible risk factors to the most critical ones. It is mainly relevant at the sector/region level, although it should be briefly revisited when confirming the scope of an entity-level assessment. It first involves defining relevant criteria and then assessing the materiality of impact drivers and/or dependencies against these criteria.

Materiality can be interpreted in different ways. In line with the Supplement, we suggest that **materiality is interpreted broadly as anything that has reasonable potential to significantly alter the decisions being taken**. In the case of natural capital credit risk assessment, the key decisions are whether or not to offer credit to a particular applicant, and on what terms. This essentially involves an assessment of whether the expected risk of offering the loan is commensurate with the expected return for similar loans. The main inputs to this risk assessment are likely to be financial, but other factors, such as reputational risks or benefits, may also affect the assessment of risk or return and might therefore also be considered material. The main financial risk is of loan default – failure to pay interest or principal on the loan when it is due. The financial health of the farming business will have been assessed separately through conventional credit assessment processes. Therefore the role of a natural capital credit risk assessment is to identify additional natural capital related risks which have reasonable potential to affect the financial health of the farming business, or which raise other important risks for the lender.

It is also worth considering what 'risk' means in this particular context. Risk can be regarded as referring to uncertainty of outcomes that are significantly different to expectations, whether in a positive or negative direction (Hardaker 2000). However, common usage tends to focus on the probability of outcomes that are negative or worse than expectations, or 'downside risks'. This also fits with credit as a form of financing that is mainly exposed to downside risks, in contrast to equity investment which is exposed to both positive and negative outcomes. Nevertheless, even in the context of lending, the concept of 'opportunities' can be employed to consider broader positive outcomes, beyond the improved performance of a specific loan, that may eventuate from extending credit to a borrower, such as the possibility of accessing a new market or improving the lender's reputation. This framework could be adapted to assess opportunities, but henceforth will focus on the core purpose of assessing risk.

Each lender will have to determine what it considers to be the threshold for 'reasonable potential' (in the definition of materiality), bearing in mind that the **significance of a risk is the product of its probability of occurrence and its impact** (Figure 1). The most significant risks are those which are highly likely to occur and whose impact is also high (high-probability/high-impact), whereas low-probability/low-impact risks can often safely be accepted (subject to periodic monitoring, in case the probability of occurrence or degree of impact should change in future). It is important to be aware of low-probability/high-impact risks, as they may be mitigated by suitable preparation, insurance or other forms of portfolio-level diversification. Likewise, high-probability/low-impact risks should be flagged as opportunities for management intervention, and checked to ensure that they do not aggregate to higher impacts at portfolio level.

Figure 1: Risk probability-impact matrix



Each lender will have metrics or rules of thumb which are used to assess conventional credit risk, and relevant thresholds for natural capital risks may potentially be extrapolated from these. For example, the main determinants of financial performance of a typical farm can be divided into input costs, yields and output prices, and a risk factor which can produce more than a certain amount of variation (e.g. >10%) in any of these might be considered to have a significant potential impact. Lower impacts might also be considered significant if the probability of this occurring is high. The threshold for 'high' probability could be set at >50%, or a higher or lower level, depending on the inherent variability of the sector and the lender's level of risk aversion. The matrix in Figure 1 can be used as a way of thinking through the appropriate levels of impact and probability to determine materiality thresholds for a particular lender. It should be noted that it may not be practicable to determine quantitative probabilities and/or impacts for a given risk, and qualitative techniques such as expert judgement may be used instead. Sector-specific industry associations are often a good source of information on key risks for that sector.

Where should one draw the line between natural capital and other factors?

Impacts and dependencies on natural capital are often inextricably linked with impacts and/or dependencies on other forms of capital, or broader social, economic or environmental conditions at a variety of scales. For example, the materiality of an individual farm's impact and/or dependency on surface water as a key input could vary considerably with changes in any of the following factors (to name only a few possibilities):

1. Water demand across the whole catchment;
2. Precipitation across the whole catchment (e.g. long-term drought);
3. Atmospheric conditions, e.g. humidity and/or temperature;
4. Regulation, e.g. the allocation of water rights or environmental flows; or
5. Water management technology.

Rather than trying to separate natural capital impacts and/or dependencies from these broader relationships, it is recommended that a pragmatic approach is taken, whereby such interactions are included in the assessment where they clearly contribute to the materiality of a natural capital impact or dependency, unless they are already adequately covered by another existing assessment (e.g. a conventional credit risk assessment may already include an evaluation of technology risk, in which case this dimension could be ignored in a natural capital risk assessment). For example, given the dependency that most forms of agriculture have on benign climatic conditions (Ray et al. 2015), it is logical that weather and climate is included in a natural capital risk assessment, despite the fact that in most classifications it is only the *regulation* of climate that is considered to be an ecosystem service, as opposed to the climate conditions themselves.

The United Nations System of Environmental-Economic Accounting (SEEA) framework (United Nations et al. 2014) provides a set of standardised concepts and terminology around natural capital and ecosystem services. It can be useful to refer to these in order to promote consistency with national-level natural capital accounting and data sources, bearing in mind that the SEEA framework operates at this level and is not intended for farm-level use. There is no single, comprehensive classification or list of relevant agricultural natural capital impact drivers and dependencies, or related risk factors or indicators, at the farm level. In principle, relevant impact drivers and dependencies should be identified in a bottom-up manner, according to the decision-making context (boundaries, scope, objectives etc.), as relying on a pre-existing classification may provide a false sense of completeness, potentially leading to important risks being overlooked. It may be helpful to map the inputs and outputs of the unit of assessment (e.g. in the case of agricultural lending, the farm), and to list the possible impacts and/or dependencies associated with each of these (see step 3.1.1 below).

Nevertheless, pre-existing classifications are helpful in practice, given that the resources for conducting a bottom-up assessment are likely to be limited. Both the Protocol and Supplement provide examples of impact drivers and dependencies (e.g. Tables 4.1 and 4.2 in the Protocol and Tables 2.3 and 2.4 in the Supplement). A number of detailed classifications of ecosystem services exist; the two most widely used being the European Environment Agency's Common International Classification of Ecosystem Services (CICES) and the US Environmental Protection Agency's Final Ecosystem Goods and Services Classification System (FEGS-CS).[2] However, whilst these are highly comprehensive, the sheer number of categories in each is likely to be impracticable for the purposes of loan assessment. In addition, these classifications focus on *flows* of services provided by ecosystems (with some debate about whether abiotic flows such as services provided by water should also be

2 https://cices.eu/ and https://www.epa.gov/eco-research/final-ecosystem-goods-and-services-classification-system-fegs-cs (accessed 5 June 2018).

included) rather than the broader concept of *stocks* of natural capital, which can cover both biotic and abiotic natural resources.

The following table, which has been based on a variety of sources including bottom-up analysis of key natural capital risks for wheat, beef, dairy and vegetable farming in Australia (Ascui & Cojoianu 2017), is proposed as a simpler starting point. Natural capital risks have been grouped into five high-level thematic areas, each including a number of example risk areas associated with natural capital impacts and/or dependencies which repeatedly arise in a variety of agricultural contexts (as explained in the final two columns). These risk areas are not necessarily comprehensive, and exceptions or additional risks are virtually inevitable, given the diversity of agricultural activities. For example, within the 'Weather and climate' theme, certain agricultural activities could be sensitive to wind conditions: if so, this could be included as an additional material natural capital risk area.

Most of the risk areas can be broken down further into more specific risk factors, only some of which are likely to be relevant to any particular sector/region. Table 2 in Step 3.2 below provides an example of the key risk factors for wheat farming in Australia. For example, the risk area 'Fertiliser' can be broken down into two separate risk factors: the use or consumption of fertiliser in itself (which drives upstream energy and resource consumption, and exposes the farm to the risk of price increases) and the way in which it is applied (which determines whether it improves or degrades various soil qualities, and influences impacts such as nutrient run-off and greenhouse gas emissions).

Finally, it should be noted that while it is useful to consider natural capital risk areas separately, many are inter-linked. For example, crop water use depends on various factors including weather and climate conditions, soil characteristics, nitrogen supply and weed cover, each of which can also be treated as distinct risk factors with other impacts beyond water use efficiency. While there are dangers in over-simplifying a complex situation, improving awareness of individual risks is still a practical first step, to which analysis of important inter-linkages can then be added, where feasible.

Table 1: Example key categories for agricultural loan natural capital risk assessment

THEMATIC AREA	EXAMPLE NATURAL CAPITAL RISK AREAS	EXAMPLE IMPACT DRIVERS	EXAMPLE DEPENDENCIES
WATER	**Water availability**	Agricultural activities may have an impact on the availability of water in the local/regional hydrological cycle, particularly for surface and sub-surface water.	All forms of agriculture depend to a greater or lesser extent on access to water, which may be obtained from rainfall, on- or off-farm surface water, or sub-surface water. Availability has a quantity dimension (how much water is available), a temporal dimension (when water is available), and a reliability dimension (how likely it is to be available when required). Too much water can be as problematic as too little water. Risks may also be associated with the reliability of water supply infrastructure, e.g. for irrigated crops or livestock drinking water.
	Water use	The absolute quantity of water use, particularly when extracted from surface flows or sub-surface reserves, can be a key impact driver.	The efficiency of use of the available water is a separate aspect of water dependency, often expressed in terms of the quantity of water used per unit of output.
	Water quality	Any farming activities which affect the quality of a water supply may constitute an impact driver.	Relevant aspects of water quality as a dependency will vary according to the agricultural system (e.g. livestock vs. crops). Key water quality indicators which are critical for livestock health include total dissolved solids, calcium, nitrate and nitrite, fluoride, chloride, acidity (pH), pathogens and parasites, and agricultural chemicals such as pesticides and herbicides.

THEMATIC AREA	EXAMPLE NATURAL CAPITAL RISK AREAS	EXAMPLE IMPACT DRIVERS	EXAMPLE DEPENDENCIES
WEATHER AND CLIMATE	**Temperature extremes**	Not generally applicable, although certain farming activities can affect local micro-climates and/or contribute to larger-scale effects, e.g. through changing the albedo of land surfaces.	Both livestock and crops may be susceptible to heat stress and/or low-temperature conditions, which can be a function of both absolute temperature (and humidity) levels, and length of exposure. Factors such as wind speed, shading/shelter and livestock characteristics (e.g. breed, coat colour, physical activity, condition, and water/feed intake) can also affect temperature risks.
	Extreme weather	Not generally applicable, although certain farming activities can exacerbate or mitigate the effects of extreme weather events.	Agricultural activities may be exposed to a range of extreme weather related risks, including floods, droughts, bushfires and storms.
LAND AND SOIL	**Soil quality**	Any farming activities which affect soil quality factors, either on- or off-farm may constitute an impact driver.	Relevant aspects of soil quality as a dependency will vary according to agricultural system. Examples include soil organic carbon (SOC), acidity (pH), salinity, erosion and compaction.
	Fertiliser	Fertiliser use is a driver of significant upstream impacts (consumption of fossil fuels, minerals and energy), on-farm impacts (e.g. on soil quality and biodiversity) and downstream impacts (including greenhouse gas emissions and run-off). The on-farm and downstream impacts can be assessed under soil quality, water quality and greenhouse gas emissions.	Many agricultural activities depend on fertiliser as a key input, particularly for maintaining and/or enhancing soil nutrients that support crop growth.
	Waste	Farming activities may discharge various forms of waste to the soil, which may affects its condition, biodiversity and/or human health.	Not generally applicable, although certain farming activities may depend on inputs which are considered wastes elsewhere, e.g. application of treated effluent as a fertiliser.
BIODIVERSITY AND ECOSYSTEMS	**Biodiversity**	Farming activities may have impacts on biodiversity through land use changes, habitat loss or degradation, synthetic chemical and fertiliser use, and nutrient run-off.	Farms often depend on biodiversity for services such as pollination or pasture cover and composition.
	Weeds, pests and diseases	The way in which the farm is managed (e.g. prevention and response to outbreaks) can be a key driver of off-farm impacts.	This is an example of a 'negative dependency' or 'ecosystem dis-service', where aspects of the natural environment can have a negative impact on a farming business.
	Animal welfare	Poor management of animal welfare has both a direct impact and can result in further impacts, such as promoting the spread of disease.	The health and welfare of farmed animals is an important factor in their growth and development, which in turn can be considered as a benefit flowing from natural capital. It is also important for a variety of legal, regulatory, reputational and moral reasons.
ENERGY	**Energy use**	The use of energy derived from fossil fuels is a driver of resource depletion and climate change through production of greenhouse gases (considered under air emissions below). This use may be direct (e.g. use of diesel) or indirect (e.g. use of electricity or upstream/downstream emissions associated with any other inputs/outputs).	Agriculture relies directly and indirectly on two main sources of energy: sunshine and fossil fuels. Renewable energy such as wind or hydro power is itself indirectly reliant on the sun's energy, but also requires manufactured capital to enable its conversion into useful energy such as electricity. Sunshine is not considered as a dependency because it is beyond the control of any stakeholders.

THEMATIC AREA	EXAMPLE NATURAL CAPITAL RISK AREAS	EXAMPLE IMPACT DRIVERS	EXAMPLE DEPENDENCIES
AIR	**Greenhouse gas emissions**	Emissions of different greenhouse gases (principally carbon dioxide, methane and nitrous oxide) may occur as a result of a variety of on-farm activities, including land clearing, energy use, fertiliser and other input use, fertiliser application and livestock.	Although plants depend on carbon dioxide for their growth, it is generally not limited in supply, and hence not relevant as a dependency, except for crops grown in greenhouses.
	Other air emissions	Other air emissions from farming may include particulates (dust), drift from pesticide/herbicide application, etc.	Generally not applicable, although there could be examples of one form of agriculture depending on emissions from another, e.g. wind erosion depositing soil nutrients from one location to another.

3. MEASURE AND VALUE STAGE: HOW?

The Measure and Value Stage of the Supplement provides guidance on indicators, changes, and trends in natural capital, and a logical three-step process for measuring and valuing the consequences of these changes:

1. Measure impact drivers and/or dependencies;
2. Measure changes and trends in natural capital; and
3. Conduct valuation of impacts and/or dependencies.

In the context of natural capital credit risk assessment, we suggest that 'measuring' is understood as the process of obtaining quantitative or qualitative data regarding a given risk factor, such that it can be 'valued' by assigning a risk level to that component. The assignment of risk levels to individual factors in turn enables an overall evaluation of whether natural capital risk is commensurate with the expected risk of a similar loan.

The three-step process is adapted in the following **model for credit risk assessment** (Figure 2), which proposes that the overall risk is a product of the **current (historical) risk level**, the **likely future trend** over the relevant timescale(s), the **probability of the risk being priced** (if relevant) and the **farmer's ability to mitigate** the risk. The current (historical) risk level for natural capital risks is analogous to a borrower's financial credit history: it provides a strong indication of the borrower's fundamental vulnerability to expected natural capital risks. In the absence of a method (such as this framework) for assessing natural capital risk at the level of the individual farm, historical natural capital risks may have been partially reflected in the lender's overall risk premium for the sector. However, what is not necessarily currently taken into account is what will happen to the risk level over time, in physical terms (the future trend) and in economic terms (the probability of the risk being priced). Many physical risks translate directly into impacts on farm financial performance (e.g. by reducing yields or increasing input prices) and therefore do not require separate assessment of the probability of being priced, but some (often regarded as 'externalities') depend on being priced in some way, for example by government regulation or changes in consumer demand. Assessing the current (historical) situation is analogous to step 1 in the Supplement, while assessing the future projection is analogous to step 2. Both of these need to be taken into account, in combination with an assessment of the farmer's ability to manage the given risk (step 2c), in order to evaluate the overall risk (step 3).

Figure 2: Risk assessment model

Risk assessment deals with uncertainties at many levels, some of which can be quantified, others at best qualitatively estimated. Given the many challenges associated with natural capital credit risk assessment, a practical objective may be only to assign a relative score to each risk factor. This could be as simple as High, Medium or Low risk, or more sophisticated, with more levels of assessment. The following steps can be followed to arrive at this overall assessment.

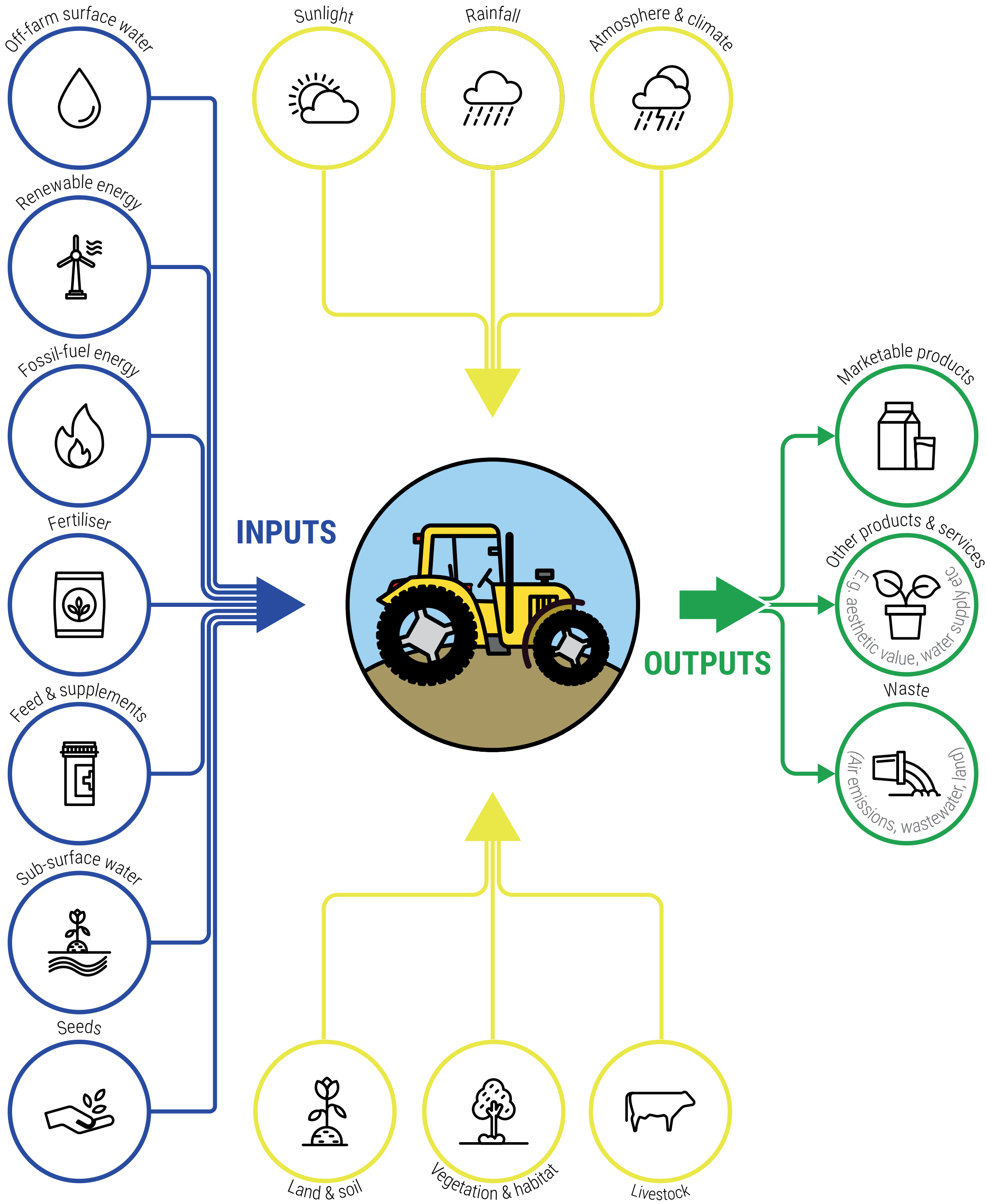
STEP 3.1: MEASURE IMPACT DRIVERS AND/OR DEPENDENCIES

Step 3.1.1: Map activities against impact drivers and/or dependencies

This step involves mapping activities against identified impact drivers and/or dependencies.

Figure 3 below presents a simplified diagram of a farm as a system of natural capital inputs and outputs, which can be adapted to specific farming situations. Local inputs include the land, soil, biodiversity, sunlight, precipitation and other relevant aspects of the atmosphere and climate. External inputs include (but are not limited to) energy, fertiliser and other chemicals, feed, seeds and supplements, and water extracted from surface flows or sub-surface reservoirs. Outputs include marketed products such as grain or livestock, other products or services, such as opportunities for recreation, and waste (including emissions to the air, land and water). The boundaries between natural capital and other forms of capital are not always clear, as many things are a mixture of different forms or a transitional phase between capitals. Therefore we include fertiliser, even though it has been manufactured, because its main inputs are natural resources; but we exclude machinery and labour. Furthermore, some inputs, such as sunlight and atmospheric nitrogen, are critically important to agricultural production, but are excluded from this risk analysis because they are assumed to be constant. By contrast, the nitrogen-fixing services provided by certain plants, such as legumes, are considered a service provided by biodiversity, and therefore could be relevant to consider in a natural capital credit risk assessment, if they play an important role in that specific sector/region.

Figure 3: The farm as an ecosystem



Step 3.1.2: Select indicators for impact drivers and/or dependencies to be measured

Each impact driver and/or dependency that is considered to be material (from step 2.3.5) may need to be further elaborated to identify specific risk indicators: parameters that can be measured, either quantitatively or qualitatively, to enable the risk to be evaluated. It may be necessary to measure more than one parameter to adequately characterise any given risk. An example is given below of how the risk area 'water availability' can be broken down into measurable risk indicators for the case of wheat farming in Australia.

Water availability risk for wheat farming in Australia

In Australia, wheat is largely rain-fed, with most wheat being grown in regions receiving 300-600mm/year of rainfall on average. The level of rainfall is the biggest predictor of agricultural productivity in a given year, and long-term averages are a key determinant of land prices (Land Commodities 2012). This suggests that long-term average annual rainfall, and projected changes from reputable climatic models, could be used to assess the exposure of a given farm to water availability risk. However, *average annual rainfall* is not necessarily a reliable indicator of whether *sufficient rainfall is received at critical times*. In a relatively small study (based on rainfall data from six weather stations in New South Wales over six years) CelsiusPro AG (2010) found a linear relationship between wheat yields and cumulative rainfall during the **late growing season** (1st August to 31st September), with rainfall over this period explaining 90% of the annual variation in wheat yield. While further work would be required to establish whether these implications hold for other regions and time periods, it suggests that **average rainfall during the late growing season** may be a better indicator of water availability risk for wheat than average annual rainfall.

This indicator could be improved further by combining it with a measurement of the **reliability** of rainfall during the relevant season. A farm that has greater certainty of receiving rainfall at the right time will be less exposed to risk than a farm that has more unreliable rainfall, even if the long-term averages for the two farms are identical. Many different measures of rainfall reliability can be constructed; the Australian Bureau of Meteorology publishes a variability index, which is expressed as:

$$\text{Index of variability} = \frac{(90^{th}\text{ percentile-}10^{th}\text{ percentile})}{(50^{th}\text{ percentile})}$$

(where percentiles are 12 month rolling rainfall percentiles)

Variability is considered to be high if the index is over 1.25 and low if under 0.75.

The biophysical complexity of agricultural systems means that any single metric will inevitably be a simplification, and therefore produce inaccurate results in some situations. One response can be to add more parameters: for example, the temperature, humidity and wind speed at the time of rainfall can significantly affect the amount of rainfall that actually becomes available to a crop. However, this increases the data collection burden, which is already high, and it can also lead to reliance on complex 'black-box' models, which reduces the transparency of decision-making. Information will always be imperfect, and it is up to the lender to determine the appropriate level of confidence required for information to be used in a given situation.

Table 2 below provides examples of potential quantitative indicators for wheat farming in Australia (for more information see Ascui & Cojoianu (2017)).

It should be noted that a different agricultural system may have a completely different interpretation of the same broad risk area. For example, water availability risk for irrigated poly-tunnel vegetable farming would likely include a completely different set of indicators, such as total water flows in the relevant catchment or irrigation source, the availability and cost of water rights and the risk of irrigation technology failure. Water rights and irrigation technology are not aspects of natural capital, but they are so closely tied to the dependency and impact on water as natural capital (in this case) that it makes sense to consider them as part of a natural capital credit risk assessment for irrigated agriculture (unless already considered as part of a broader financial risk assessment).

Step 3.1.3: Identify how you will measure impact drivers and/or dependencies

The Supplement notes that either **primary** or **secondary** data may be used for an assessment, and provides further guidance on the pros and cons of each. Data may be **quantitative** or **qualitative**. Given that credit risk assessment is conducted at an entity-specific level, **farm-specific data** will often be required and is generally preferred. However, in many cases, **regional or national data** may also be sufficient.

Forward projections may be based on **extrapolation** from past trends (where data are available, and continuation of past trends is a reasonable expectation), bespoke **evaluations** (e.g. of planned management or policy interventions) or various forms of **modelling**. Again, depending on the data and type of projection, the results may be farm-specific, regional or national level.

The farmer's ability to manage risks can be assessed by means of a questionnaire, supported with evidence (farm records, training certificates, photos etc.) as appropriate.

Table 2 below sets out possible data sources for each identified indicator for wheat farming in Australia, as an example.

Step 3.1.4: Collect data

Credit risk assessment is usually conducted at the level of the entity applying for the loan. Care should be taken if attempting to aggregate data across significantly different contexts. For example, if the borrowing entity owns multiple farms in different areas, it might be necessary to conduct an assessment at the level of each individual farm, or at least for the farm(s) representing the majority of the revenues and costs for the business as a whole. The same point may apply in certain cases, even when the unit of assessment is a single farm, for example where the farm covers significantly different soil types, micro-climates, or mixed farming activities (e.g. in Australia, wheat farming is often combined with livestock grazing). Further guidance on data collection can be found in section 5.2.4 of the Protocol.

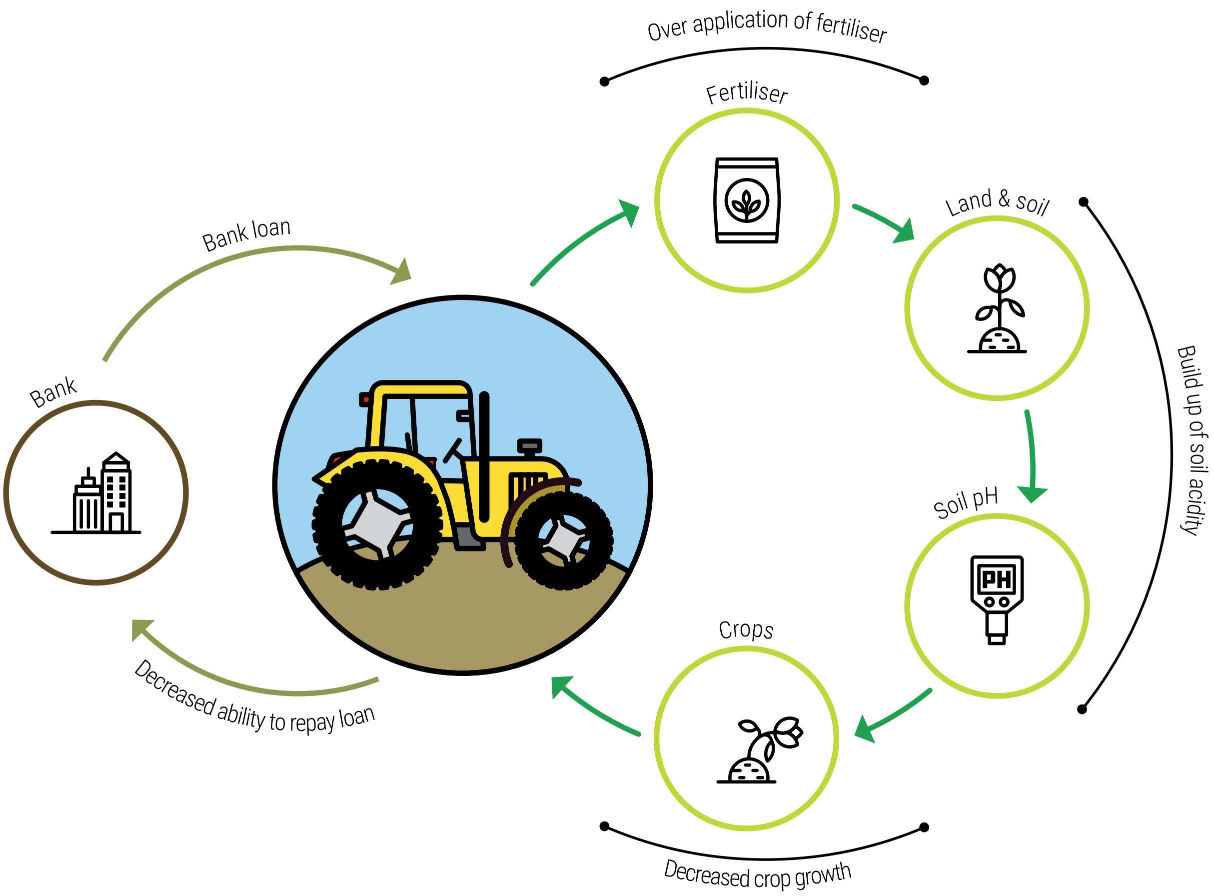
STEP 3.2: MEASURE CHANGES AND TRENDS IN NATURAL CAPITAL

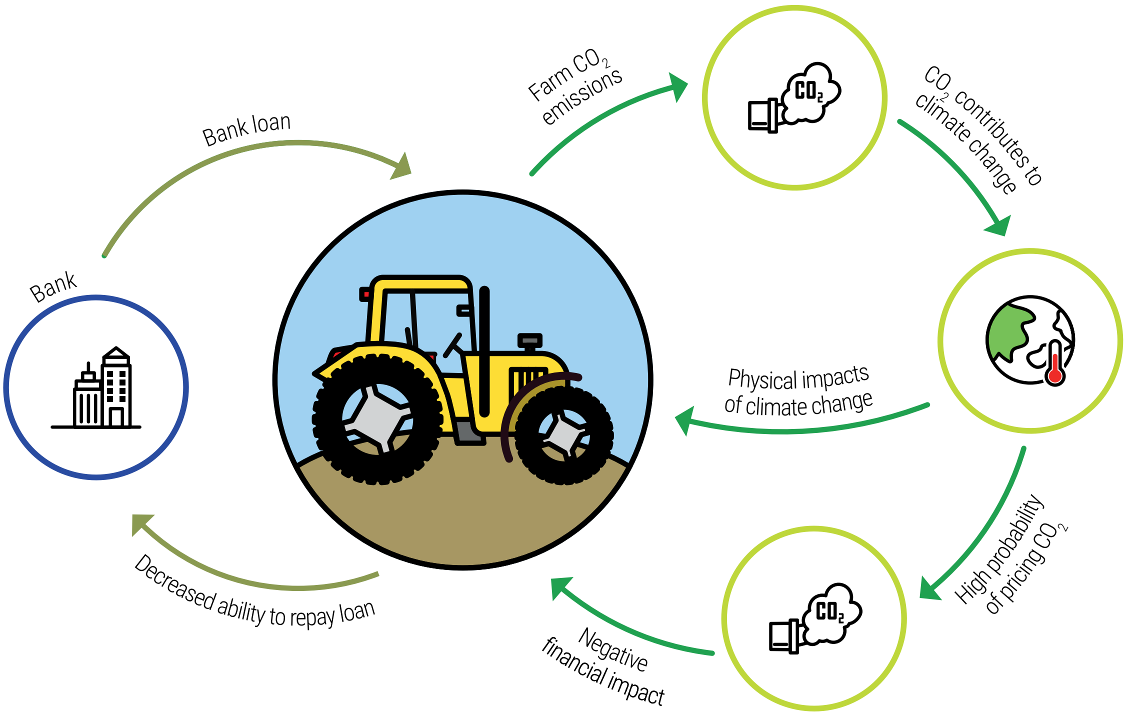
The Supplement recommends identifying changes in natural capital attributable to the entity in question, separately from changes associated with external factors, which can be further disaggregated into natural and human-induced changes. The recommended steps include:

Step 3.2.1: Identify changes in natural capital and/or dependencies associated with impact drivers and/or dependencies;
Step 3.2.2: Identify changes in natural capital associated with external factors;
Step 3.2.3: Measure changes and trends in natural capital.

In agriculture, the changes most likely to be attributable to the actions of the entity in question (the farmer) will have to do with the major inputs and outputs identified in Figure 3, especially where these have local effects. For example, a farmer is particularly likely to have a significant effect on local soil health, biodiversity and surface/sub-surface water, all of which may in turn have an impact on the business. Other impacts such as energy consumption and greenhouse gas emissions are also attributable to the entity, but the likely impact on the business will depend on regionally or globally aggregated impacts, and society's response to these impacts (e.g. pricing greenhouse gas emissions). Figure 4 below illustrates two different pathways from natural capital impacts or dependencies to credit risks for a specific business.

Figure 4: Example pathways from natural capital impacts or dependencies to credit risks





Measuring changes and trends in natural capital risk from a credit risk assessment perspective involves the middle steps identified in Figure 2 (future projections, probability of pricing). As the extension of credit is a forward-looking action, assessing past changes is usually only relevant if this is the only means available for establishing a forward projection (e.g. a simple extrapolation from the past trend). In other cases, assessing future trends may rely on some form of modelling. Some examples of potential sources of information on future trends are provided in Table 2 below.

Table 2: Example risk factors, possible indicators and potential data sources for wheat farming in Australia

THEMATIC AREA	RISK AREA	RISK FACTOR	INDICATOR	DATA SOURCES (CURRENT/HISTORICAL SITUATION)	DATA SOURCES (FUTURE PROJECTION/PRICING)	RISK MITIGATION EVIDENCE
WATER	**Water availability**	Growing season rainfall	Millimetres of rainfall during growing season for the region (historical average)	Regional rainfall datasets	Regional outputs from long-term climatic models	Farmer's ability to use rainfall prediction tools and adapt accordingly
		Rainfall reliability	Variability index for the above			
	Water use	Water use efficiency	Total annual millimetres of rainfall divided by tonnes of wheat yield (historical averages)	Regional or farm-specific rainfall datasets combined with farm-specific yield records	Extrapolation of historical trend	Farmer's ability to improve water use efficiency
	Water quality[3]	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*
WEATHER AND CLIMATE	**Temperature extremes**	Heat stress	Total annual high degree hours (historical average)	Regional or farm-specific temperature records	Regional outputs from long-term climatic models	Farmer's ability to use temperature prediction tools and adapt accordingly
		Frost damage	Total annual frost days (historical average)			
	Extreme weather	Floods, cyclones, hailstorms, bushfires, drought	Number of significant events in last 10 years	Regional data from government agencies or insurers, or farm-specific records	Regional outputs from long-term climatic models	Farmer's ability to use extreme event prediction tools and adapt accordingly
LAND AND SOIL	**Soil quality**	Soil acidity	Percentage of crop area with soil pH <4.5	Farm-specific soil samples	Extrapolation of historical trend	Farmer's ability to monitor and actively manage these risks
		Soil salinity	Percentage of crop area with soil salinity >100mM/L			
		Soil organic carbon	Percentage of crop area with soil organic carbon <1% in top 10cm			
		Soil erosion	Percentage of farm with ground cover <50%	Farmer observations (e.g. photos); ground cover maps derived from satellite data		

3 Not considered applicable in this particular example, because wheat farming in Australia is primarily rain-fed and there are no significant risks associated with the quality of this water input. Nevertheless, water quality could be a relevant risk factor for irrigated wheat farms, and it is highly likely to be relevant for any livestock farming. Agricultural activities may also impact on water quality; however, in the case of wheat farming, the main water quality impact risk is of fertiliser run-off, which is considered separately under 'Fertiliser use'.

	Fertiliser	Fertiliser use	Total tonnes of fertiliser used divided by application area (historical average)	Farm-specific records	Extrapolation of historical trend	Farmer's ability to monitor and actively manage these risks
			Fertiliser cost as % of total farm costs	Farm-specific records or analyst reports		
		Fertiliser application	Partial Nutrient Balance (kg nutrient removed from soil/kg applied)	Farm-specific soil samples combined with farm-specific application records		
			Partial Factor Productivity (kg yield/kg nutrient applied)			
			Kilogrammes of nitrates released to surface water	Farm-specific records and/ or environmental protection agency water quality monitor-ing data		
BIODIVERSITY AND ECOSYSTEMS	**Biodiversity**	Extent and/ or quality of biodiversity	% of land set aside for biodiversity/native vegetation	Farm-specific records and/or satellite data	Scientific assessments of likely future changes in ecosystems and biodiversity; or extrapolation of historical trend	Farmer's awareness of biodi-versity and implementation of conservation strategies
			Quality of biodiversity	Biodiversity maps, e.g. Atlas of Living Australia		
	Weeds, pests and diseases	Rate and/ or severity of incidents	Cost per hectare of weeds, pests and diseases control (historical average)	Farm-specific or regional records	Scientific assessments of likely future changes in weeds, pests and diseases incidence; or extrapolation of historical trend	Farmer's capacity and equipment to respond to weeds, pests or diseases outbreaks
	Animal welfare[4]	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*	*Not applicable*
ENERGY	**Energy use**	Energy use efficiency	Total energy used divided by tonnes of wheat yield (historical averages)	Farm-specific records	Extrapolation of historical trend	Farmer's ability to monitor energy consumption and implement energy efficiency measures
		Energy cost	Energy cost as % of total farm costs		Analysts' energy cost projections	
AIR	**Greenhouse gas emissions**	Carbon intensity	Total tonnes of greenhouse gas emissions (in CO2 equivalent) divided by tonnes of wheat yield (historical averages)	Farm-specific records	Extrapolation of historical trend	Farmer's ability to monitor greenhouse gas emissions and implement emission reduction measures
		Cost of carbon	Greenhouse gas emissions cost as % of total farm costs		Analysts' carbon price projections	
	Other air emissions	Other emissions intensity	Total tonnes of other air emissions divided by tonnes of wheat yield	Farm-specific records	Extrapolation of historical trend	Farmer's ability to monitor other air emissions and implement emission reduction measures

4 Not considered applicable in this particular example, because it focuses only on the activity of growing wheat. However, in Australia, wheat farming is often combined with livestock farming, in which case animal welfare would be a relevant risk factor for the latter activity.

STEP 3.3: CONDUCT VALUATION (RISK EVALUATION)

The finance sector Supplement suggests the following steps:

Step 3.3.1: Define the consequences of impacts and/or dependencies

This is closely related to the selected scope and objectives. For a credit risk assessment, the consequences would usually be limited to those which have the potential to affect the lender either through reducing the borrower's ability to repay the loan, or by other means, e.g. negatively affecting the lender's reputation.

Step 3.3.2: Determine the relative significance of the costs and benefits

This is a screening step, in which consequences identified in step 3.3.1 which are minor or negligible could be excluded from further analysis.

Step 3.3.3: Select appropriate valuation (risk evaluation) technique

Many different valuation techniques are available, and the Protocol and Supplement provide further guidance. For the purposes of credit risk assessment, the objective of the valuation stage is to support the lender making a decision whether or not to provide credit (of a certain amount and under specified conditions), or to re-assess the risk of an existing loan. Given the challenges of natural capital data collection and assessing the uncertainty of future conditions, quantitative or monetary valuations are unlikely to be feasible in many circumstances. The exceptions might be for certain narrowly defined risks (e.g. if legislation has been passed which will introduce a specified cost of carbon for certain on-farm emissions which were previously unregulated, or a water source is being depleted and there is a probability of reduced revenue or additional costs to maintain supply, these risks could be quantified and assigned a monetary value, which could in turn be added as a cost in a model of the farm's financial situation). In many other cases, however, a qualitative assessment, based on a combination of quantitative and qualitative inputs from the measurement stage, will be feasible in order to assign a risk level to each risk factor. Ideally, over time, such qualitative assessments would be validated by back-testing against quantitative performance data, enabling the development of more robust and replicable metrics.

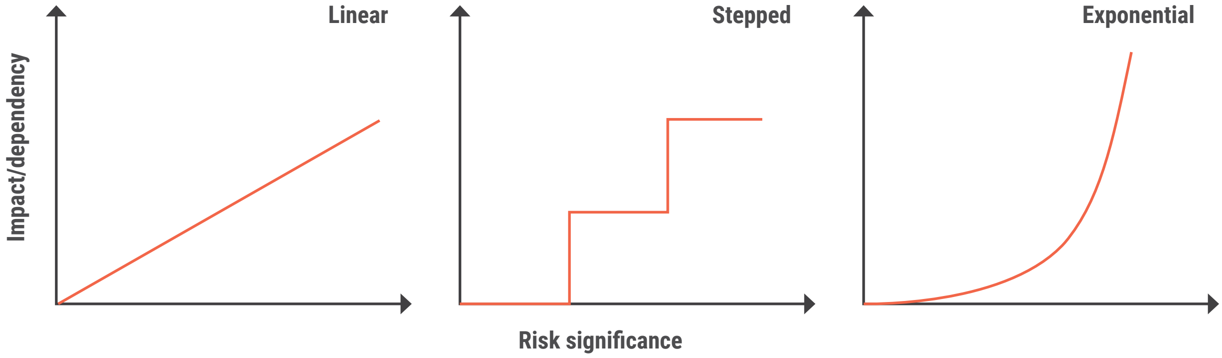
A variety of techniques can be used to convert information gathered through the measurement stage into assessed risk levels. If data is available across a portfolio of loans, then one way of assigning risk levels may be on the basis of **benchmarking** against peers, with risk levels assigned to percentiles. For example, water use efficiency could be assigned the following risk levels, based on performance relative to peers:

- High risk = below 40th percentile;
- Medium risk = between 40th and 60th percentiles;
- Low risk = above 60th percentile.

The chosen percentile ranges should be based on evidence of impacts, such as historical information showing that the lowest 40% of farms have significantly lower yields than the upper 40%.

Use of percentiles is particularly appropriate when the risk factor has a linear relationship with impacts or dependencies. For example, water availability risk, measured as millimetres of rainfall during the late growing season, was found to have a linear relationship with wheat yields in New South Wales, Australia (CelsiusPro AG 2010). However, risks may have a variety of relationships. For example, a risk may increase sharply at certain thresholds (a stepped relationship, as described in the case of soil acidity below, which falls naturally into low, medium and high categories based on soil pH being above, between or below the critical thresholds of 5.5 and 4.5), or it may increase exponentially towards some limit (such as total crop failure or death of livestock). These relationships are illustrated conceptually in Figure 5 below; however, it should be noted that many other relationships are possible. It should be noted that the type of relationship, as well as its critical parameters (e.g. threshold levels) may vary by sector/region, as well as depending on the materiality criteria (what level of impact or dependency is considered to be significant). Furthermore, it should be noted that in some cases the critical parameters or their relationships may be unknown, or imperfectly understood.

Figure 5: Types of risk relationship

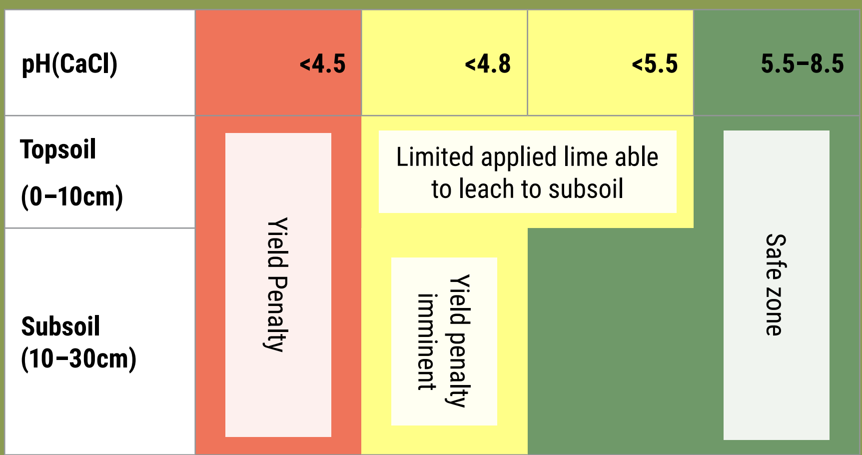


Example: risk thresholds for soil acidity – wheat farming in Australia

Soil acidification is a slowly-occurring natural process which is accelerated by agriculture, mainly due to excessive use of ammonium-based fertilisers, and partly because the product removed (e.g. grains or other crops) is alkaline. Nitrogen in ammonium-based fertilisers is readily converted to nitrate and hydrogen ions in the soil. As acidity increases, aluminium becomes more soluble, resulting in poor root growth, which in turn restricts access to water and nutrients. Acidification can also make nutrients chemically unavailable, and negatively affect soil microbial activity.

It is estimated that more than 70% of surface soils and half of subsurface soils across the Australian Wheatbelt are affected by soil acidity, which results in up to A$500m/year in lost production (AGRIC 2015; Wheatbelt NRM 2013). The optimal pH range for wheat is around or above pH 5.5 in the topsoil and 4.8 in the subsurface – key thresholds below which aluminium begins to dissolve and starts to affect root growth (Gazey & Andrew 2009). One technique to help overcome this risk is to apply lime, which can help increase grain yield when soil pH is a constraint.

Figure 6: Key thresholds for soil pH for wheat



Source: Wheatbelt NRM (2013)

While the existence of these biophysical thresholds provides a relatively clear identification of risk levels at the level of a specific soil sample site (e.g. High risk = pH<4.5, Medium risk = 4.5<pH<5.5 and Low risk = pH>5.5), further steps are required to convert data from soil samples to a risk assessment for the farm as a whole. If sampling has been done correctly, it should be possible to infer the proportions of the farm's arable land that fall into the above three risk categories. Quantification of the yield penalty and/or cost of liming could be used to derive rules for converting these proportions into an overall risk assessment. For example, if the proportion of the farm's arable land that is High risk = A; Medium risk = B and Low risk = C, then the overall farm assessment could be given by the following rules (which assume that land in the High risk category is weighted at twice the impact of land in the Medium risk category):

If (A+B/2)>10% = High risk

If 2%<(A+B/2)<10% = Medium risk

If (A+B/2)<2% = Low risk

The percentages in this example are arbitrary: suitable values would depend on regional norms and the lender's risk appetite.

Step 3.3.4: Undertake or commission valuation (risk evaluation)

The risk assessment model in Figure 2 proposes that the overall risk is a product of the risk level of the current (historical) situation, the expected future trend (including the probability of pricing, where relevant) and the farmer's ability to mitigate the risk. The question therefore arises, how should the latter factors be considered to alter the current risk level?

One approach is to use expert judgement to evaluate each stage iteratively, on its own merits. For example, let us assume that the current risk level for a given risk factor is assessed as being medium. Reputable forecasts project that the risk will increase in future, but an expert (either the assessor themselves, or a third party) judges that the risk level is still best described as medium. Based on the farmer's demonstrated capability to manage the risk, however, an expert (again either the assessor themselves, or a third party) judges that the overall risk is best described as low.

Another alternative, which may be used in the absence of a basis for expert judgement, is to construct a risk logic table or algorithm to determine how risk assessments for each stage will be combined into an overall risk assessment. An example is given in Table 3 below, in which the assessment at each stage moderates the preceding risk level (up, down or keeps it the same). Similar tables can be constructed for assessments with more risk levels or stages. Tables such as these, or algorithms built on their logic, can help automate the overall risk assessment, but care should always be taken to ensure that they do not inhibit better judgement, where it is available. In other words, it should always be possible to over-ride the automated process, where the assessor has good reason to believe the overall risk should be assessed otherwise.

Table 3: Example risk logic table

CURRENT (HISTORICAL) RISK	FUTURE PROJECTION	RISK MITIGATION	OVERALL RISK
Low	Decrease	Ineffective	Low
Low	Decrease	Moderately Effective	Low
Low	Decrease	Highly Effective	Low
Low	Stay the same	Ineffective	Medium
Low	Stay the same	Moderately Effective	Low
Low	Stay the same	Highly Effective	Low
Low	Increase	Ineffective	High
Low	Increase	Moderately Effective	Medium
Low	Increase	Highly Effective	Low
Medium	Decrease	Ineffective	Medium
Medium	Decrease	Moderately Effective	Low
Medium	Decrease	Highly Effective	Low
Medium	Stay the same	Ineffective	High
Medium	Stay the same	Moderately Effective	Medium
Medium	Stay the same	Highly Effective	Low
Medium	Increase	Ineffective	High
Medium	Increase	Moderately Effective	High
Medium	Increase	Highly Effective	Medium
High	Decrease	Ineffective	High
High	Decrease	Moderately Effective	Medium

4. APPLY STAGE: WHAT NEXT?

The Apply Stage of the Supplement provides guidance on how to **validate** and **verify** your assessment and results, and the actions you will take to **apply** results and **integrate** them into existing processes.

STEP 4.1: COLLATE RESULTS

The end result of conducting the risk assessment may be a set of 'traffic lights' as illustrated below. This may be sufficient for the assessor to factor into their overall judgement (along with other qualitative inputs, such as an assessment of the farmer's financial management ability) in order to make a decision about whether or not to offer credit to the applicant. Alternatively, a further step could involve assigning weights (for example based on expert judgement) to the different risk factors and risk levels, in order to calculate an overall risk assessment automatically. As with combining current, future projection and risk mitigation assessments into an overall risk assessment for single risk factors, any automated overall risk assessment for the applicant entity as a whole should be treated with caution, and not allowed to inhibit better judgement, where it is available.

Table 4: Example overall risk assessment

THEMATIC AREA	RISK AREA	RISK FACTOR	RISK LEVEL	FUTURE PROJECTION	RISK MITIGATION	OVERALL RISK
WATER	Water availability	Growing season rainfall Rainfall reliability	Medium	Increase	Highly effective	Medium
	Water use	Water use efficiency	Medium	Stay the same	Highly effective	Low
	Water quality	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
WEATHER AND CLIMATE	Temperature extremes	Heat stress Frost damage	High	Increase	Moderately effective	High
	Extreme weather	Floods, cyclones, hailstorms, bushfires, drought	High	Increase	Moderately effective	High
SOIL	Soil quality	Soil acidity Soil salinity Soil organic carbon Soil erosion	Low	Stay the same	Moderately effective	Low
	Fertiliser use	Fertiliser use efficiency Fertiliser cost Fertiliser application Fertiliser run-off	High	Stay the same	Highly effective	Medium
BIODIVERSITY AND ECOSYSTEMS	Biodiversity	Extent and/ or quality of biodiversity	Low	Increase	Ineffective	High
	Weeds, pests and diseases	Rate and/ or severity of incidents	High	Increase	Moderately effective	High
	Animal welfare	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

ENERGY	Energy use	Energy use efficiency Energy cost	Medium	Decrease	Highly effective	Low
AIR EMISSIONS	Greenhouse gas emissions	Carbon intensity Cost of carbon	Medium	Increase	Moderately effective	High
	Other air emissions	Other emissions intensity	Low	Stay the same	Moderately effective	Low

STEP 4.2: VALIDATE AND/OR VERIFY FINDINGS

Once a risk assessment framework has been constructed for a given sector/region, it should be validated, reviewed and continuously improved. Validation can take many different forms. One option could take the form of an expert review. Alternatively, a quantitative validation could be based on applying the framework to a set of loans and then comparing the performance of those loans with a control sample, over a suitable period of time. It may be possible to conduct a hypothetical risk assessment exercise on a set of historical loans (i.e. backtesting), in order to avoid the problem of having to wait a long time to see the effect of natural capital risk factors on performance.

STEP 4.3: DISSEMINATE RESULTS AND TAKE ACTION

At the level of the individual loan, the action that is expected to flow from undertaking a natural capital credit risk assessment exercise is simply an internal decision whether or not to extend credit to an applicant, and if so, at what price and terms. Ideally, natural capital credit risk assessment should be seamlessly integrated into the lender's credit risk assessment process, along with assessment of the borrower's financial history and other factors. This means that once the natural capital risk has been evaluated along with all other risks, it should feed into the pricing and terms of the loan. The principle of pricing risk is that the borrower's interest rate should reflect the lender's expected loss, based on the probability of default, thus compensating for expected losses on average across a portfolio of loans (Weber et al. 2008). Therefore lenders could encourage more sustainable agriculture by offering lower interest rates to farmers who can demonstrate lower exposure and/or better management of natural capital risks. However, given the challenges in identifying and evaluating natural capital risks in agriculture, as well as the difficulties disentangling natural capital from other business risks, it may be unrealistic for lenders to price natural capital risk efficiently. In addition, lenders doing so could risk losing business to less diligent competitors. Past evidence suggests that banks generally prefer to compensate for environmental or natural capital risks through the terms of the loan, rather than its pricing (Coulson 2002). Such terms might include various natural capital related covenants, for example requiring the borrower to undertake specified risk mitigation actions, or to alert the lender if certain thresholds are breached. In this way, the lender's natural capital credit risk assessment can be expected not only to improve outcomes for the lender, but also for the environment, and thus, at least in the longer term, for the farmer as well.

Beyond this, there is scope for the natural capital credit risk assessment process itself, which will require close interaction with the farmer, to help educate and/or focus attention on key natural capital risks. As banks begin to implement the framework across a portfolio of loans, they will gain valuable information on best practices and other benchmarks, which (if shared) could also benefit farmers. Farmers could also use the framework themselves, in order to identify key risks to target for management interventions, or to improve their chances of obtaining loans in future. The framework could also be used by banks after the loan has been made, for monitoring purposes (e.g. helping to identify key natural capital risk indicators which should be monitored in order to have early warning of potential problems) and communicating the bank's overall natural capital lending strategy.

Example: natural capital credit risk assessment at National Australia Bank (NAB)

National Australia Bank (NAB) is Australia's largest agribusiness lender, with a A$26 billion agricultural loan book and banking one in three Australian farmers. NAB's journey towards protecting natural capital began with listening to its customers. NAB has now surveyed 10,000 agricultural customers over four years and heard a consistent message that farmers are concerned about a variety of natural capital risks, including energy costs, water scarcity, soil health, runoff and biodiversity. 74% of NAB customers have already made changes to their business in response to natural resource challenges. Furthermore, it is increasingly clear that Australia's brand as a producer of agricultural products and its access to export markets is dependent on the quality and sustainability of its natural assets. NAB has recognised that impacts and dependencies on natural capital can increase a customer's risk profile, and impede their wealth creation. Yet current credit risk assessment processes do not take these risks into account: to date, credit decisions to agribusiness customers are still based on standard banking considerations such as cash flow, assets, risk analyses and banker-customer relationships.

As one of the founding signatories to the Natural Capital Declaration in 2012, NAB has taken seriously the NCD commitment to develop methodologies that can integrate natural capital into the decision-making processes for all financial products and services. That is why, from 2015, NAB supported and contributed to the research that led to the production of this natural capital credit risk assessment framework, alongside other research which has investigated, among other things, the linkages between natural capital and financial performance, linkages between water risk and loan default rates, and the economics of native vegetation on farms. NAB also chaired NCD Working Group 3, which supported the development of the Natural Capital Protocol and its finance sector supplement.

NAB's Chairman, Ken Henry, announced in 2016 that NAB would include natural capital management in its credit risk assessment decision-making processes within the next 3-4 years. The bank has been working hard to build capacity internally to help achieve this objective, training agribusiness bankers, developing a network of natural capital champions, and establishing a Credit Risk working group to connect external research results with customer data and incorporate within internal decision making, and a Natural Value Steering Committee to drive buy-in across the business. NAB has adopted a Natural Value Framework which considers how the current and projected future condition of natural capital assets determines natural capital risks, which in combination with farm-level risk management, impact on farm performance. NAB has supported further research to develop a spreadsheet tool to assess natural capital credit risk for wheat farming in Australia, and is considering a variety of other options for providing relevant information to its agribusiness bankers, including supporting the development and uptake of emerging Agtech platforms such as the use of satellite monitoring data to inform rural valuations and understanding of risk at the farm scale. As a next step, NAB is exploring how natural value can be integrated into sectors beyond agribusiness, such as infrastructure investment.

CONCLUSIONS

This framework sets out a generic procedure that can be applied to undertake a farm-specific natural capital credit risk assessment within a given agricultural sector and region, as demonstrated with examples from wheat farming in Australia as a case study. It extends the overarching frameworks of the Natural Capital Protocol and the Connecting Finance and Natural Capital supplement by providing guidance for undertaking a particular type of natural capital assessment (credit risk assessment) for a specific sector (agriculture). Furthermore, it complements the ENCORE natural capital risk assessment tool[5] by providing a framework for moving from high-level identification of generic risks towards more detailed evaluation of location-specific risks, including consideration of how these risks are likely to change over time, and the impact of risk mitigation actions.

Agriculture is a front-line sector in terms of both its dependencies and impacts on natural capital, yet the finance sector has relatively little experience with assessing agricultural sustainability and its effect on long-term productivity. While the framework focuses on agriculture, the generic credit risk assessment guidance could be adapted for secured lending in other sectors, particularly other primary industries such as forestry, fisheries and aquaculture.

Incorporating natural capital considerations into the credit assessment process addresses a gap in the ESG landscape around smaller-scale secured lending, and is an important step for financial institutions to meet their commitments under the Natural Capital Declaration (Natural Capital Declaration 2012; Mulder et al. 2013). The objective of systematically assessing natural capital risks is to improve financial institutions' overall assessments of credit risks. An improved understanding of a borrower's risk profile should enable improved allocation of capital and enhance overall loan performance, thus allowing increased finance to flow towards more sustainable agriculture.

One of the benefits of a standardised procedure is that it reduces the risk of each lender developing different measurement and valuation approaches to natural capital risks, thereby obtaining different results. There is a distinct 'public good' advantage to the standardisation of methods as far as is practicable. It is therefore to be hoped that banks will continue to collaborate on further methodological development of the framework.

Data collection is another area where collaboration would be highly desirable. The data collection requirements to conduct an individual natural capital credit risk assessment can be intense. This places costs on both borrower and lender, which ultimately constrains lending and economic activity. Data integration platforms could potentially integrate data from multiple external sources (such as meteorological data, soil quality, satellite data etc.) as well as holding farm operator data in confidence, which the farmer could then elect to release to different lenders or other parties as required. The Natural Capital Coalition is working with a variety of partners to address natural capital data issues through its Data Information Flow project.[6]

Areas for further research and development include:

- Developing and refining natural capital risk factors, indicators and thresholds for different sectors and regions;
- Validating the application of the framework against loan performance;
- Developing cost-effective data gathering, sharing and processing;
- Quantifying the impact of risk mitigation on overall risk impact;
- Developing methods for dealing with interlinked risks;
- Developing methods for aggregation at different levels (e.g. diversified farms, regions or lending portfolios); and
- Extending the framework for use in ongoing monitoring and farmer engagement.

5 See https://encore.naturalcapital.finance/en/ (accessed 1 April 2019).

6 See https://naturalcapitalcoalition.org/projects/data-kit/ (accessed 18 October 2018).

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ABOUT

Natural Capital Finance Alliance

Finance sector leadership on natural capital

SECRETARIAT:

UNEP FINANCE INITIATIVE

global canopy

The Natural Capital Finance Alliance (NCFA) is a finance sector led initiative, providing expertise, information and tools on material aspects of natural capital for financial institutions. It works to support these institutions in integrating natural capital considerations into their risk management processes and products as well as helping them to discover new opportunities. The NCFA secretariat is run jointly by the UN Environment Finance Initiative and Global Canopy.

NATURAL CAPITAL COALITION

The Natural Capital Coalition is a global multi-stakeholder collaboration that brings together leading initiatives and organizations to harmonize natural capital approaches. The Coalition works to achieve the vision of a world that values, conserves and enhances natural capital. The Coalition is home to the Natural Capital Protocol, the internationally standardized decision making framework for the identification, measurement and valuation of natural capital impacts and dependencies.

This piece of work “Natural Capital Credit Risk Assessment in Agricultural Lending: 'An Approach Based on the Natural Capital Protocol” has been developed in collaboration with the Coalition and is aligned with the Natural Capital Protocol.