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DriveNet

A methodology for participatory analysis of the causes and causal mechanisms of deforestation and land-use change

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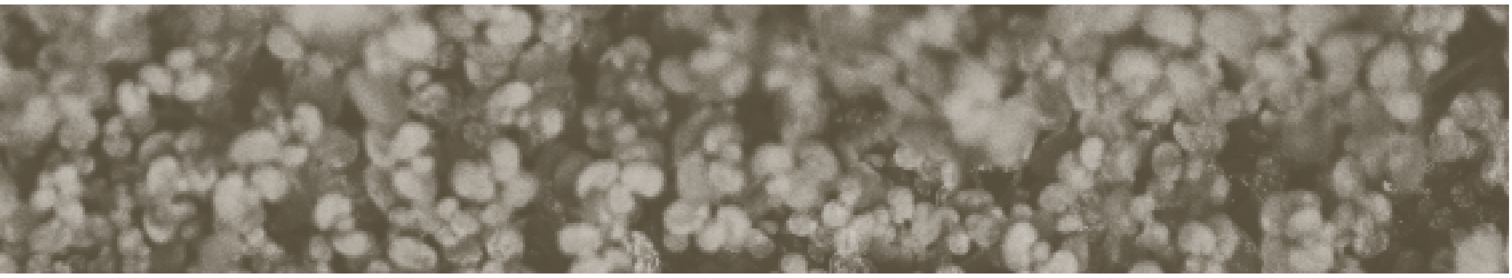

Foreword

Many jurisdictions around the world are now designing strategies for sustainable, low-emissions rural development. Others are preparing or reviewing national and subnational action plans to achieve climate change mitigation targets through avoided deforestation. Such strategies and plans are supported by abundant satellite imagery and sophisticated quantitative models produced by specialists.

Unfortunately, such models are often incomprehensible to local authorities, who are unable to fully grasp the information and use it strategically to halt or reverse deforestation. While this is problematic, a more fundamental difficulty also exists: such approaches rarely recognize local views or knowledge of context, socioecological dynamics, or causal mechanisms. Consequently, the models have limited capacity to reflect complexity of processes, as they rely on the data that exists rather than on the data that is needed – data about causes, especially underlying causes, which can rarely be described in quantitative databases. The result is a causal narrative based on what is known and what can be quantitatively represented; the rigidity of such narratives limits the possibility of exploring more-complex relationships. To be able to understand land-use change at a level that fully informs interventions that can change unfavourable trajectories, allow correction of failures, balance trade-offs, and promote sustainable land use, we need to understand the underlying causal mechanisms.

DriveNet is an innovative tool that enables such understanding. It was developed by World Agroforestry (now CIFOR-ICRAF) under the project *Building concerted Low Emissions Rural Development through Integrated Analysis of the Causes of Deforestation and Land Use Change in Six Regions of Peru*[1] (GCF-TF Peru Window A*), implemented in partnership with the Earth Innovation Institute. It showed itself to be a potent methodology that helps policy makers to think in terms of systems: of interconnected processes, causes, and causal mechanisms. In doing so, it makes it possible to identify entry- and leverage-points for effecting real change on the ground.

After positive experiences in applying DriveNet in formulating low-emissions rural development in six regions of Peru, its developers have prepared this first English version of the DriveNet manual, revised for international users. It provides local, regional, and national actors, and multi-actor platforms in general, with a much-needed methodological framework that can be broadly applied to systematically assess

1 Concertando el Desarrollo Rural Bajo en Emisiones a partir del Análisis Integrado de Causas de la Deforestación y Cambio de Uso en seis Regiones Peruanas

the causes of deforestation and land-use change at the scale of specific jurisdictions. I believe that it will be warmly received by practitioners worldwide; practitioners who, like those in Peru, are committed to finding real solutions to the complex challenges of sustainable land use.

Gustavo Suárez de Freitas
Earth Innovation Institute

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Introduction: The DriveNet process

At least a decade has passed since many countries made their REDD+ (Reducing Emissions from Deforestation and Degradation) commitments. During this time, technical professionals, officials, experts, and researchers in the sector have become more aware of the complexity of deforestation processes and their causal mechanisms. Understanding such complexity – including the interactions between causes of deforestation and the socioeconomic, institutional, and political contexts in which they play out – provides information about the elements that can be combined in policies and other interventions aimed at reducing deforestation. With such understanding, we can also design intervention strategies that target leverage-points: constraints or opportunities that, if addressed, can generate changes in the system. To represent the system and to analyse it, we need information produced by different types of knowledge and disciplines, contributed by a variety of experts and other actors.

The DriveNet methodology involves local actors, officials, and technical experts in multi-actor participatory processes that foster dialogue and bring together different types of knowledge – scientific and local. In doing so, it harnesses prior studies and experiences to build understanding of deforestation and land-use change factors. Elucidation of the direct and indirect causes that most influence deforestation and land-use change then allows identification of suitable interventions. The methodology also responds to the need to create local capacity and develop a standardized analytical process that can be replicated without experts or sophisticated technologies; a process that can also be used when data are partially absent (for example, non-continuous series) or heterogeneous.

DriveNet is implemented by a small team, supported as needed by other technical experts and local actors. An effective DriveNet process depends on strong participation, a precondition for which is good team coordination. DriveNet addresses sensitive issues related to forest loss (such as the existence of social conflicts or deforestation associated to illegal activities) without stigmatizing or blaming any specific social group. An effective team can establish the local relationships of trust that allow fruitful discussions of such issues and can quickly channel and connect the information provided by participants.

DriveNet is an iterative process, alternating between participatory stages and desk studies. The participatory stages concentrate on the identification of causes and analysis of how they relate to each other, based on local views. Desk studies prepare the baseline information and analyse information received to date, prior to further iteration. Each stage of the process is important and feeds into the next stage. The quality of the result depends on the quality of the process, which in turn depends on the time and attention dedicated to each stage. None of them should be reduced or eliminated: short-cuts may lead to the wrong destination.

The methodological framework draws on three existing methodologies:

1) Conceptual elements from Vayda's (1985) causal analysis by progressive contextualization, in which the causes of forest loss are introduced gradually, advancing through increasingly general and broader contextual levels.
2) Methodological and analytical elements from the prospective participatory analysis methodology of Bourgeois and Jesús (2004).
3) Network analysis methodologies, used to analyse and visualize the structure of the system and causal mechanisms.

Bourgeois and Jesus's (2004) approach to analysing the agents of change when developing local strategies is a valuable point of entry. It engages local stakeholders and decision makers in an open, transparent, and concerted process, identifying the causes from the bottom up. We have found this procedure to be quite flexible and well aligned with the progressive contextualization approach.

Network analysis makes it possible to visualize the structure of causal influences and mechanisms, including the different levels of horizontal and vertical interaction between causes of deforestation, and possible feedback mechanisms.

In terms of outputs, a completed DriveNet process will:

- Identify and characterize land-cover and land-use changes.
- Identify and characterize the causes of the changes and the factors that influence them.
- Explain how the causes presented in an influence matrix influence and depend on each other.
- Illustrate causal relations in the form of a network, and provide network metrics.
- Identify causal mechanisms and leverage-points.

In the territory analysed, DriveNet enables:

- Construction of a shared representation of the dynamics of deforestation.
- A common vision among multiple actors, based on interactive discussion of different perspectives and types of knowledge, and an interpretation of causal mechanisms that provides valuable input for the construction of jurisdictional strategies.

Characteristics of the DriveNet methodology[2]

Efficient: it achieves results quickly, with a small team that combines technical skills and diverse knowledge.

Inclusive: it incorporates the views and knowledge of local actors in a general framework used to interpret the current state of the territory.

Participatory: it encourages interaction between participants, making sure that their views and knowledge are considered.

Flexible: it adjusts to the characteristics of the study area and allows activities to be combined.

Replicable: its standardized methodology can be applied in other contexts.

Capacity-developing: through a co-learning process, participants learn to debate in a structured manner and share relevant information more efficiently.

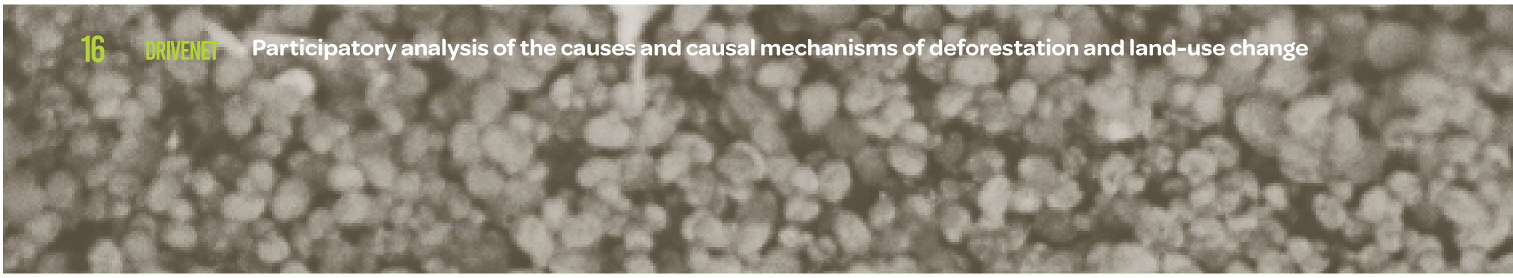
Characteristics of the results

Consistency: outcomes display internal coherence, because each of the rigorous sequence of stages leads to outputs that become inputs for the following stage, using the technical materials produced by the team.

Transparency: all DriveNet stages are clearly and systematically documented. All participants and interested public have access to the outcomes.

Relevance: decision makers can use the outcomes as inputs for sustainable development strategies.

2 Modified from Bourgeois R, Liswanti N, Mukasa C, Zamora A, HerawatiT, Monterroso I, Mshale B, Banjade MR, Mwangi E and Larson A. 2017. Guide for co-elaboration of scenarios: Building shared understanding and joint action for reform and security of forest tenure. Bogor, Indonesia: CIFOR.



Basic definitions

Deforestation: process through which forest is converted to another type of land use, or its tree canopy cover is reduced below a specific minimum (for example, in Peru the threshold is 10%). It implies the permanent loss of forest cover and its transformation into another land use. Such loss may be caused or maintained by human-induced conversion or by natural disturbance. Deforestation includes areas of forest converted to agriculture, grassland, water reservoirs, and urban areas (FAO, 2010). In this manual 'deforestation', 'forest loss', and 'land-cover changes' are used as equivalent terms, without negative connotations.

Forest degradation: process through which the capacity of a forest to provide goods and ecosystem services is reduced (FAO, 2010). It does not imply conversion of the forest into another land use; rather, the forest – as land cover – is maintained. For example, selective logging produces forest degradation but not forest loss.

Forest: ecosystem with tree canopy cover above specified agreed or legal thresholds. These may vary between countries and even between regions of the same country. For example, in Peru, the thresholds are >10% in arid or semiarid conditions and >25% in more favourable conditions (SERFOR, 2015). Similarly, the meaning of 'tree' follows legal definitions: for example, in Peru, a woody plant with adult minimum height of 2 m (coast, Andes) or, in the Amazon region, woody plants of at least 5 m and that are growing in areas > 0.5 ha with a minimum width of 20 m (MIDAGRI, MINAM, 2013).

Land cover: biophysical cover observed on the surface of the Earth. The term describes vegetation and anthropic elements that overlay rock or bare soil. Usually, the term is extended to include natural and human-made water bodies. Some examples of land-cover categories are lakes, grassland and forest (Di Gregorio & Jansen, 2005). The Land Cover Classification System (Di Gregorio & Jansen, 2005) considers eight broad land-cover classes: cultivated and managed terrestrial areas, natural and semi-natural terrestrial vegetation, aquatic or regularly flooded cultivated areas, aquatic or regularly flooded natural and semi-natural vegetation, artificial surfaces and associated areas, bare soil, artificial water bodies and natural water bodies. None of these classes refer to land use and all are limited to biophysical features.

Land use: the arrangements and activities that society undertakes on a certain type of land cover; they may lead either to change or maintenance of land cover. This concept establishes a direct link between land cover and the actions of people in their environment (Di Gregorio & Jansen, 2005). Some examples of land-use categories are cultivated grasslands, annual crops, permanent crops.

Land-use change: according to Di Gregorio & Jansen (2005) there are two types of change. 'Modification' is a change in conditions within a given land-use category. For example, from cultivated, rainfed grassland to cultivated, irrigated grassland. 'Conversion' is a change in land use that also entails a change in land-cover, for example from managed forest to cultivated grassland or from cultivated grassland to cropland.

Landscape: dynamic outcomes of the functional interactions among the different components in a geographical area: actors, institutions (laws, standards, and regulations) and multiple ecological, social, and economic components (Minang et al.; 2014).

Landscape approach: an approach that seeks to achieve multiple economic, social, and environmental objectives in a given landscape, supported by concepts, tools, and methods drawn from relevant disciplines.

Primary forest: "naturally regenerated forest of native tree species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed" (FAO, 2020).

Secondary forest: "forest regenerating largely through natural processes after significant human and/or natural disturbance of the original forest vegetation at a single point in time or over an extended period, and displaying a major difference in forest structure and/or canopy species composition with respect to the nearby primary forests on similar sites" (Chokkalingam & De Jong, 2001).

Causes of deforestation and land-use change: conceptual and methodological framework

Campo Verde, Ucayali.

Deforestation is the result of a set of interacting causes. In any geographical unit – for example, a watershed or geopolitical jurisdiction – various economic, social, cultural, and institutional factors are at play. They exert influences at varying levels and speeds. The extent and nature of their effects (changes) depend on the context and on the agents that produced them. These changes in turn cause a feedback response by the components and agents of the system.

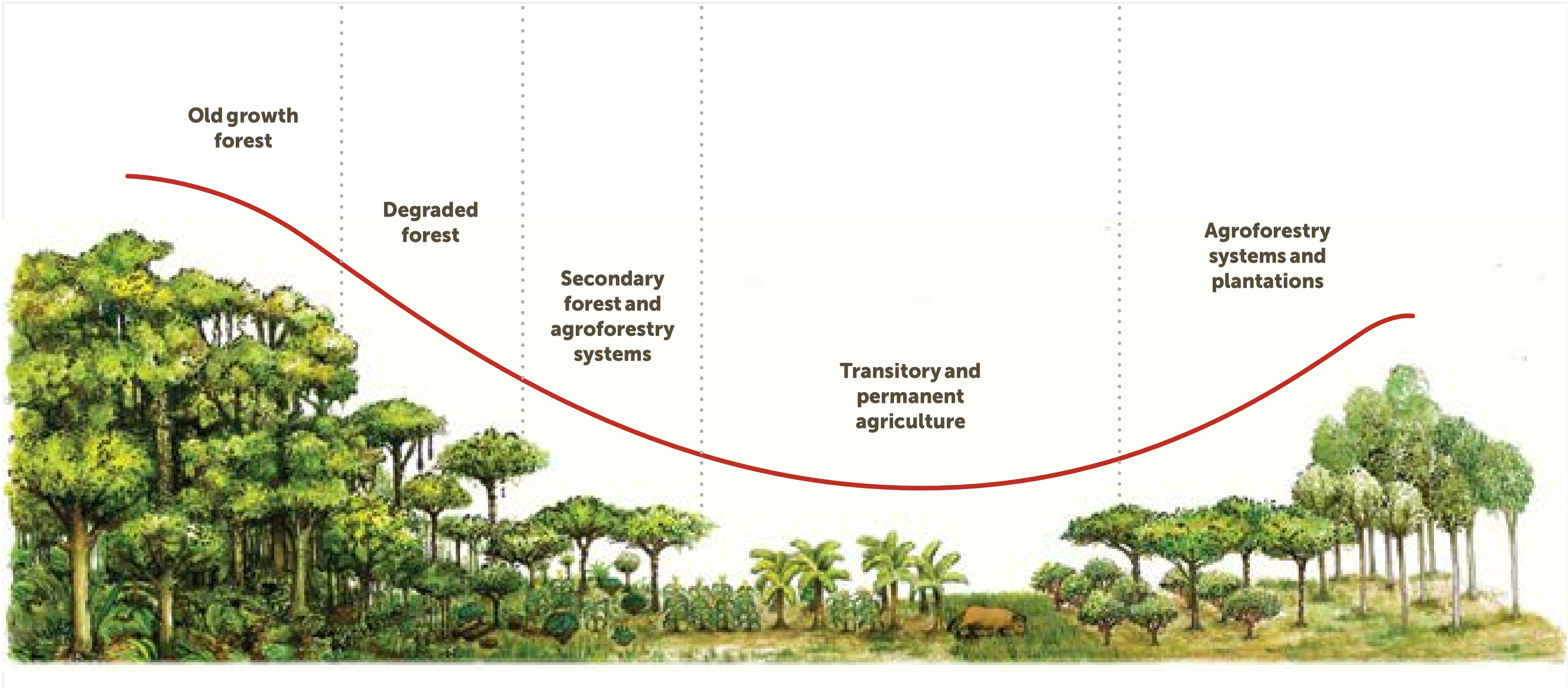
Landscape management to reduce deforestation requires a systems-based strategy, designed to understand the practices and processes that take place in the landscape and how they affect the system. These practices and processes include causes and causal mechanisms. Leverage-points can then be identified: causes that can have an effect on the entire system, both immediately and in the longer term, if their mode of action is modified. These points allow the definition of intervention strategies capable of producing system-level change in the structure or functions of the set of causes identified and in their interactions within causal mechanisms. That is, they make it possible to recognize and discuss measures that can produce change in the mechanisms that were found to produce deforestation.

LANDSCAPE. Dynamic outcomes of the functional interactions between the different components in a geographical area: actors, institutions, and regulations) and multiple ecological, social and economic elements (Minang et al., 2014).

The development of mapping tools and analytical techniques (such as remote sensing and specialized software) and the production of open-access geospatial data have made it possible to characterize the effects of deforestation and land-use change and to obtain technically precise information about the direct causes of deforestation. However, in-depth studies that go beyond identifying the direct causes are still lacking. They can be used to inform strategic processes by elucidating complex relationships of cause and effect.

Forest landscapes undergoing deforestation go through different phases that constitute a transition in time and space (Illustration 1), beginning with an initial degradation process. These phases correspond to different socioecological conditions, where different causal mechanisms are operating. At the start of the analysis, it is important to identify the current stage (phase) of the landscape by considering past changes, ongoing changes and future trends. These stages are determined in relation to the percentage of forest cover, its origin, and the types of land use. The forest transition curve (Illustration 1) can be used as a conceptual framework.

ILLUSTRATION 1. In what phase of the deforestation process is our landscape?

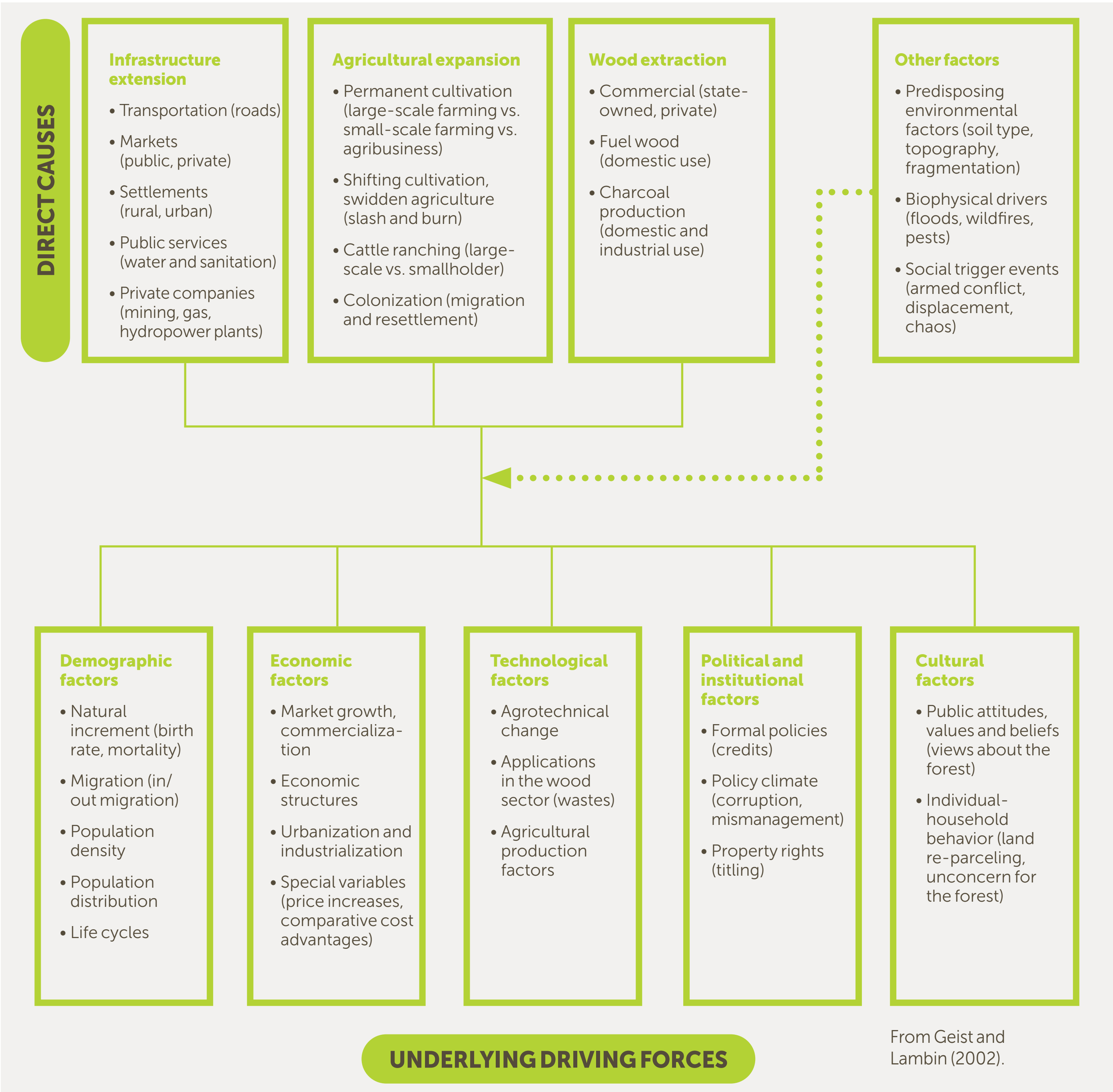


A forest landscape under human pressure passes through different phases, starting with an initial degradation process. The phases are described according to the percentage forest cover, previous land cover, and the types of land use.

Theoretical framework

The literature on deforestation describes a variety of direct or indirect causes or factors. To analyse them and to standardize the description of causal mechanisms, we can classify causes by type, scope and scale, and divide them into easily understandable categories. Illustration 2 shows the conceptual framework developed by Geist & Lambin (2002) to analyse causes of deforestation.

ILLUSTRATION 2. Causes of deforestation



From Geist and Lambin (2002).

The ABCs of a DriveNet Analysis

In DriveNet, a systems approach is used to analyse the causes of deforestation. A system is a set of interconnected elements that interact. It is defined by the structure of its component elements and their functions, the functional relationship between its components (different types of interactions), the outcomes of these interactions, and the combinations of the outcomes. Often, systems are characterized by loosely coupled factors, non-linear (that is, indirect) relations, and feedback mechanisms that are not always apparent.

In landscapes, pressures on the elements of the system lead to various processes. Observed landscape dynamics result from the combined effect of these processes. The DriveNet approach reflects this complexity. DriveNet seeks to identify and make visible the system of causes of deforestation. No cause acts independently or in isolation. Each is part of a larger mechanism born from its functional relationship with the others. Causal relationships are built from two complementary dimensions: causal effects and causal mechanisms.

TABLE 1. The ABCs of a DriveNet analysis

CONCEPT	DEFINITION	NOTES AND EXAMPLES
Outcome **(outcome chain)**	An event, phenomenon, or variable that we want to explain.	In DriveNet, this typically means a land-cover change or land-use change. This concept is linked to the concept of causal effect (see below), which offers greater precision. The two terms can be used interchangeably. An outcome can be one of a chain of intermediate outcomes caused by the same set of factors. To identify the direct and indirect causes it is important to define which level of the outcome chain we are interested in: **a)** If the outcome is a change in **land cover**, its cause is the introduction of a (new) use of the land or of its natural resources. **Outcome:** forest loss. Why was the forest (= land cover) lost? To plant coffee (=use). **b)** If the outcome is a change in **use** of the land or its resources, its causes equate to the reasons for which an actor changed the land use. **Outcome:** expansion of coffee cultivation. Why was the area under coffee expanded? To produce more coffee. If the land-use change is the direct cause of the land-cover change (a), then the direct cause of the land-use change (b) is an underlying cause of the land-cover change.

CONCEPT	DEFINITION	NOTES AND EXAMPLES
Cause	Factor that produces an outcome or causal effect.	Smallholder land-use policies and agricultural intensification were two of the causes of reforestation in Vietnam (Meyfroidt and Lambin, 2008)[3].
Causal effect	The change in a characteristic (for example, magnitude) of the outcome brought about by a change in a characteristic of a cause.	Causal effects define outcomes more precisely by specifying the characteristics of the change. For example, deforestation (outcome) expands (causal effect) when the road density (cause) increases (change in cause).
Direct cause	Factor that produces the outcome, without any intermediate factors.	Also known as 'proximate cause' or 'immediate cause'. For example, "The expansion of coffee plantations was one of the main proximate causes of deforestation in north-eastern Peru."
Indirect cause	Factor that influences the direct cause.	Also known as 'underlying cause'. An indirect cause influences other causes and produces intermediate outcomes in the outcome chain. For example, "Deforestation is the outcome of the expansion in coffee production. Croplands expand because coffee farmers need new areas to farm after being hit by coffee rust, which reduced their productivity. New farmers in the area also want to start growing coffee. These farmers are migrants who have left their lands to take advantage of national policies to support coffee production." Here, coffee expansion is a direct cause of deforestation. Coffee rust is the cause of the expansion because farmers need to expand coffee production to keep up their productivity. Migration and policies to promote coffee have also led new farmers to start growing coffee. **Coffee rust and migration are two examples of indirect causes of deforestation.**

3 Meyfroidt, Patrick. and Lambin, Eric. 2008. Forest transition in Vietnam and its environmental impacts. Global Change Biology, 14: 1319-1336.

CONCEPT	DEFINITION	NOTES AND EXAMPLES
Causal mechanism	A set of interrelated causes that produces a causal effect.	Interactions between various causes, not individual causes, produce effects or outcomes. Indirect relationships may not be evident. Rather, they become evident once the direct relationships between causes have been identified. This makes it possible to build a causal system. In two different contexts, the same cause may be part of different mechanisms and may generate effects through indirect processes. For this reason, it is important to identify mechanisms, rather than limit an analysis to identification of individual causes. In some contexts, urbanization can lead to the abandonment of land (causal effect) due to the reduction in availability of rural labour (causal mechanism), generating a reduction in agricultural production. However, in other contexts, the causes that act in conjunction with urbanization might be distinct and could generate other causal mechanisms: for example, an increase in demand for agricultural products that generates costs and opportunities to maintain or expand production. The effects of urbanization can differ (Rudel et al. 2005, Lambin and Meyfroidt, 2011).
Causal chain	A series of causes in a causal mechanism that link a cause to a final outcome through direct relations.	A causal chain includes all the causes that are directly and linearly related to a final outcome (and to the outcome chain). A cause may be direct or indirect, depending on the level of the outcome analysed in the outcome chain. A causal chain consists of linear elements. A causal mechanism consists of elements with complex and systemic interrelationships, including direct and indirect relationships and, potentially, feedback loops.
Factor	An event, condition, or variable that predisposes or mediates the causal relations in a causal mechanism.	A factor is a causal element that is part of a mechanism, but which acts by increasing or reducing the influence of a cause or outcome of a causal mechanism. **For example:** Differences in legal land categories are among the factors that explain the differences in changes land cover (ENBCC, MINAM, 2015.)[4]

4 MINAM. 2015. "Estrategia Nacional de Bosques ante el Cambio Climático." Lima, Peru. Ministry of Environment.

Causal mechanisms and causal effects

A causal mechanism is a process, consisting of interaction between multiple causes, that produces an **outcome or causal effect** (see Table 2). The interaction can be direct (A→B, A influences B) or produced by feedback reaction (A→B and B→A, A influences B and B influences A, or A→B, B→C and C→A. Causes A, B, and C are part of the same causal mechanism.

For example, in the present context a causal effect might be a reduction in forest area in a certain location, observed and measured using remote sensing and monitoring systems; its cause could be a farmer's planting of a coffee plot. The combination of various types of elements that result in the farmer's decision is the **causal mechanism.** These may include both immediate factors and others, such as land occupation strategies, prices, and markets. Sometimes, **causal mechanisms** can come together at different levels, from local to global. A combination of causal mechanisms is known as a **causal chain.**

TABLE 2. Why is it important to identify the causal mechanism?

Because the set of interactions between the causes may result in the same cause having different effects. Identifying the cause is not enough; we also need to understand how it operates in relation to the other causes.

The same cause can be part of different causal mechanisms, in each of which it may produce different effects.

The cause interacts with different factors. Reversing a given cause that is part of different causal mechanisms may require various interventions.

For example:

Demographic pressure in rural areas leads to rural migration and agricultural encroachment on forest areas with weak governance.

Demographic pressure in rural areas leads to migration to urban centres where there is demand for labor in growing economic sectors. This leads to increased land transactions and land prices in peri-urban areas and urban encroachment on agricultural and forest areas.

Cause	Effect	Causal mechanism
Demographic pressure in rural areas	Agricultural expansion	Migration to forest areas
	Urban sprawl	Migration to urban centres

In this manual we use 'cause' or 'factor' instead of 'driver of deforestation'[5] because we are analysing causal effects and identifying causal mechanisms.

We classify direct and indirect causes in different ways.

Atalaya, Ucayali Region, Peru.

5 Factors that are typical or hypothesized causes of land-use changes and for which there is some evidence of association with the outcome, but for which the evidence or knowledge is not sufficient to firmly establish the causal effects and explain the causal mechanisms.

Categorization of causes

To analyse and standardize the description of causal mechanisms, causes can be organized by classes and categories, depending on cause, scope, scale, type of impact, type of agent, and speed of action, etc.

Analysis can be enriched by treating these characteristics as additional attributes of the causes. This makes it possible to identify the leverage points more precisely and move through the different levels of aggregation (that is, political, legal, economic and institutional categories).

Two important terms used to characterize causes

Predisposing factors and triggering factors: these are indirect causal elements that contribute to the causal explanation but are in themselves insufficient to explain an event. They are causal factors that are relatively unimportant in explaining an outcome but may be important causes of when or where an event occurs (Meyfroidt, 2016).

Determinants: may be proximate causes, underlying causes, or predisposing factors. Their association to the outcome may reflect a direct causal effect or be undefined. We prefer using terms like ‘spatial determinants’ or ‘location factors’, which are factors that are spatially associated to an outcome and provide a statistical explanation of the location or other spatial characteristic of the deforestation event.

For example, the conversion of specific areas of forest to agriculture may be caused by a demand for agricultural products (the underlying structural cause), in combination with different predisposing factors such as favourable soil for planting, favourable climate, or good accessibility to markets, each of which may increase the value of land in a given location. Although these three predisposing factors are less influential than the demand for agricultural products, because any one of them is insufficient to produce a combination of causes, they determine that the outcome – the change – occurs in a specific place or context. Triggering factors are not the most structural or important causes of an outcome. They explain why it happened at that exact moment; other combinations of the same structural causes with the other triggering factors would probably lead to the same outcome.

Actors and agents

To analyse the causes of deforestation correctly it is also important to identify the relevant actors and social groups (agents) that influence forest conversion and degradation directly or indirectly in specific areas of influence and specific land-use categories, at various spatial scales. Examples of social actors and their areas of influence are family farmers and their properties (or the areas in which they manage natural resources), or logging companies with concessions. Agents are distinct "decision-making units" whose decisions directly influence forest-cover change in specific areas. Political, institutional, and legal decision makers can also be agents. They influence the design of local and regional policies, thereby affecting the territory. In DriveNet it is most effective to identify the agents that are related to the leverage points and that have the ability to generate changes in the functionality of these points.

Prior studies of causes of deforestation

Prior studies, including documents analysing the causes of deforestation and land-cover change processes, are quite likely to be available for many territories where DriveNet will be deployed. Statistical time series analysis is one of the most popular tools for exploring changes (causal effects) in relation to socioeconomic, market, and geographic data.

However, because such analyses can only work with the quantitative data that are available, their explanatory power is limited. Variables for which no data exist cannot be included in explanatory models. In many contexts, they implicitly adopt a reductionist approach that cannot elucidate complex, dynamic systems. The same correlated variables analysed in these studies can be both causes and outcomes, depending on the level of the causal chain at which they are analysed.

Nevertheless, such studies may provide very valuable input for preparing a DriveNet analysis, if the following factors are considered:

First, when using existing information, careful attention should be paid to the following:

- **Precision in definition of the event** (or change) that one wishes to explain and its scale (see the next two tables). For example, an analysis of causes of change in cover is not the same as one that looks at causes of changes in use (Table 1).

- **Clear definition of causality:** in some cases, deforestation analyses may confuse correlation with causation.

  For example, it may be assumed that protected areas are a sufficient mechanism for reducing deforestation, because there is less deforestation in protected areas. Nevertheless, this may be due to locational factors or to the absence of threats (that is, these are isolated areas, not exposed to threats because of inaccessibility). Hence, when faced with a lack of statistical evidence we cannot establish with certainty a clear mechanism of causality between the existence of a protected area and reduced deforestation.

- **The data and information used for the study:** the format of the data, their scale, the classification system, and the type of analysis and algorithms used have a great influence on the outcome. It is important to know and evaluate the metadata and technical information on existing studies to make proper use of the information they produce. (Table What can remote sensing and maps tell us?).

Deforestation? Or expansion of the agricultural frontier?

Change in land cover or change in land use? For example, change from forest cover to agricultural land use?

A crucial aspect of the causal analysis is to clearly specify the event of interest and characteristics of the outcome (Table 1) that one seeks to explain.

For instance, it is one thing to analyse **forest loss** and another to analyse **forest conversion** in relation to the expansion of a class of agricultural use, for example, livestock production. Forest loss is a change in land cover, while conversion is a change in use; a change in use produces a change in cover. Forest loss, as an outcome, is (or can be) caused directly by the expansion of a given crop. By contrast, the direct causes of conversion and crop expansion are the decisions of the agents (such as farmers and companies) to establish or manage a crop.

Loss and expansion are stages of an outcome chain. The concepts of causal chain and causal mechanism allow us to address them in a complementary manner. This complementarity fosters a more precise understanding of deforestation processes, relating processes observed in the forest sector to processes produced in the agricultural sector.

It is important to note that some land-use changes produce increases in the vegetation cover. For example, shifting cultivation or fallow techniques entail revegetation and natural reforestation, and agroforestry systems or forest plantations allow the plant cover to recover.

In **forest loss**, the expansion of a given crop is a direct cause of the outcome. In **conversion and crop expansion**, the direct causes are the determinants of the decisions of the agents (such as farmers and companies) to establish or manage a crop. Loss and expansion are stages of an outcome chain; the concepts of causal chain and causal mechanism allow us to address them in a complementary manner. This enables greater precision in understanding deforestation processes and in relating processes observed in the forest sector to those in the agricultural sector.

Do roads cause deforestation?[6]

Yes – both directly and indirectly, but to different degrees, depending on the time frame:

1) In the **short term**, a single small road may not have a significant direct causal effect on the amount of deforestation in a large area (depending on the scale and size of the area considered). But the road may be found to be a trigger or a determinant of the precise location of deforestation events within a large area, or the amount of deforestation within a small study area close to the road (compared with another small area farther away).

2) Roads may be an important indirect causal factor if we consider the **long-term development trajectory** and land-use dynamics that they trigger in the area, including infrastructural development, land-value changes, farm-price changes, which in turn modify the opportunity costs of developing economic activities in these areas.

This distinction is related to the aforementioned terms 'predisposing factors' and 'triggers'.

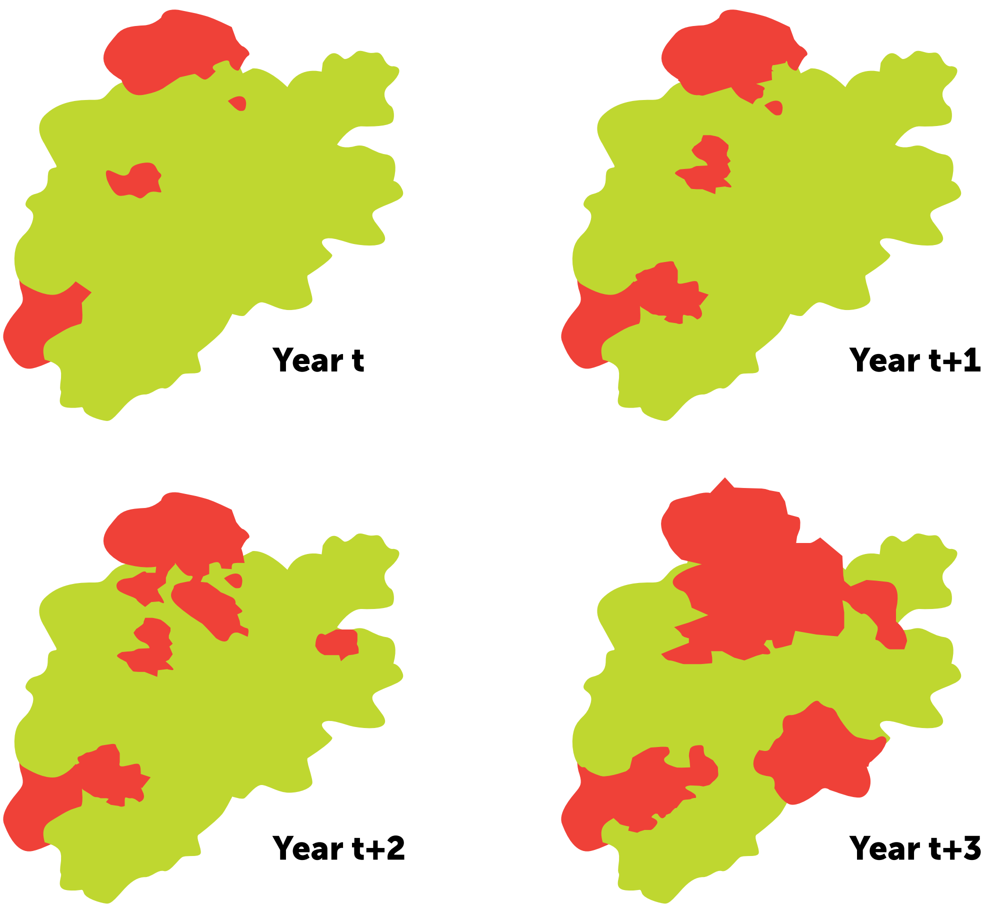
What can remote sensing and maps tell us?

Remote sensing and land-cover maps make it possible to visualize many of the processes that take place in a territory, including deforestation. Time series allow us to observe deforested areas and their spatial distribution, and spatial models allow us to predict future trends.

For example, consider a forested territory in which, in year t, three small, deforested areas have been converted to agriculture. Based on this information alone, we might assume that smallholders are responsible for the change. Then, as time goes by, the number of deforested patches grows, until in year t+3 the patches meet and form one larger patch. We might still attribute this to smallholders moving through the territory. However, the change may no longer be caused by smallholders, but rather by mid-size or even large-scale farmers who have bought the land from the smallholders. To test this hypothesis,

6 CIFOR-ICRAF, in collaboration with the Group for the Analysis of Development (GRADE), has carried out a new study: "Analysis of deforestation frontiers 2000-2020 and the influence of transport infrastructure on land use dynamics in three case studies in the Peruvian Amazon". https://forestsnews.cifor.org/83412/how-does-transport-infrastructure-influence-deforestation-dynamics-in-the-peruvian-amazon?fnl=

we would require information from other sources that complement the maps, validated with field observations or expert information.



How to identify indirect causes and build causal mechanisms

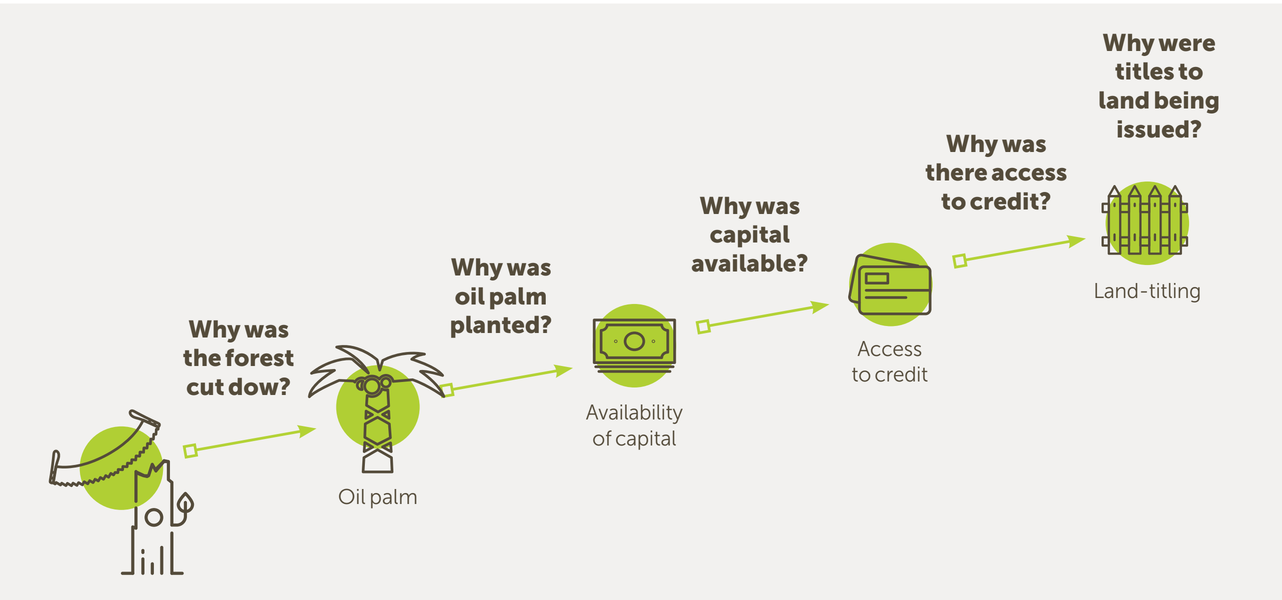
It is simple to identify the direct causes of forest conversion and the responsible agents and to quantify their impacts on forest cover. But when we use a systems approach, special tools and methods are needed, because the indirect causes that act on a causal system are not always evident. Furthermore, as shown in Table 2, these causes operate in a hybrid manner at different levels of the system and can have different impacts depending on their combination with other causes in different contexts. The ways that they influence deforestation may change through time. We saw above how, in the short term and at the local level, roads can be a direct cause of change while also being indirect predisposing factors in the long term. In the latter case, they contribute to conditions that favour land-use change, for example, by improving investment potential, increasing land value, and lowering production costs.

The technical-scientific literature provides statistical econometric models of land-cover change and land-use change based on predefined causal theories that are validated using quantitative variables from existing data or new data generated by projects. We saw how this approach can limit both understanding of systemic processes and identification of leverage-points to inform the definition of effective strategies.

DriveNet uses an open systems-approach based on event ecology to identify the causes of deforestation and land-use change in a territory without adopting predefined models or causal theories. This methodology seeks to answer a sequence of questions about the "why" of specific events (outcomes/causal effect chains in a defined context) (Table 1). Changes can be explained by building causal chains and narratives through a process of inference, using the progressive contextualization approach developed by Vayda (1985). The process starts by identifying and characterizing the outcome, and continues by identifying the proximate causes, which in turn become the outcome of other combinations of causes at increasingly general scales throughout the chain.

Starting from an event such as the conversion of an area of forest to another use, a large amount of information on the possible causes is explored through a sequence of questions in which the explanation of an event becomes an outcome that itself requires explanation (Illustration 3).

ILLUSTRATION 3. Exploration of the causes of forest conversion



Smallholder mosaic landscape with citrus plantations in Chanchamayo Province, Junín Region, in the Peruvian Amazon.

Land-use change is the result of agents acting in a context

An agent's decision to convert forest land into cropland or another use depends partly on the larger-scale context in which they operate, and partly their propensity to produce those changes in relation to their roles, strategies and aspirations.

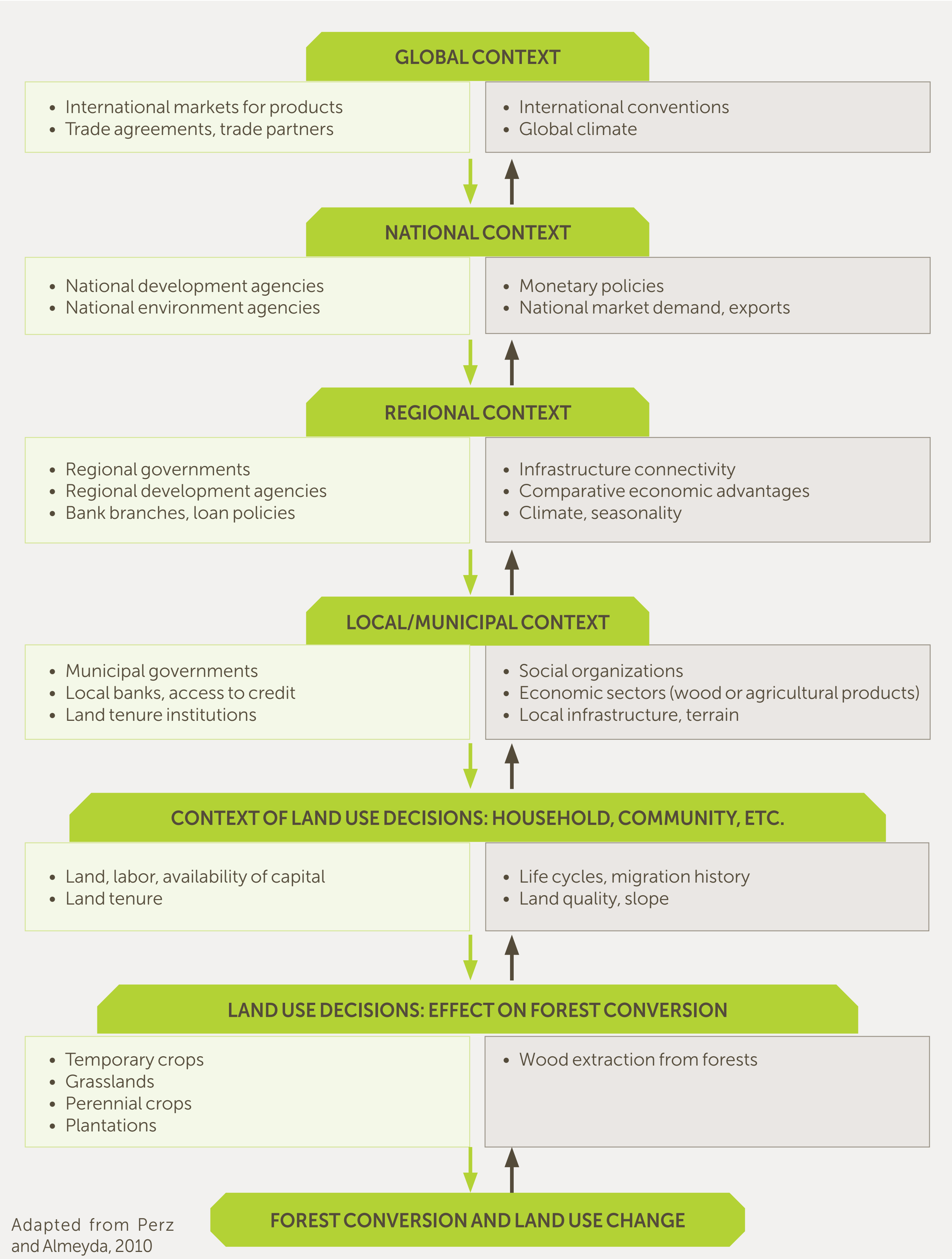
For example, families and agricultural or logging companies operating in a specific location face contextual circumstances defined by local politics, infrastructure quality, market access, market demand and prices, technological capacity, etc. These reflect the local conditions, determined by external factors, under which they operate. These elements depend on the political, institutional, and strategic decisions of other actors, agents, and institutions that have influence in a given context. They can also operate directly or indirectly to influence land-use decisions.

Incentives, such as access to land titles for farmers willing to settle and produce cocoa in lands that formerly produced coca, are examples of elements that might influence an agent's decision to convert forest to cropland.

The DriveNet methodology contextualizes such decisions progressively. It looks first at the immediate surroundings of the agent and the decision, and to the elements that contribute directly to the decision to convert the forest. The next stages consist of observing increasingly broad and distant contexts like the community, local government, jurisdiction, and markets, to identify distal factors that can influence the decision.

Progressive contextualization works upwards, that is, from the micro- to the meso- and macro-levels. This makes it possible to identify "descending" causality through a framework that emphasizes the mechanisms that operate at a larger scale and influence what happens at smaller scales (Illustration 4).

ILLUSTRATION 4. Hierarchical conceptual framework of causal agents that influence forest conversion and land-use change



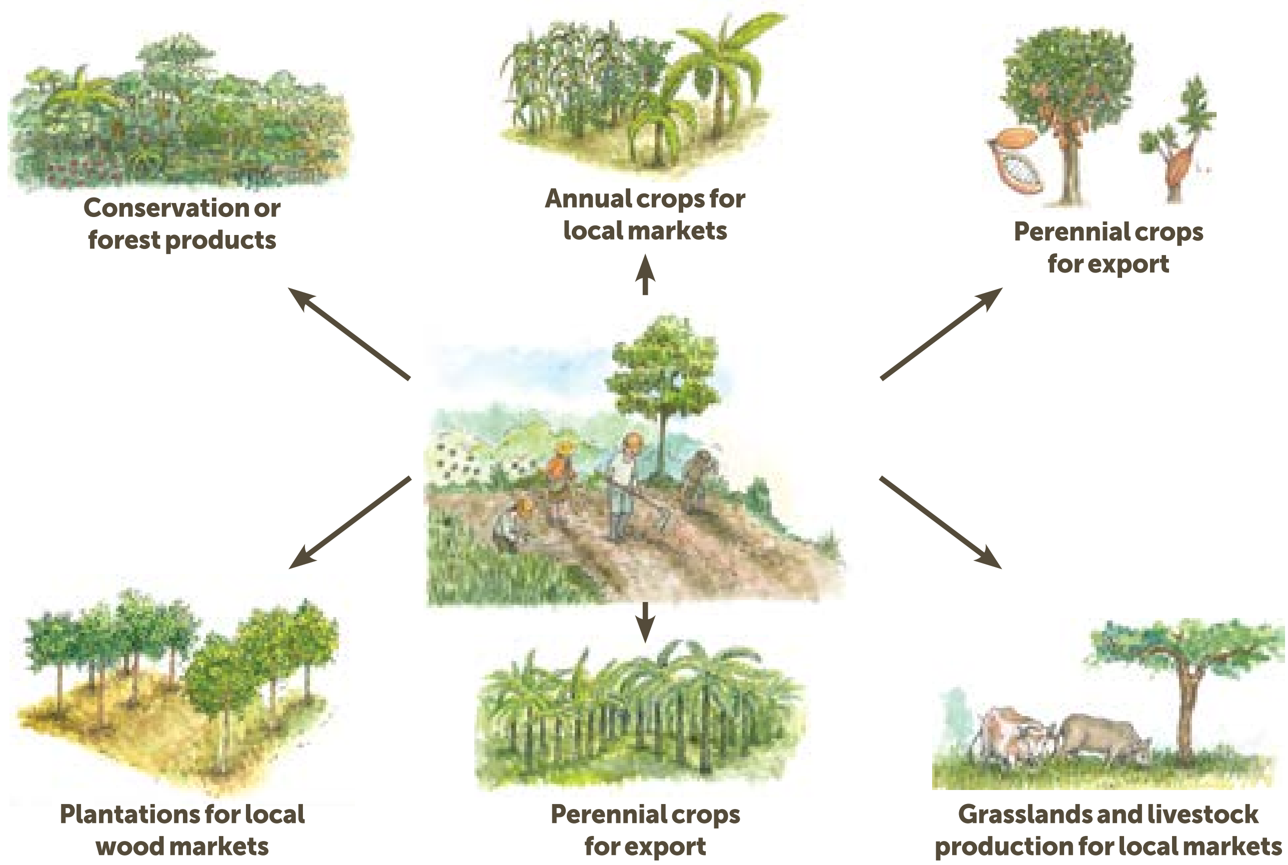
Adapted from Perz and Almeyda, 2010

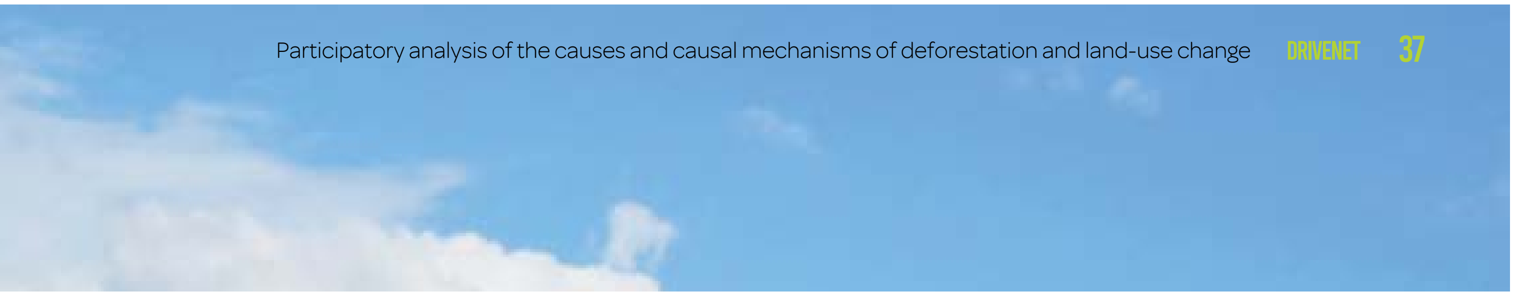
By applying progressive contextualization, we can identify the factors that determine the choice of a land use. By inductive processes, we are able to organize a set of causes from the micro-level to the different macro-levels. Although the causes can be focussed at one scale, the methodology does not prescribe, a priori, a predefined level of aggregation. In the analysis, one can increase or decrease the causal aggregation levels or scale in relation to governance processes or decisions made by the actors or institutions involved, for example, in strategic jurisdictional strategies.

Depending on the purpose of the progressive contextualization, it may not be necessary to identify the causes in advance or at a predetermined spatial scale. In this sense, a causal hierarchy does not favour one explanation over the other. Instead, it provides a structure in which various explanations can exist and interact by seeking patterns at higher levels, and this leads to identifying the common or structural causes at higher levels that trigger various land-use change processes in the study area.

Although the decision of a family, a company, or other social actor to convert forest into cropland is made in a local context at the micro-level (village, town, or other centre of population), it may also be influenced by specific policy programs at the watershed, municipal or regional Amazon levels. It can also be influenced at the national level by an environmental policy or at the global level by commodity prices, markets, and trade agreements.

ILLUSTRATION 5. Options farmers have, depending on the land uses within their productive units



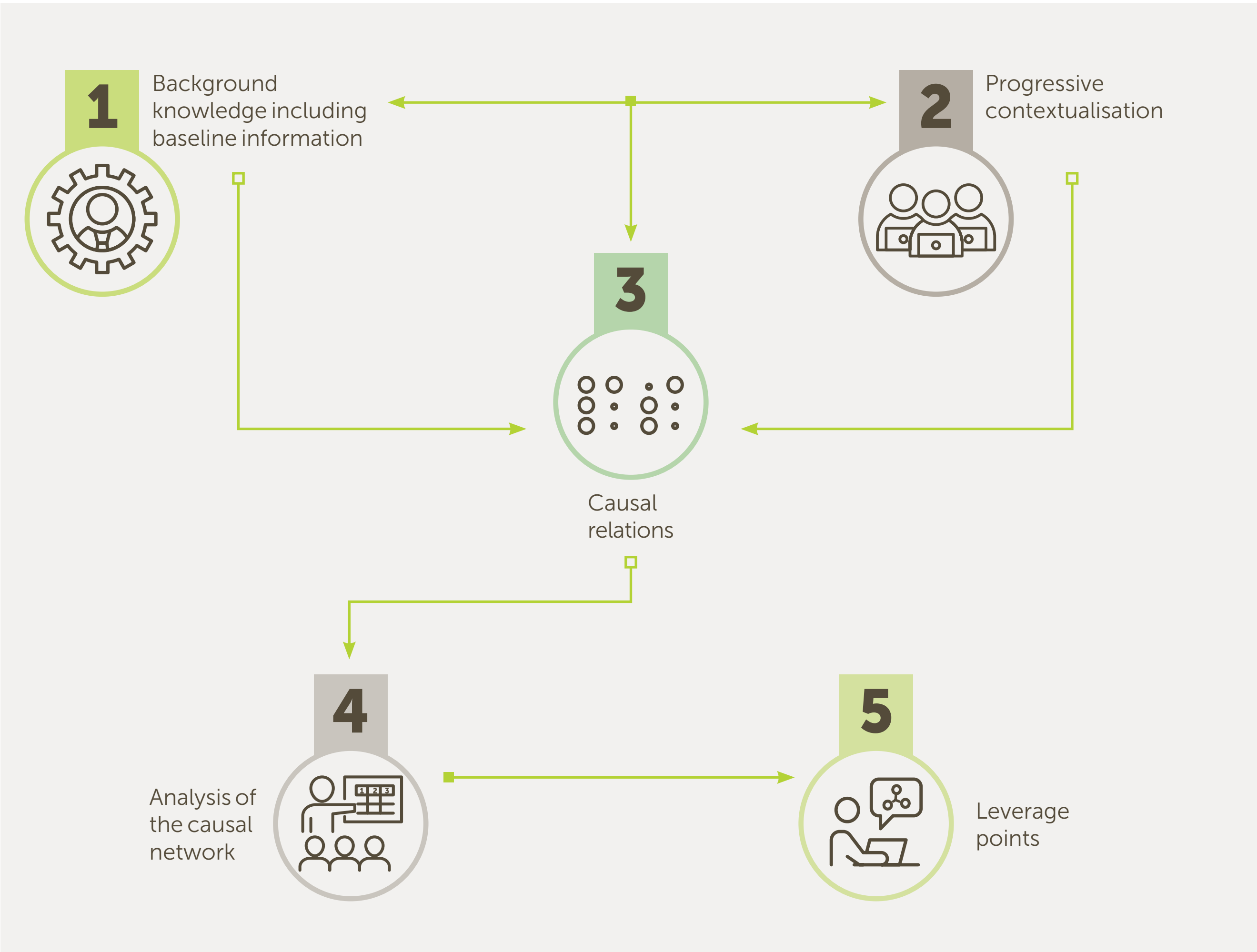


Before starting

Huicungo District, San Martín Region, Peru.

DriveNet consists of a five-stage process (see Illustration 6) that brings together different methods to gather information about the causes of deforestation. It is a participatory process in which the causal mechanisms are progressively contextualized with local actors, after which the influence matrices and networks are analysed to identify leverage points that can be used to design intervention strategies.

ILLUSTRATION 6. Stages of the DriveNet methodology



Each of these stages is described below. First, though, we explain several key considerations that need to be taken into account when beginning a DriveNet process. Careful attention to each is important and will help to avoid problems that might affect success.

Institutional engagement

If DriveNet is to be used to produce input for jurisdictional strategies for low emissions rural development, it is important that local political actors understand the process and the type of information it produces. It is also important that the different stages take place in an environment that encourages participation and sharing of information and prior experience related to land management. It is essential for local government stakeholders to be involved.

RECOMMENDATION. Hold an introductory meeting with local government officials to acquaint them with the goals of the process and introduce the stages of the methodology, thereby securing their support and commitment.

Cacao field in Irazola District, Ucayali Region, Peru.

The technical team: required expertise and terms of reference

DriveNet is implemented by a technical team that must be previously trained to apply the methodology. They must also know how to use Microsoft Office (Word, Excel, PowerPoint) and licensed or open-source geographic information system (GIS) software. The team may need to involve other experts on an ad hoc basis in the different stages. **A good job cannot be done without investing in a good technical team.**

The team should have at least three members, including:

- ☑ A technical coordinator, responsible for organizing, planning, and executing DriveNet activities; leading the analysis; and writing the intermediate and final reports.
- ☑ A logistical coordinator.
- ☑ An information manager, responsible for digitizing data and systematizing information.

As a group, the team should cover the following competencies and skills:

- ☑ Understanding of the local socioecological context, deforestation dynamics, and production systems, including the regulatory and institutional framework.
- ☑ Ability to handle spatial data, databases, and GIS.
- ☑ Ability to facilitate focus groups and multi-actor participatory dynamics.
- ☑ Ability to work with quantitative and qualitative methodologies.

RECOMMENDATION. Team members should decide what their duties will be. For example, one member can facilitate the focus group, one can take notes, and the third can be in charge of the spatial data and GIS. The distribution of responsibilities will depend on their individual and teamwork skills, as well as on the characteristics of the group of participating actors.

If necessary, the technical support group should include:

- Officials and technicians of regional, provincial, and district governments.
- Non-governmental experts in land management, forestry, agriculture, tenure issues, and climate change (e.g. academics, Indigenous representatives, NGO personnel).

Planning the work

It is important to plan the DriveNet stages: estimate the time, human, and financial resources needed, and map out the required logistical arrangements.

Identification of information

The technical team should consider the type of data and information that can be used as input for the DriveNet process, and then identify the sources, collect the information and systematize it. This information will consist of reports, study documents, and diagnostic assessments that provide general information on the socioecological history of the territory, as well as socioeconomic and statistical data – for example, about crops. They will also need spatial data in the form of maps (shapefile or raster digital formats, or analogue).

RECOMMENDATION. Identify critical information gaps (by assessing the information available in relation to needs) and identify the most cost-effective means to fill them (DriveNet Stage 1). By knowing the characteristics of the data available the team can define additional needs, such as acquisition of equipment to conduct analyses (software and hardware).

Irazola, Ucayali.


Irazola, Ucayali Region, Peru.

Stakeholder engagement

Because DriveNet is based on a participatory methodology, it is important for the technical team to identify which groups of actors will be involved from Stage 2. The groups and individuals chosen should:

- Ensure accurate representation of the universe of local actors and experts.
- Represent a group of actors whose activities have a direct or indirect impact on deforestation and land-use change.
- Typically, be drawn from participants from some or all of the following groups:
  - Indigenous communities
  - Public and private organizations
  - Farmers' associations
  - Local agencies or jurisdictional governments (officials and technicians)
  - National and international agencies that work with forests, agriculture or land issues (NGOs, thinktanks, donors)
  - Universities (researchers)
  - Knowledgeable or influential individuals, with or without institutional affiliation

RECOMMENDATION. Make sure to have a heterogenous group of participants, for instance with smallholders and large farmers, and men and women of different ages. A heterogeneous group with an imbalance of power and capacities may be a challenge for the facilitator, who will need to ensure that all the participants can voice their opinion and answer questions throughout the process.

As soon as they identify the participants, the technical team should contact them to inform them of the process and ensure their commitment to the different stages. Keeping a good work environment in which participant actors are kept informed of progress, and in which dialogue and cordial relations are fostered, ensures their effective participation and increases the likelihood of achieving good results.

Focus group workshops

Focus-group workshops are fundamental elements of the DriveNet methodology, particularly in Stages 2 and 4. It is important to introduce the actors and describe the activity, its objectives, and the importance of them participating in the entire process. In this way, their interest can be secured. Participants include members of the groups referred to in the previous section.

Workshops require four days, and the same actors must participate in all the workshops. There are no strict rules for their overall organization; this may vary according to the local context of the territory under analysis and the participants available. Possible alternatives include the following:

Option A (3+1):

A workshop lasting at least three days:

- ☑ **Day one:** identification and discussion of land-use changes and the agents linked to them.
- ☑ **Day two:** identification and discussion of the causes of deforestation and land-use changes, characterizing each one and their causes.
- ☑ **Day three:** assessment of the causes and the relations of influence between them (causal relations of influence) (Stage 2).
- ☑ A one-day workshop to present and validate the results of the causal network analysis and to identify leverage points (Stage 5).

Option B (2+1+1):

A two-day workshop:

- ☑ **Day one:** identification and discussion of land-use changes and the agents linked to them.
- ☑ **Day two:** identification and discussion of the causes of deforestation and land-use changes, characterizing each one and their causes.
- ☑ A one-day workshop to validate the causes and assess the relations of influence between them.
- ☑ A one-day workshop to present and validate the results of the causal network analysis and to identify leverage points (Stage 5).

Option C (1+1+1+1):

- ☑ A one-day workshop to identify and discuss land-use changes and the agents linked to them.
- ☑ A one-day workshop to identify and discuss the causes of deforestation and land-use changes, characterizing each one and their causes.
- ☑ A one-day workshop to validate the causes and assess the relations of influence between them (Stage 2).
- ☑ A one-day workshop to present and validate the results of the causal network analysis and identify leverage points (Stage 5).

Local-level workshops

The above options are suitable for analyses at larger geopolitical scales (that is, in most countries, the first level of subnational government, for example, department, region, state). If the team later decides to apply DriveNet at a smaller scale – for example, county or local authority – it should consider repeating Stages 2 and 3 and adjusting the timeframes.

RECOMMENDATION. Constructing the influence matrix and causal networks (Stage 3) is fundamental and requires time to systematize the data and produce the outputs that will be presented to the actors in Stage 4. Hence, care must be taken to allow extra time to process and interpret the data and find the best way to present the outcomes.

Depending on the context, level of participation of the actors, and volume and quality of the information obtained and addressed in the workshops, it may be necessary to hold additional, more technical workshops with experts from the support network. For example, if information collected about crop types and the areas they occupy is incomplete, the technical team may decide to convene an additional workshop or roundtable with experts familiar with the data. This also means that the technical team needs to have the flexibility to reprogramme their time, so that the outcomes can be incorporated in the information to be taken to the next stage.

Time and cost estimates

Implementation of the five stages of DriveNet requires about 14 weeks (four months). Illustration 7 shows the stages and their respective activities, as well as the estimated time needed for each. At least four days must be set aside at the end of each stage to prepare the logistics for the next one.

ILLUSTRATION 7. **Activities and estimated time for each DriveNet stage**

Stage 1 **Background knowledge and preparation of the baseline information**	• Collect and prepare data and secondary information. • Prepare the database, maps, and lists of causes and actors.	3 weeks
Stage 2 **Participatory analysis using progressive contextualization**	• Workshops in focus groups to identify changes, causes, and agents.	4 weeks
Stage 3 **Identification of causal relations of influence**	• Focus group workshop to identify influences between the causes.	2 weeks
Stage 4 **Building of the relationship matrix and analysis of the causal network**	• Digitize and systematize data. • Network analysis. • Interpret influence matrix and network metrics.	2 weeks
Stage 5 **Analysis of the mechanisms and identification of leverage points**	• Identify and analyse leverage points in relation to priorities. • Workshop to present and validate the outcomes. • Technical follow-up.	3 weeks

The financial costs of implementing DriveNet—excluding remuneration of the team—are mainly due to the focus-group workshops.

RECOMMENDATION. Budget for the costs of sending invitations and transporting equipment and participants between their homes and the workshops. When participants come from distant locations and have to arrive the day before (or leave the day after), it is important to make sure that all their costs are covered (for example, extra nights' accommodation).

The team should consider paying a participation allowance to compensate those who are not participating on behalf of their institutions and who therefore may lose income by attending the workshops.

For workshops, include the costs of renting the venue, which must allow for comfortable group sessions: it needs to be spacious, well ventilated, and equipped with worktables and chairs. In addition, since the venue should ideally allow for images to be displayed with a projector, budget for materials to block outside light (curtains). Possible venues include auditoriums of government offices, or communal meeting places if the location is a village.

Finally, budget for snack and lunch services and 10% of the total for contingencies.

The five stages of DriveNet

Smallholder land-use mosaic in Irazola District, Ucayali Region, Peru.

Every territory has physical, social, and political processes whose interactions influence the configuration of the current forest landscape. The starting point for a DriveNet analysis is to know and document these processes, what and who is responsible for them, and how and where they developed.

This section describes the different stages of DriveNet, with emphasis on practical and methodological aspects. It presents the criteria to assess the inputs of analyses, make decisions during the facilitation process, systematize data and network analyses, and interpret the results. It also includes examples using data from DriveNet pilots in some jurisdictions of the Peruvian Amazon.

RECOMMENDATION. The five DriveNet stages are standard and apply to any analysed territory. However, the information and data used in each stage may vary, and DriveNet should be adapted to the local context in the jurisdiction of application.

Stage 1. Background knowledge and preparation of the baseline information

Overall objective: collect, organize and document current knowledge on deforestation processes and allow the team to familiarize themselves with the study area.

Venue: technical team's office or workspace.

Participants: technical team.

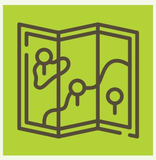
Duration: 3 weeks.

This stage consists of collecting, organizing, and documenting the current knowledge on deforestation in the study area, which must be defined from the start. It familiarizes the technical team with the target area, whether defined geopolitically (for example, district, canton, province, department, state, region, country) or biogeographically (for example, watershed). It also involves judging the quality of the information, planning its use, preparing for the following stages, setting up the materials needed to facilitate the focus groups, and identifying the main actors who will participate in the process.

The construction of knowledge of the study area is based on secondary data. This is information and data produced or managed by national (or federal) or subnational government agencies, NGOs, universities, and research centres. The data can be obtained from their offices, from publications, or from websites.

The data available may differ between jurisdictions; the technical team will need to choose which is relevant to the analysis. Relevance depends on information content and usefulness in answering the following general questions:

What have been the most significant changes in land cover (according to surface area, frequency, and distribution) in the last 15 years? And in the last 5 years? What is the most evident current deforestation trend? And what is expected in the future?



Where (jurisdiction, watershed) did it happen in the past? Where is it happening now and where might it happen in the future?

Which land uses and production systems are most associated with past, present, and future land cover changes?

Which agents produced or are producing these changes?

Data and information on the socioeconomic and production context

Information on the socioeconomic and production context comes from texts such as development plans, study reports, or thematic assessments prepared by the government, national and international NGOs, research centers, and development agencies, as well as statistical data (Table 3).

TABLE 3. Example of documents collected in the San Martín Region of Peru

The documents contain relevant information on biophysical, social, economic, and institutional aspects of San Martín, including its land settlement history. The technical team can use the information to identify the causes of deforestation, considering trends in production systems and infrastructure development. In San Martín, much of these data are available from the Regional Government and are publicly accessible on its website.

Document	Source	Year
San Martín Concerted Regional Development Plan for 2021	San Martín Regional Government	2015
Agricultural production statistics	Ministry of Agrarian Development and Irrigation (national government)	2017
Forest Zoning Implementation Plan, Department of San Martín	San Martín Regional Government	2017
San Martín. Economic Analysis of Alternative Development Impacts in relation to Deforestation and Coca-Growing Activity	United Nations Office on Drugs and Crime, Lima, Peru	2014
Regional Forest Plan of San Martín	San Martín Regional Government	2008
Ecological Economic Zoning Proposal as a basis for Land Use Planning	San Martín Regional Government	2005

Rapid analysis of relevant actors

After checking the documents, prepare a list of deforestation agents and identify the groups of actors from which the DriveNet participants will be drawn.

Depending on the results of the first analysis of the information collected and on the scale at which DriveNet will be applied (regional, provincial, watershed), consider including:

- **Livestock producers** (independent, belonging to different associations or cooperatives, from different unions and subsectors).
- **Representatives of Indigenous communities** or other groups such as peasant communities, ejidos, forest communities.
- **Local authorities** (mayors, etc, or their delegates).
- **Personnel of local NGOs**
- **Extension workers**
- **Officials** (current or former) of relevant levels of subnational and local government, particularly those assigned to specialized agricultural, environmental, forest, or land-use planning agencies.
- **Personnel of development agencies** working in the study area.

Spatial data

Textual information is complemented by spatial data (that is, those that are spatially referenced). These data – for instance, maps of forest cover, deforestation, elevation, and road networks – provide answers to "what" and "where" questions linking deforestation to geographical variables such as elevation, slope, and accessibility and to legal categories of land use or land suitability (CUM in Spanish)[7]. This makes it possible to identify the areas most exposed to future deforestation, and which changes are within the law.

Spatial data or geographic data are managed and analysed in a GIS. The choice of data depends on availability, quality, and relevance to the context. For example, some jurisdictions include distinct ecosystems and agroclimatic zones – due, for example, to mountain ranges and associated elevation ranges or rain shadows. These different zones have vegetation, climatic, and land features that may be characterized by different socioecological processes.

Example of Padre Abad, Peru

Padre Abad is a province of Ucayali Region in the Peruvian Amazon. It is located in the Aguaytía river watershed and has two clearly recognizable zones: one is a flat and easily accessible zone, rising to a maximum altitude of 400 m a.s.l., with relatively compacted soils and a predominance of grasslands; the other has undulating topography, rising to 1200 m a.s.l. in the Divisoria mountain range to the west, with steep slopes and less compacted soils, where annual and perennial crops and forests predominate. These biophysical differences influence the contexts in the province. In such a case, the team would need to decide if it is worth distinguishing between these zones.

It is important to note that in mountain regions slope and access may be spatial determinants or causes that trigger land-use change. The use of particular types of spatial data needs to be justified by possible assumptions about causes of deforestation in the specific contexts in question. For example, a map of population density might be used if population growth is a probable cause of deforestation.

In the following section, we present some criteria that are useful in deciding what data to collect and what data to incorporate in the spatial database as input for the causal analysis.

7 For example, in Peru, CUM refers to major land suitability.

Methodological protocols

The data must comply to standards documented in a technical protocol[8]. In some locations, appropriate government-approved protocols may be available and should be used. For example, the DriveNet pilots in Peru observed protocols approved by the Peruvian Ministry of Environment, such as the 2001-2017 Forest, Non-Forest and Forest Loss Map[9]. Such standards assure scientific rigour and consistency in terms of scale, minimum mapping area, and other elements, and make it possible to know the characteristics and limitations of the information that will be used. Although the mentioned map indicates only forest loss (from "Forest" to "Non-Forest") and provides no information about changes in land use (land use in deforested areas is categorized as "Non-Forest"), it provides valuable input for analysing deforestation.

For maps that include land use[10], it is essential to understand the classification system applied. For example, the Peruvian Ministry of Environment's 2013–2016 Land Use Change Map (MINAM, 2017), which informs the monitoring, reporting and verification (MRV) and GHG inventories found in the Ministry's Geobosques Platform for Monitoring of Forest Cover Change[11] uses the generic categories of the Intergovernmental Panel on Climate Change (IPCC) (see table 4). These categories are of limited use in understanding the dynamics of land-use change. For example, the class "Agriculture" does not provide information about the type of crop (annual: rice, maize; perennial: cacao, oil palm, coffee; lands lying fallow). In this case, if the team considers understanding of the type of crop involved in forest conversion to be important, then they would have to adjust this class to the local context by disaggregating the class "Agriculture" and spatially locating the subclasses.

The systems used for classification and generation of legends with land-cover and land-use classes use standards and certifications that make it possible to assess the quality of the information in each map[12].

A useful way of enhancing land-use maps with incomplete information is to incorporate non-spatial information that nevertheless has a spatial reference in their records, for example, national agricultural censuses[13]. Statistical data from such sources can be used to disaggregate the generic classes, reducing the ambiguity of class definitions and enabling a more precise analysis of changes linked to other sectors, such as agriculture.

8 UA technical protocol is a document that describes the methodology and technical procedure used to produce spatial data. It contains information about the input data, the criteria applied for process decisions, the analysis conducted, and a description of the final outcome. It also contains information about data restrictions.

9 MINAM (2020) 'Datos de bosque y pérdida de bosque 2001-2019'. Lima, Peru. Available at: http://geobosques.minam.gob.pe/geobosque/view/perdida.php.

10 See the definitions of land cover and land use in the Basic Concepts section.

11 https://geobosques.minam.gob.pe

12 For more information about the subject see: Di Gregorio, A & Jansen, L (2005). Land Cover Classification System. FAO.

13 For example, the Peruvian CENAGRO (see Annex 1).

TABLE 4. IPCC land-use and land-cover categories

Land use	Forest land	Forests
		Marshes in forest
	Agricultural lands	Agriculture
	Grasslands	Secondary vegetation
		Hydromorphic savannas
		Meadows / pastures
	Wetlands	Waterbodies
		Marshes Non-Forest
	Settlements	Artificial areas
		Mining areas
	Other lands	Barren land

Adapted from IPCC, 2003

Formalizing data management

Only data produced by recognized institutions should be used. For example, in Peru, data produced by regional governments in their jurisdictions are considered official data (Table 5). The use of data from non-official sources, such as reputable NGOs, is acceptable, if local institutions recognize them as valid and trustworthy and if they are compatible (definitions, scale, formats) with other information used locally.

Production date and currency of data

The production date refers to the year the data was generated, the currency to the period that it covers. For example, a road-network map may have been prepared in 2017 but may present information for 2012. As a result, any roads constructed after 2012 will not appear on the map. Before such a map can be used it may be necessary to add additional information from sources such as Google Earth, or from the focal-group discussions in Stages 3 and 4. Data should be as up to date as possible.

We also recommend that data collected follow the Datum WGS84 UTM spatial reference system[14], which facilitates the calculation of areas and distances. The UTM coordinates system divides the world into "zones", and it is important to know in which zone the study will be carried out. For example, in Peru, depending on where the study area is located, the zone may be 17 South, 18 South or 19 South. San Martín is located in UTM zone 18 South.

Data can be in either of two formats: vector (point, line or polygon) or raster (pixel grid) and must be stored in a database organized with a hierarchical and thematic structure that allows for new data collected or produced throughout the process to be incorporated (Illustration 8).

A workshop participant presents the group work results in Irazola District, Ucayali Region, Peru.

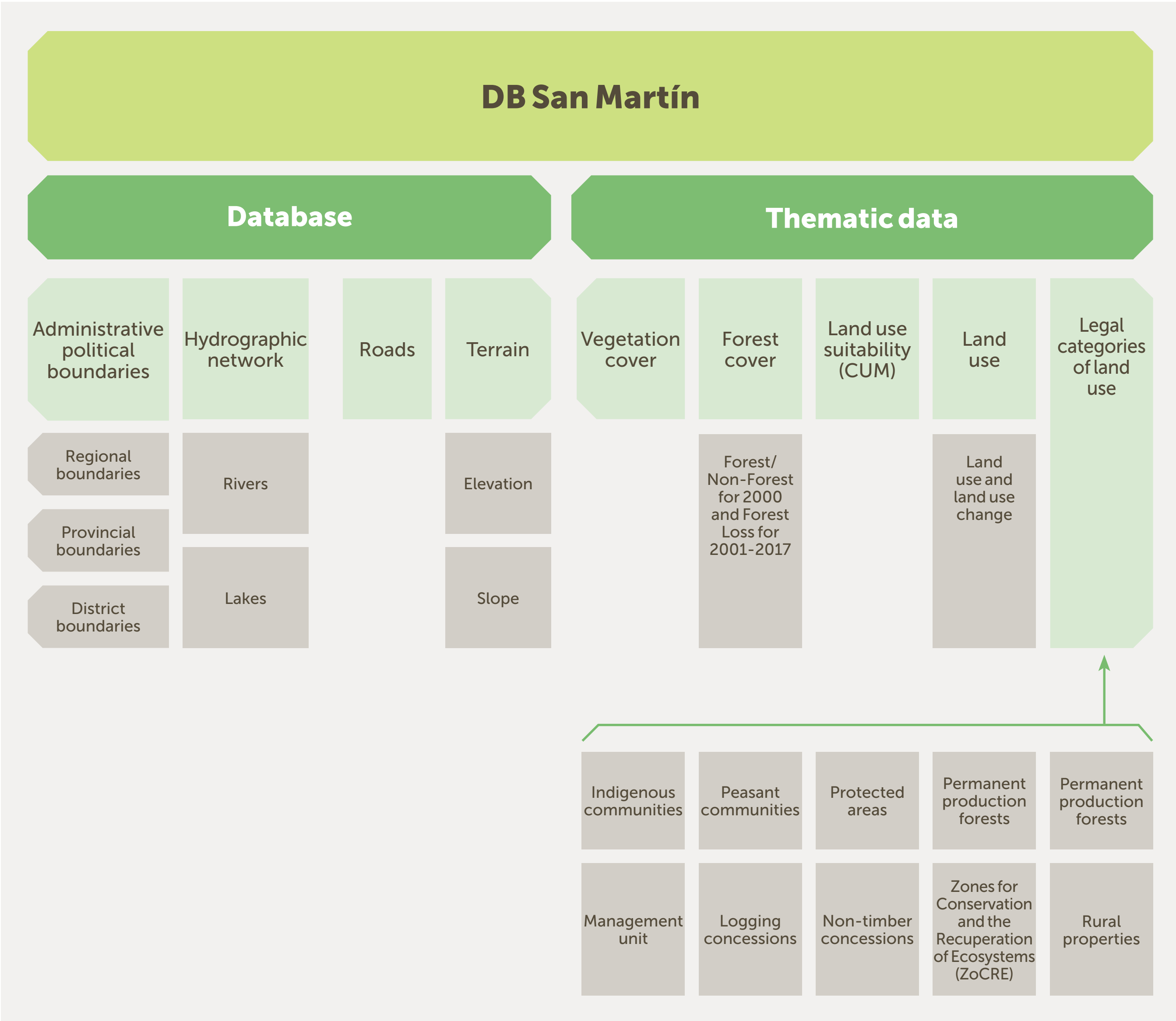
14 Universal Transversal Mercator.

TABLE 5. Example of spatial data collected in San Martín Region, Peru

Spatial data		Source	Institution
Political-administrative boundaries		IDERSAM	San Martín Regional Government
Centres of population		IDERSAM	San Martín Regional Government
Road network		Ministry of Transport and Communications (MTC)	MTC
Hydrographic network		IDERSAM	Regional Government of San Martín
Forest, Non-Forest and Forest Loss 2001-2017		Geobosques platform	Ministry of Environment - National Forest Conservation Program
Vegetation cover		Geoservidor platform	Ministry of Environment
Elevation		Shuttle Radar Topographic Mission (SRTM)	SRTM
Slope			Derived from SRTM
Land use suitability		IDERSAM	San Martín Regional Government
Legal categories of land use	Indigenous community	IDERSAM	San Martín Regional Government
	Peasant[15] community	IDERSAM	San Martín Regional Government
	Protected Area	SERNANP SIG	National Service of Natural Protected Areas (SERNANP)
	Permanent production forest	IDERSAM	San Martín Regional Government
	Management unit	IDERSAM	San Martín Regional Government
	Logging concession	IDERSAM	San Martín Regional Government
	Non-timber concession	IDERSAM	San Martín Regional Government
	Ecosystem conservation and recovery zone	IDERSAM	San Martín Regional Government
	Rural property	IDERSAM	San Martín Regional Government

15 Refers to 'Comunidad Campesina', a legal category in Peru.

ILLUSTRATION 8. Example of a database structure (San Martín Region, Peru)



Data must be in WGS84/UTM zone 18S, organized in a GIS database with a hierarchical and thematic structure.

In addition, the spatial data must be accompanied by metadata that describe them and allow them to be evaluated. Metadata should be adjusted according to the specifications in Annex 2. If the data do not have metadata, they should be prepared and incorporated them in the Annex 2 table.

Base maps

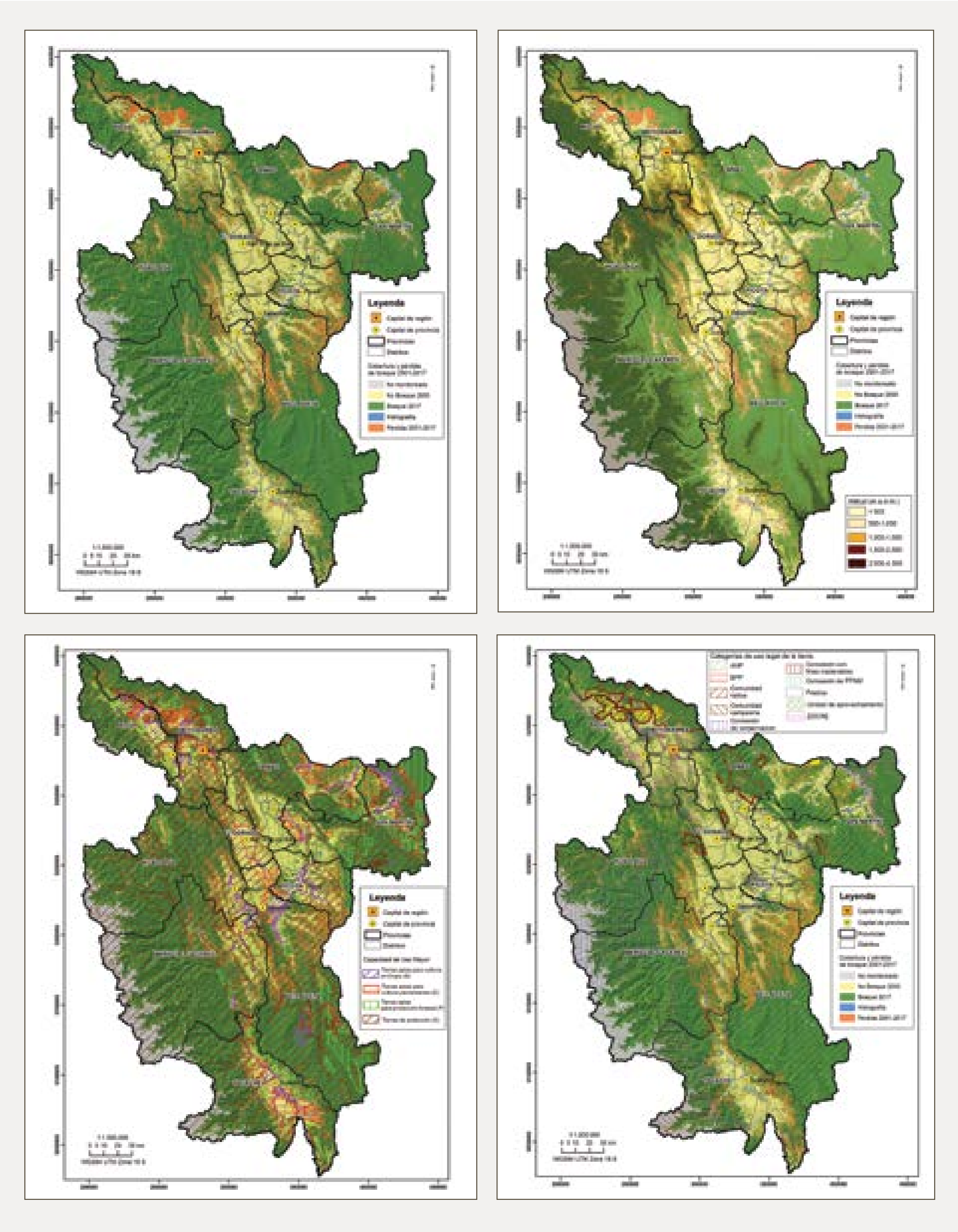
Base maps are prepared using the spatial data in the database, both directly and after preliminary analysis. They ensure the availability of quantitative input and a graphical base for the Stage 2 workshops, in which participants will discuss and analyse the geographical distribution of land-use changes, their causes, and agents. The number and type of maps will depend on what topics are relevant for the specific study area: for example, deforestation in relation to elevation, deforestation in relation to land-use-suitability categories, deforestation in relation to legal categories of land use.

The map of forest cover and deforestation is important because it provides information on the distribution of forest cover and forest loss in a jurisdiction. Maps have the advantage of allowing the spatial analysis of two or more variables. For example, deforestation can be analysed in terms of elevation, to estimate how much forest was lost, to see if this loss is concentrated between 500 and 1000 m a.s.l., or in areas above 2000 m a.s.l.

Crop fields and remnant forests in Campoverde District, Ucayali Region, Peru.

Deforestation can also be analysed in relation to legal, normative land-use categories. Such an analysis can identify areas of illegal deforestation. A similar analysis can reveal the most-deforested categories; for example, these might be rural land properties in one jurisdiction, but Indigenous communities in another. This analysis provides a preliminary identification of the agents linked to deforestation; it might be useful to share such information during the focus-group workshops.

By way of example, we present below some thematic maps from the San Martín Region, Peru, and complementary tabular data (Tables 6 to 9), as used in workshops during the DriveNet pilot in San Martín.



Upper left: **MAP 1:** Base-map, Upper right: **MAP 2:** Map of forest cover and deforestation in relation to elevation. Lower left: **MAP 3:** Map of forest cover and deforestation in relation to CUM. Lower right: **MAP 4:** Map of forest cover and deforestation in relation to legal land use categories

TABLE 6. Areas of forest cover and forest loss in 2001–2017

Cover	2000		2017	
	Area (ha)	%	Area (ha)	%
Forest	3 807 642	78	3 388 799	69
Non-forest	1 019 888	21	1 019 888	21
Forest loss 2001-2017	N.A.	0	418 842	9
Hydro	72 077	1	72 077	1
Total area monitored	4 899 606	100	4 899 606	100

TABLE 7. Areas of legal land use categories, forest cover and forest loss by legal land-use category, 2001–2017

Legal land use category	Total area		Legal land use category	Total loss 2001–2017	
	Area (ha)	%		Area (ha)	%
Not categorized	1 419 379	28	Not categorized	150 829	36
Native communities	227 475	4	Indigenous communities	40 573	10
Rural communities	85 266	2	Rural communities	1366	0
Natural Protected Areas	1 096 855	21	Protected Areas	15 733	4
Permanent production forest	293 322	6	Permanent production forest	60 997	15
Management units	200 303	4	Management units	18 242	4
Non-timber concessions	131	0	Non-timber concessions	1	0
Logging concessions	572 109	11	Logging concessions	57 590	14
Conservation concessions	599 122	12	Conservation concessions	12 127	3
ZoCRE	405 751	8	ZoCRE	29 422	8
Properties	234 341	5	Properties	31 961	7
Total	**5 134 052**	**100**	**Total**	**418 842**	**100**

A list of districts[16] with active deforestation processes could be created by analysing the MINAM Forest, Non-Forest and Forest Loss Map for 2001–2017 with the shapefile of political-administrative boundaries. This spatial analysis can be carried out using the tools provided by GIS programs. The spatial analysis results can be tabulated and exported to an Excel spreadsheet for work on the selected districts.

Probable direct and indirect causes

A list of direct and indirect causes of deforestation is prepared by consulting the documents and analysing the maps. The list should also define the causes, if necessary. At the same time, data such as the geographic location, the year in which the event occurred, and whether it was a single event or one repeated over multiple years or multiple areas can be added (Annex 3).

Outcomes and outputs of Stage 1

After completing Stage 1, the technical team will be ready to move to Stage 2 of DriveNet. At this point, the team should have the following outputs:

- ☑ Database and list of documents consulted on the socioeconomic and production context, with a summary of the main issues linked to deforestation and land-use change.
- ☑ Spatial database with the relevant information for the study area, with its respective metadata.
- ☑ Thematic maps in digital and printed versions, including maps of forest cover and deforestation in relation to legal land-use categories and in relation to land-suitability classes or slope.
- ☑ Document or presentation synthesizing the context, including lists of jurisdictions with ongoing deforestation and those with more forest or more forest loss; a list of probable causes of deforestation and land-use change; and a preliminary list of probable deforestation agents.
- ☑ List of key actors with full name, institution, job, geographic location and contact information.

Contextual information synthesis

The information in the PowerPoint document will serve as input for the final synthetic document or presentation that should be prepared at the end of Stage 1 and presented in the first workshop. The thematic maps should be printed in poster size or A0 (84.1 cm x 118.9 cm) to facilitate workshop activities.

16 In Peru, the district is the third tier of subnational government (below region and province).

Stage 2. Participatory analysis through progressive contextualization

Overall objective: identify and contextualize the causes and causal mechanisms of deforestation.

Duration: 4 weeks.

Participants: technical team and participating actors.

Location: workshop venue.

DriveNet works by identifying causal mechanisms with local experts and actors, who contribute to the narrative by progressively contextualizing deforestation causes, starting with a given deforested area and moving towards a more general scale.

Stage 2 focuses on engaging the actors, integrating knowledge and views, and on fostering debate, through which participants can understand and build a system that shows how causes of deforestation are related to each other. Participants provide their insights to the analysis of land-use change, helping to identify the agents, causes, and relations between the causes as they see them.

Preparation: identification and engagement of actors

The selection of participants is very important and should be done carefully. Based on the preliminary list prepared in Stage 1, the team confirms the participation of actors from sectors relevant to deforestation dynamics, using telephone or email. These should be important actors whose decisions and activities have an impact on deforestation and land-use change. The selection of participants may pose different challenges in different territories, depending on the local dynamics and agents involved in deforestation processes (for example, large companies, migrant settlers, Indigenous communities, land speculators, or informal sawmills).

When extending the invitation, the technical team should strive to generate interest and a feeling of contribution and commitment that, subsequently, will allow the workshops to take place in a non-confrontational environment of solidarity and empathy. This way, the results of the analysis can be translated to actions that produce a favourable change in the participants themselves.

Potential participants will have different professional profiles, technical capacities and experience. As such, it is important to consider the following when assembling and interacting with the group:

Heterogeneity of gender, age, livelihoods, ethnicity

The diversity of participants should reflect the diversity of the territory and of the people that influence deforestation and land-use change. The fundamental principles are those of inclusivity and the need to incorporate different groups' perspectives on causes of deforestation. If members of Indigenous communities participate, a translator should be available to ensure that Indigenous representatives are fully involved in the discussions. The translator should be a woman, to encourage participation of female Indigenous representatives.

Knowledge

It is important to consider all the dimensions that explain the causes of deforestation: social, economic (market), cultural, institutional, formal and informal legal instruments, technical (production and management practices).

A diversity of participants will ensure that direct and practical knowledge will be available on all important dimensions.

Group size

Although there is no ideal number of participants, experience from DriveNet pilots suggests that around 20 participants is a suitable number, that is, neither too many nor too few. A large number of participants can hinder participation without increasing workshop effectiveness, while, if participants are too few, results may be unrepresentative.

Availability

The activities and topics discussed in the workshops are interconnected. As such, if participants do not participate enough – or do not participate at all – in one workshop this may create problems in degree and quality of participation in the other workshops, which will affect the outcomes. For this reason, efforts should be made to encourage full participation by each participant in all the workshops.

RECOMMENDATION. Approach each individually or through their institution well in advance to invite them to commit to the process. Once the workshops start, the group can receive progress updates through email or any platform designed for this purpose, where they can also leave comments and suggestions for each stage.

Focus groups workshops

The section on "Planning the work" (see page 41) suggests alternative ways of organizing the focus groups, including general information on logistics.

Suggestions to organize successful workshops

1	2	3
Select the date for the workshop according to the availability of the participants and workshop venue. Consider the possibility of holding the focus groups during the weekend if farmers or government officials are unable to interrupt their activities in the field or office.	**Invite participants formally through an official letter.** It is common practice for the organizing entity to cover the costs of participants' food and transport. It is important to confirm and ensure the participation of all of the invited participants and sectors.	**During the workshops, and to optimize the time set aside for group work,** it is important to present the objectives and agenda of the workshop.

At the start of the workshop, the technical team welcomes everyone and introduces the DriveNet process, so that all participants understand its objectives, its context, its scope, and how the stages of the workshop are interconnected.

Subsequently, it is important to invite participants to introduce themselves and explain why they are participating (their connection to forest conversion into croplands, or forest resource use, or to the production systems they manage, or their role in all of these things, for instance, as decision makers or as personnel of NGOs or organizations that promote a type of crop or practice). This usually takes some time, but it is an important step in building participants' identification with the process.

Workshops can be organized in different ways. Below, we describe the sessions that address the various interconnected topics.

Session 1. What change(s)?

The session begins by defining the type of causal effect that will be analysed: whether forest-cover change (deforestation), forest conversion to a particular type of use, such as a crop (land-use change), or both. Conversion can be analysed only if data (statistics, maps, shapefiles) of sufficient specificity is available.

Next, define the boundaries of the study area, building on the synthesis of prior knowledge (Stage 1), and considering the geographical and administrative boundaries (watershed, jurisdiction), the main agroclimatic and ecosystem characteristics, the predominant types of natural vegetation, and other features relevant to the analysis, such as legal land use categories. This information is presented at the end of Stage 1. It is important to display the printed thematic maps on a wall so that participants can refer to them whenever they want.

The technical team should present the content of each map so that participants understand what information they show and how to use them to identify and analyse changes. During the presentation the facilitator uses quantitative information from the secondary data analysis to help the group understand the maps and to ask questions of the participants.

It is important to validate and deepen the understanding of the outcomes of Stage 1. During discussions with the focus group, the first indications of the causes of the changes should emerge. In addition, initial discussions may also reveal that some changes may be analysed at a higher level of aggregation than was initially thought necessary (for example, by county, rather than by municipality-within-county). Similarly, it may be that causes of deforestation do not need to be analysed separately for each legal land-use category. However, after everyone understands the different categories of causation (Table 1), it is essential also that the technical team expresses its view on these aspects, so that a joint and consensual decision may be taken.

Example of a contextual synthesis for Irazola District, Ucayali region, Peru

Irazola (268 000 ha) District is located in Padre Abad Province, Ucayali Region, and covers part of San Alejandro and Shambillo-Neshuya sub-basins within the Aguaytía river watershed. Its vegetation consists of tropical rainforest, which covers 75% of the district, mainly in the south (the Indigenous communities of Sinchi Roca and Puerto Nuevo) and the north (Permanent Production Forest). The area deforested from 2001 to 2017 totals 72 133 ha (27% of the district) and is located along the main roads: the Pucallpa–Lima Federico Basadre highway that crosses the district from west to east, and the Neshuya–Curimaná road, located within rural properties and uncategorized areas. According to the 2012 agricultural census (CENAGRO IV), 40% of Irazola is occupied by about 3600 production units farmed by small- and mid-size farmers. The principal land uses in the production units are forest (42%), grassland (25%), and perennial crops (10%).

Adapted from Reyes and Robiglio, 2017

Form groups of 4–5 people. To encourage varied discussions and to generate as much information as possible, each should have a heterogenous composition. Groups may or may not work on the same subject and geographic area. For example, a first group might focus on changes exclusively in the south of the jurisdiction or in a specific basin, while a second group might focus on the north of the jurisdiction and or in a different basin. The technical team should assign the remit of each group based on the number of group members and their background, experience, and interests.

Introduce the following questions and discuss them as a group:

- **What are the most relevant changes?** Characterize each by specifying the before (B) and after (A) land cover, and order them by magnitude of area affected, in absolute (ha) and relative (percentage) terms. Indicate whether each type of change is becoming more common, and whether it is a trend that is expected to continue or whether it could disappear in the coming years.
- **Where are the changes taking place?** Indicate geographic location[17]; names of specific locations[18]; terrain features (flat land, sloping land, upper wateshed, lower watershed).
- **In what legal land-use category (if these have been defined) are these changes happening?** (According to any land-suitability map and according to any map of legal categories of land use).
- **What are the characteristics of the change?** The group should indicate how the change occurred and whether it considers it to be a change that represents an overall net benefit to society.
- **Which of these changes are viewed as legitimate by local actors (accepted and made, even if illegal under current law) and which are not?** Describe their perceptions.

At the end of the session complete the "Matrix of key changes" that systematizes all the information produced during the exercise (Table 8).

17 A geopolitical unit (for example, county or district) or topographic unit (for example, watershed) can be used to define the location. Geoplitical boundaries are not always the best way to define an ongoing change.

18 Participants often mention the names of specific localities (for examples, townships or other settlements, or perhaps a specific sub- or microwatershed. It is important to take note of this information, because it assists in locating the areas in the maps. The information can be included in the GIS.

TABLE 8. Example of a matrix of key changes (Irazola District, Ucayali Region, Peru)

Change	From use A to use B (specify the uses)	Where they occur (indicate geographic location)	Characteristics (indicate spatial and temporal features of the change)	Legal land-use category (Indigenous communities, logging concessions, etc.)	Is it legal or illegal (explain why and specify the relevant law)
Conversion of forest to agriculture	Primary or old growth forest to annual crops	Sloping land from km 72–86 of the Federico Basadre Highway	Forest cut, slashed, and burned to grow annual crops (maize, cassava)	Rural properties	No, because this type of forest conversion is forbidden unless legally licensed
Conversion of forest to agriculture	Primary or old growth forest to annual crops	North of district, right bank of San Alejandro River	Forest cut, slashed and burned to grow annual crops (maize, cassava)	Permanent production forest	No, according to the Peruvian main-use soil capacity categories[19], these are forest lands, conversion of which is forbidden
Conversion of forest to rangeland	Primary or old growth forest to grassland	Sloping land along the Federico Basadre Highway	Forest cut, slashed and burned for grassland	Uncategorized areas	No, according to the Peruvian main-use soil capacity categories[20], these are forest lands, conversion of which is forbidden

Each group presents its results in a plenary session.

19 Capacidad de uso mayor del suelo.

20 Capacidad de uso mayor del suelo.

A group representative presents the main changes in Irazola District (Ucayali Region, Peru).

Session 2. Who are the agents of change, and what are their characteristics?

This activity begins with a brief review of the changes and their characteristics, as discussed in Session 1. Session 2 seeks to identify and describe the actors who **directly** produced the changes identified. Depending on where they take place, the same type of change can be produced by two different actors. For example, forest conversion to agricultural land along the main roads can be produced by a mid-size, capitalized, migrant farmer who is linked to the market, or, if occurring in on Indigenous land, by migrant smallholders with little capital.

In identifying and describing the actors that directly produced the changes, the following questions should be answered:

- **Who are the agents who usually produce a type of change?** These might be, for example, smallholders for household use, smallholders connected to the market, mid-size farmers, livestock producers, investors, or loggers.

- **Where do they act?** Specify geographic region, terrain features, legal category of land use, etc.

- **Where do they come from?** For example, specify whether they are Indigenous communities, long-established farmers, migrants, or other categories (according to national and subnational context). If they are migrants, note where they came from and the type of migration[21] – describe migratory and land acquisition processes, specifying whether past or present, and causes (for instance, due to violent conflict, natural disasters, etc).

- **What are their socioeconomic and productive characteristics?** This will enable understanding of how the different actors operate in the territory. Issues to consider include land tenure (titling); balance between production for market and for direct consumption; markets; income diversification (inside or outside the farm); integration into local, regional, national, or international production chains; etc.
- **What influenced their decisions in the past and what could influence them in the future?** For example, policies, type of incentives, special projects or programmes (such as "alternative development"[22] in Andean countries), availability of land, existing social or family networks.

At the end of the session, complete the "Matrix of Key Actors"). This systematizes all the information produced during the exercise. As an example, Box 7 shows a matrix of key actors for Irazola District, Ucayali Region, Peru, prepared in 2015.

Group discussing and completing the matrix of key actors in Puerto Bermúdez District (Pasco Region, Peru).

21 e.g permanent temporary, return migration.

22 Programmes aimed at developing viable alternatives to the production of illegal crops.

TABLE 9. Example of a matrix of key actors in Irazola district (Ucayali)

Group typology (description)	Area of operation operate	Origin (where they come from)	Strategies (how they operate)	Factors that influenced them in the past and may influence them in the future
Mid-size oil palm growers (6–10 ha)	Along paved roads (Federico Basadre Highway, Neshuya–Curimaná road), flat areas, titled areas, permanent production forests	Other Peruvian regions (Huánuco, San Martín, Cajamarca, Ayacucho)	Invasion, purchase, group organization, market integration	"Alternative development", flagship products (regional government campaigns), national and local policy, ongoing government programs (PROCOMPITE, AGROIDEAS). Financial, industrial development
Smallholder oil palm growers (<5 ha)	Land without direct road access	Other Peruvian regions (Huánuco, San Martín, Cajamarca, Ayacucho)		Regional policy, ongoing government programs (PROCOMPITE, AGROIDEAS)
Large oil palm grower (>10 ha)	Along Federico Basadre Highway, flat land, former grasslands	Cities of Iquitos, Lima. Andean region of Peru	Purchase	National policy, industrial development, price
Small cacao growers (<10 ha)	Along unpaved transitable roads or tracks, along River San Alejandro. Titled and untitled land occupation	Other Peruvian regions (Huánuco, San Martín)	Invasion, purchase, group organization, market integration, subsistence	"Alternative development" programmes, markets, media, development policies
Livestock producers	Titled lands, along paved road, flat and sloping lands. Invaded lands	Huánuco Region, Peru	Invasion (of concessions, permanent production forests, Indigenous communities). Purchase. Group organization. Dairy plant, regional and national market (cattle-fattening)	National policies, regional policy

As in the previous session, each group presents their results in a plenary session.

Session 3. What are the causes and how are they related to each other?

The purpose of this session is to identify the causes that influence the changes discussed in Sessions 1 and 2. This session is more complex than the previous ones. It therefore takes more time and requires all participants and technical team members to be engaged in constant interaction.

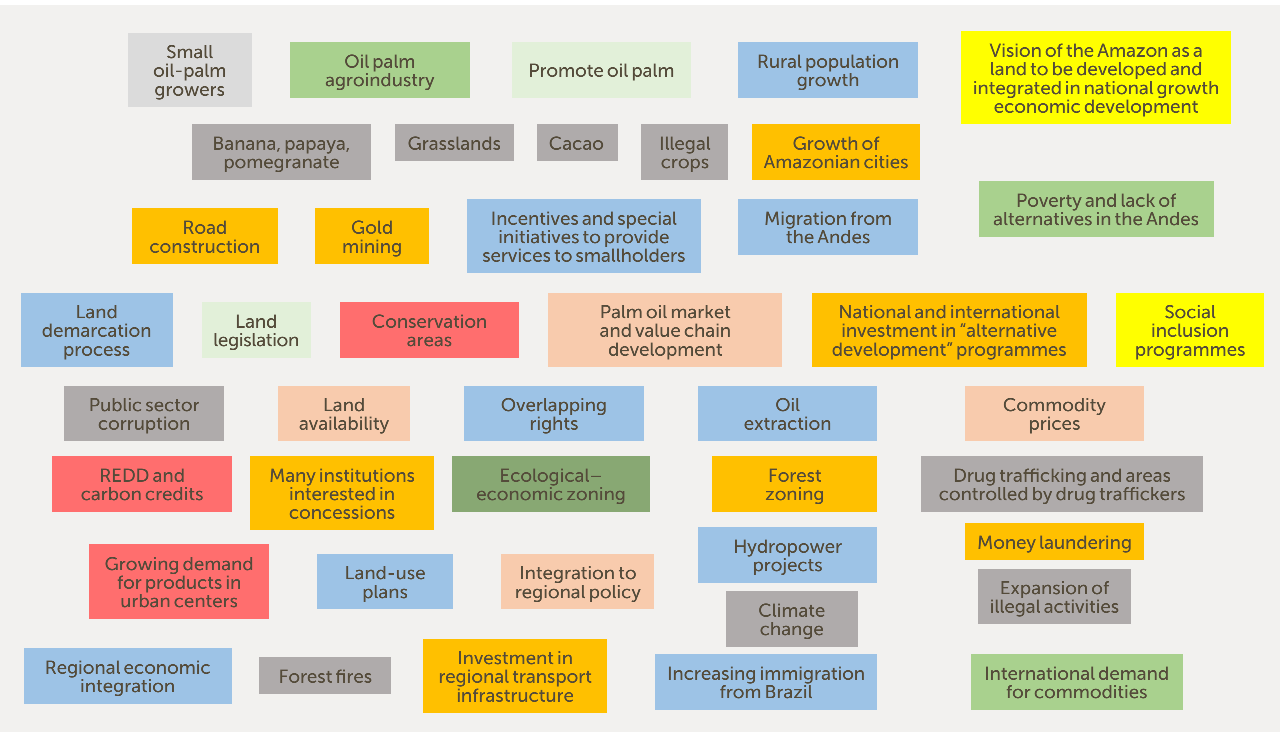
RECOMMENDATION. Brainstorm factors (political, institutional, socioeconomic, cultural, environmental, technological, or geopolitical aspects) that might affect or play a role in land-use changes; they may involve actors at any level, and may directly or indirectly influence the changes in the system that the group is analysing.

List of causes

In the plenary session, the facilitator explains what is meant by “causes”. Subsequently, he or she explains the process of progressive contextualization and how, through a sequence of questions, it enables identification of causes. A list of candidate causes can be found in Annex 3. Nevertheless, we suggest that at this point the technical team explores progressively the actors’ perceptions about the causes of the changes identified and characterized previously.

In the plenary discussion it is important to consider the causes of past, present, and future changes, as well as the history of deforestation and land-use change in the territory (Illustration 9).

ILLUSTRATION 8. Group brainstorm on causes in a territory: example from the Peruvian Amazon



During brainstorming, participants normally produce many phrases that describe causes and causal relations. By the nature of the brainstorming process, these usually need to be reframed in neutral terms, possibly with an associated state. This then allows a rigorous and consistent analysis (Table 10).

For example:

- «Lack of inspection» is a negative statement. «Inspection» is the name of the factor, its associated state is «lack of». This distinction can be part of the explanation and definition of the cause and makes it possible to determine whether the cause may change over time.
- «Unfertile soil» is not precise. The «aptness of soil for agriculture» is the factor, the level of aptness (high or low) is the associated state.
- «Credit» is a vague expression. «Ease of access to credit» would be the correct way of describing the factor. «Easy or difficult» are the states that define the cause.

This stage is very important because changes in the state of the factors can suggest leverage-points that may generate changes in the system (for example, if the state of the cause "ease of access to credit" is identified as "difficult", then a possible leverage-point emerges). This first stage is completed by the definition and selection of a "nickname" for each cause, so that it can be easily but unambiguously referred to. To do so, create a database with the complete name of each cause (factor + state), definition, and nickname (Table 11). Use the nickname in the analysis.

The technical team can orient (without imposing or prompting) the formulation of the causes, as presented in Annex 3. After sharing examples in the plenary, divide the participants into groups. Based on the changes identified and prioritized, each group should then brainstorm using progressive contextualization, at each stage asking "why?" for each action or cause (Stage 3).

The progressive contextualization should stop when the causal chain reaches two successive levels of answers (that is, causes) that are external to the system: causes that local, national or regional actors cannot change through their strategies.

TABLE 10. Extract from the list of causes of deforestation

Infrastructure expansion & settlements	Settlements
	Private companies
	Public services
	Storage and processing facilities
	Land invasions
Demographic factors	Natural population growth
	Immigration
	Emigration
	Population density
Economic factors	Demand for products
	Investment opportunities
	Prices

After brainstorming the causes linked to each identified type of change, the groups come together in a plenary session to integrate their results and examine the various lists of causes.

Groups identify deforestation causes in Alto Amazonas province, Loreto Region, Peru.

RECOMMENDATION. Use coloured cards (one per cause) to ensure that all the causes identified by each group are reported. Collect and read aloud all the cards and display them on a board or wall. Discuss their content and discard repeated cards. This requires agreement between the authors of the cards that the cards represent the same idea. Otherwise, the authors should rewrite their cards to express a different meaning and show them to the group.

It is important to keep the group's attention and ensure that they examine the different aspects of the causes and levels at which they act (for example, separating international prices from local prices). This can be done by involving the group members in facilitating the plenary session while the facilitator from the technical team observes and guides the resulting interaction.

Definitions of the cause

The participants need to agree on one clear definition for each cause that they have identified. In general, the definition consists of a sentence that explains the nature of the cause and describes its action.

TABLE 11. Examples of causes, definitions and nicknames

Category	Cause	Definition	Associated state	Nickname
Infrastructure	**Settlements**	Appearance of human settlements, usually along highways.	Increasing	Settlements
	Storage and processing facilities	Establishment of storage and processing facilities for agricultural products. For example, oil palm processing plants.		Plant
Demographic factors	**Land invasions**	Invaded (informally occupied) land, usually associated with agricultural activities or illegal crops.	Increasing	Invasions
	Immigration	Arrival of migrants, usually farmer settlers, from other regions.	Increasing	Immigration
Economic factors	**Price**	The sale value of the product in question.	Falling	Price
Institutional and political factors	**Implementation capacity**	Ability of local governments to execute the budgets of programs to improve agricultural production.	Weak	Implementation

To facilitate the process and promote consistency and conceptual rigour, the technical team can define the causes at the beginning, while the participants are presenting and discussing the cards. A technical team member can take notes while the groups are presenting their work. These notes can be used as input for the subsequent discussion of the definitions.

If any ambiguities are detected in how the actors and groups interpret the information, team members can help to clarify the concepts by asking specific questions about the characteristics of the cause being discussed. For instance: What do you want to describe with that cause? What type of influence does it have on the elements considered? Can you be more specific?

At the end of the session the facilitators can improve on these definitions by considering other important aspects, such as:

- Whether the causes are direct or indirect (see Basic Concepts).
- The scale (local, regional, national, international): if the causes are controlled by agents directly involved in the system (at the jurisdictional level), these actors may have the power to change them. For example, the price of a commodity is defined internationally, not locally. The price of a product that is produced and consumed locally is defined locally.
- Location internal or external to the system: After linking each identified cause to an actor, it becomes possible to establish whether these actors have the power/ability to modify the state of a cause, and therefore, effect a change in the system . The statement of the cause and its explanation (definition) should be indicators of future states and possible modifications to be introduced through a strategy focussing on leverage-points.

RECOMMENDATION. The team should be prepared to challenge preconceptions and to be sceptical of what is considered as evidence, but it should also be open and flexible to incorporate new or surprising arguments if they are well supported by evidence. At the same time, it must be willing to find strategies better suited to answer to the question under consideration.

Semi-perennial crops (papaya, banana) in Irazola District, Ucayali Region, Peru.

Causes and the relationships between them (causal relationships)

Once the causes have been identified and conceptualized, we can identify the causal relationships. The technical team should assign a half-day for this activity. The exercise will require a whiteboard with different coloured markers and a whiteboard eraser. This allows for changes to be made throughout the process until the exercise is finished and the participants have defined almost all the relations.

The different colours are used to differentiate the elements in the network. There are no rules for use of the colours, but, for example, the following scheme could be used:

- Green for the forest.
- Black for the names of the causes.
- Red for arrows that show a direct influence between causes.
- Light blue for annotations of observations or specific characteristics of the cause or the relationship that may be useful in the analysis.

The following procedure is used to identify these relationships:

1) Write 'forest' (or use a symbol or sketch) in the bottom left corner of the board.

2) Begin the progressive contextualization by asking: "Why is an area of forest cleared?" The answers may include: "to grow coffee", "to grow oil palm", "to grow cocoa", "to grow coca", "to grow annual crops". These land uses are direct causes of the change in forest cover. Indicate this by drawing an arrow to show that there is a direct relationship between (for example) the coffee crop and forest loss.

3) Select a land-use, for example "coffee"; explore the direct reasons that may have led a farmer to choose it by asking: "What led the farmer to plant coffee?" Answers may include "access to capital", "access to labour", "access to technical assistance". Document the relationship by draw an arrow from "access to capital" to "to grow coffee".

4) For each of the causes, explore the reasons that allow the causes occur. For example, the answer to "Why did the farmer have access to capital?" may be "Because he had access to credit". In such a case, draw an arrow that shows a direct relationship.

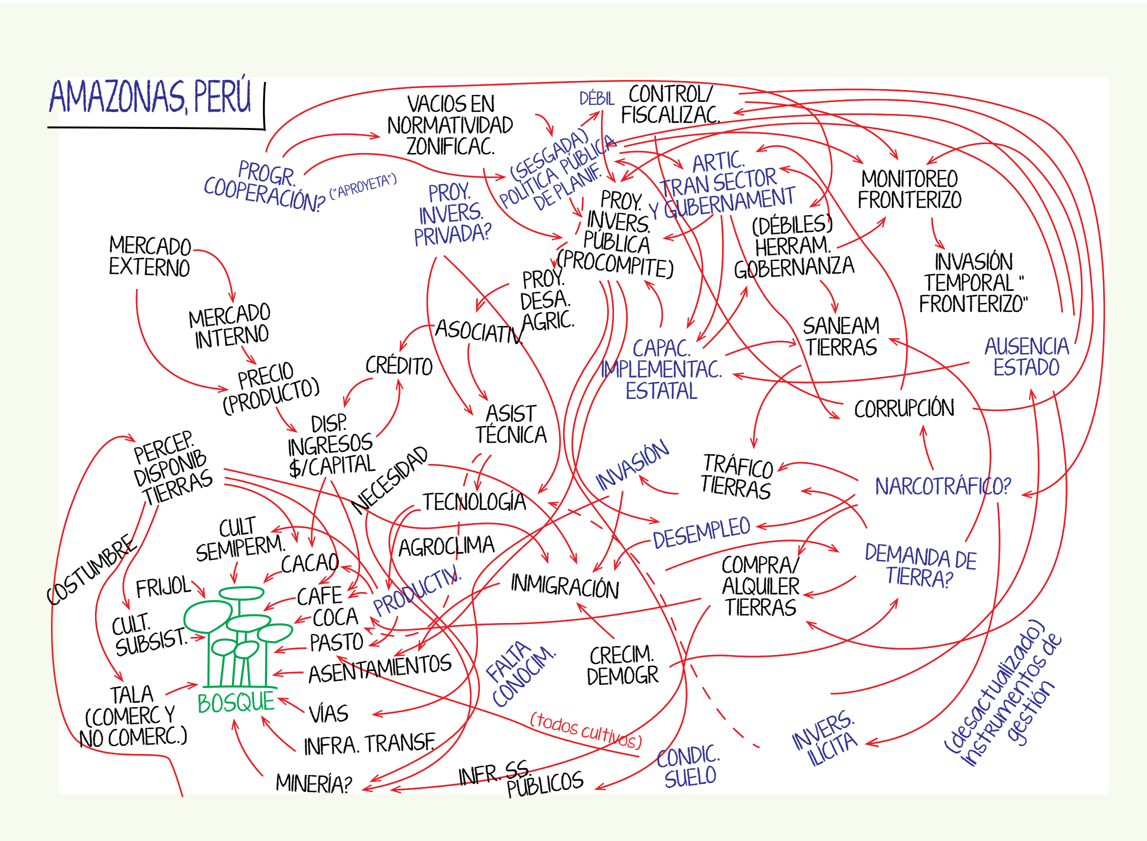
5) Continue this sequence of questions until the causes are sorted from the plot level to the local level, and then to the regional, national, and even global level.

6) End the exercise for "coffee" when you reach causes that are external to the system or that local, regional or national actors will not be able to modify (see page 71).

7) Conduct steps 1 through 6 for "oil palm", "cocoa", and the other direct causes identified in step 2.

8) As you move up through the levels, the relations of direct influence will become more complex. When participants explain why there is a direct relationship between two causes it is important for a technical team member to write down the details, since these elements will help to develop – and build the arguments for – the causal mechanisms and chains.

It is important to try to identify all the direct relationships possible, in both directions, at the same level or between different levels. The result is a causal network diagram that will be used to inform the binary relationship matrix.



Causes and causal relations (in Spanish), identified through a participatory progressive contextualization analysis at the regional level in Amazonas Region, Peru.

Stage 3. Identifying relationships of influence between causes

General objective: to analyse relationships of influence between the causes and to build the causal mechanisms of deforestation.

Duration: 2 weeks.

Participants: technical team, workshop actors.

Location: workshop venue.

To elucidate relationships between causes and to build causal mechanisms, we analyse systematically the nature of these relationships, assessing the direct influence that each cause can have on the others and the level (intensity) of this influence.

The existence (or absence) of a direct influence between two or more causes, its nature, intensity and the possible synergies it might give rise to, allow construction of an influence matrix and a network structure – a chain of causal mechanisms that produce changes in the territorial system analysed. The networks allow us to visualize the system and identify the leverage-points based on the state of its causes and the relations of influence or dependence between them. The graphics show the most influential causes, their scale, and the causes linked to each one. As part of this analysis, it is important to determine the principal and most powerful causes in the system.

Relationships of influence between causes

The relationships between the causes are analysed in a new workshop. This analysis works with the list of causes prepared in Stage 2 and revised by the technical team and with the definitions approved by the group (see section Focus group workshops).

To assess how one cause influences others, a reciprocal scoring system is used. If cause A has no influence on cause B the score is 0 and no link appears between A and B. If there is an influence, the intensity is scored as 1 (weak: a change in cause A produces a minimum change in cause B), 2 (average: a change in cause A produces a proportional change in cause B) or 3 (strong, a change in cause A produces a disproportional change in cause B). When working cause-by-cause, the relation between B and A is also analysed and it is possible that although A has no influence on B, B may have an influence on A.

Dependence is another aspect of causal influence. A cause may be very influential but also very dependent, which means that many options exist to change the way the cause operates.

Like the definition, the relationship needs to be explained clearly, taking into account whether the influence determines a change, and whether it increases or decreases it. This information will be very valuable when the time comes to interpret the results and identify the most important causes.

Finally, a card or file is completed for each cause. This makes it possible to focus on one cause at a time and reduces the risk of mixing them up or losing information about the cause being analysed.

Note that at this stage only direct relationships of influence are addressed. Indirect influences will be visualized when the digitized data are presented in a matrix of influence and network structure (Stage 4).

Example of causal relations in Codo del Pozuzo District, Huánuco Region, Peru

Among the causes identified were “cacao expansion”, “expansion of annual crops”, “coca-growing” and “forest-clearing”. The participants determined that “cacao expansion” has a strong influence on, and magnifies the effect of, “expansion of annual crops”. Before planting cacao, staples such as maize, cassava, and plantain are established, both to take advantage of the newly cleared land and provide shade. Hence, the greater the area of cacao, the greater the area of temporary crops. Likewise, “cacao expansion” has a strong influence on “coca-growing”; but as the area of cacao increases, the coca crop decreases, since the latter is replaced by the former. On the other hand, “cacao expansion” does not influence “forest-clearing”.

For each cause, the causal relations are analysed and discussed until all the causes on the list have been exhausted and everyone agrees on the values and explanations. This activity is central to the DriveNet methodology and should therefore be afforded the necessary time (approximately 8 hours). To prevent participants from getting bored, the technical team must remain constantly active, both concerning technical aspects and knowledge, and in maintaining an interesting group dynamic that will ensure that the group remains focussed and active.

It takes about 25 minutes to discuss the binary combinations for each cause, which means that if there are 20–30 causes the discussion will require an intense, full day. It is not advisable to do this task in subgroups since this would create consistency and consensus challenges when analysing inverse relations and interpreting the definitions and logical explanations.

Semi-perennial crops and secondary forest in Irazola District, Ucayali.

Given the time it takes to do the structural analysis, this phase is challenging for participants and the facilitators need to prepare carefully: this involves reviewing the notes taken during the sessions, making sure they have the materials needed, and that they thoroughly understand the facilitation process. The facilitator should be ready to make observations and comments that help participants recall prior discussions and agreements made in previous stages.

The following are two particularly important functions of the technical team during this stage:

- To ensure that the group considers only direct relations of influence that have an explanation that is logical and shared by all the participants. In case of doubt the facilitator should intervene, challenging the group to consider whether an influence is direct versus inverse, indirect, correlated, or synergistic.

- To ensure that all discussions are based on the definition of the cause, not on the nickname. For instance, if the cause identified is "cacao expansion", avoid simply saying "cacao". Using the definition helps the discussion to be more rigorous and consistent and makes it easier to answer the questions.

Coloured cards can be used to indicate the sequence of binary combinations (listing the causes in the cards). For each combination, assess the direct influence and its intensity. Participants should discuss the logical explanation and assign a value to the intensity of the influence. Depending on the group, they can use cards and move them, or once they understand and are familiar with the causal mechanism, they can fill in data sheets. This requires prior preparation and printing of blank data sheets so that participants can follow the process and fill in their own sheets. This approach is less dynamic than working with papers or cards that can be grouped together, but it ensures that all the causes are discussed. It also permits assessment of the strength of any causal relations.

Ultimately, the specific procedure used will depend on the group's preferences and capabilities, and on the size of the technical team.

DriveNet in a context of remote or distance work

In some circumstances, things do not go as planned and face-to-face activities may need to be limited. For example, the COVID-19 pandemic has restricted the movement of people and made it impossible to have face-to-face focus groups and other participatory activities, impeding the implementation of DriveNet as originally conceived. Nevertheless, DriveNet Stages 2 and 3 can still be conducted if communications technology is well used. Annex 4 explains the structure and other details of these stages.

Stage 4. Construction of the relationship matrix and analysis of the causal network

General objective: to build and analyse the influence matrix and causal network.

Duration: 2 weeks.

Participants: technical team.

Location: technical team workspace.

Once back in the office, having examined the direct influence of each force on the others and agreed on their values, the technical team prepares for the final analysis of the outcomes. An influence matrix can be created by cross-tabulating the list of causes and noting the numerical values that show the intensity of influence between the causes. Also, network analysis software can be used to provide a graphic display of the multidimensional system of causes and causal relations, and then to analyse it using methods applied to analyse social media networks.

Below is an example of an influence matrix (Table 12) that shows the factors of influence between various causes, validated by the workshop participants.

TABLE 12. Part of an influence matrix of causes in Codo del Pozuzo District Huánuco Region, Peru

	CACAO	GRASSLANDS/ LIVESTOCK PRODUCTION	ANNUAL CROPS	PAPAYA	COCA	PLANTATIONS BY REFORESTATION	LEGAL LOGGING	ILLEGAL LOGGING	COMMUNICATION ROADS	INFORMAL LAND OCCUPATION SUBSEQUENTLY LEGALIZED	IMMIGRATION
CACAO		1	2	0	1	0	0	0	3	3	3
GRASSLANDS/ LIVESTOCK PRODUCTION	1		2	0	0	0	0	3	3	2	2
ANNUAL CROPS	1	0		0	0	0	0	2	0	2	0
PAPAYA	0	0	0		0	0	0	1	2	1	1
COCA	2	0	0	0		0	0	3	0	0	3
PLANTATIONS BY REFORESTATION	0	0	0	0	0		0	3	3	2	3
LEGAL LOGGING	0	0	0	0	0	2		0	0	0	0
ILLEGAL LOGGING	0	1	1	0	3	3	0		1	3	3
COMMUNICATION ROADS	3	0	0	0	0	2	1	0		2	2
INFORMAL LAND OCCUPATION SUBSEQUENTLY LEGALIZED	0	0	2	2	1	0	0	2	1		1
IMMIGRATION	0	3	2	2	0	0	0	1	2	2	

The matrix aids understanding of the nature of the causes: to what extent they influence and depend on each other; whether they are active or passive (difference between the number of causes that influence them and the number of causes they influence); and whether they act quickly or slowly (depending on how they influence the direct causes).

The matrix should include the following summary values:

- The number of non-zero values in each row (indicates the influence power of the cause).
- The mean of non-zero values in each row (indicates the intensity of influence of each cause).
- The sum of the scores in each column (indicates the dependence of the cause on the other causes).

The combination of these values suggests the relative power of each cause to influence the system, that is, how many other causes it influences and by how many causes it is influenced. Each cause may have:

1) Many relations of influence and dependence.

2) Few relations of influence and dependence.

3) More influence than dependence functions.

4) More dependence than influence functions.

A table can be prepared to communicate clearly the results of the analysis (Table 13).

TABLE 13. Values that explain the nature of the causes

Cause (Nickname)	Typology	Influence/ Active	Dependence/ Passive	Balance	Intensity
Political interests	Indirect	25	26	-1	1.76
Annual crops	Direct	24	26	-2	1.75
Need to invest	Indirect	19	26	-7	2.42
Private investment	Indirect	21	25	-4	2.05
Market demand	Indirect	26	24	2	2.42
Public investment	Indirect	18	24	-6	2.17
Cacao	Direct	27	23	4	2.37
Oil palm	Direct	23	23	0	2.57
Grasslands	Direct	23	23	0	1.78
Coca	Direct	22	23	-1	2.18
Price	Indirect	21	23	-2	1.95
Legal logging	Direct	20	23	-3	1.6
Associativity	Indirect	19	23	-4	2.05
Invasions	Direct	17	23	-6	2.12
Cooperation	Indirect	14	23	-9	2.14

The technical team can classify the causes as active if they are more influential, or passive if they are more dependent on other causes or are influenced by them. This distinction is not always clear, in which case **all the notes taken and explanations about the influence values assigned in the binary causal combination exercise need to be reviewed to interpret the cause correctly.**

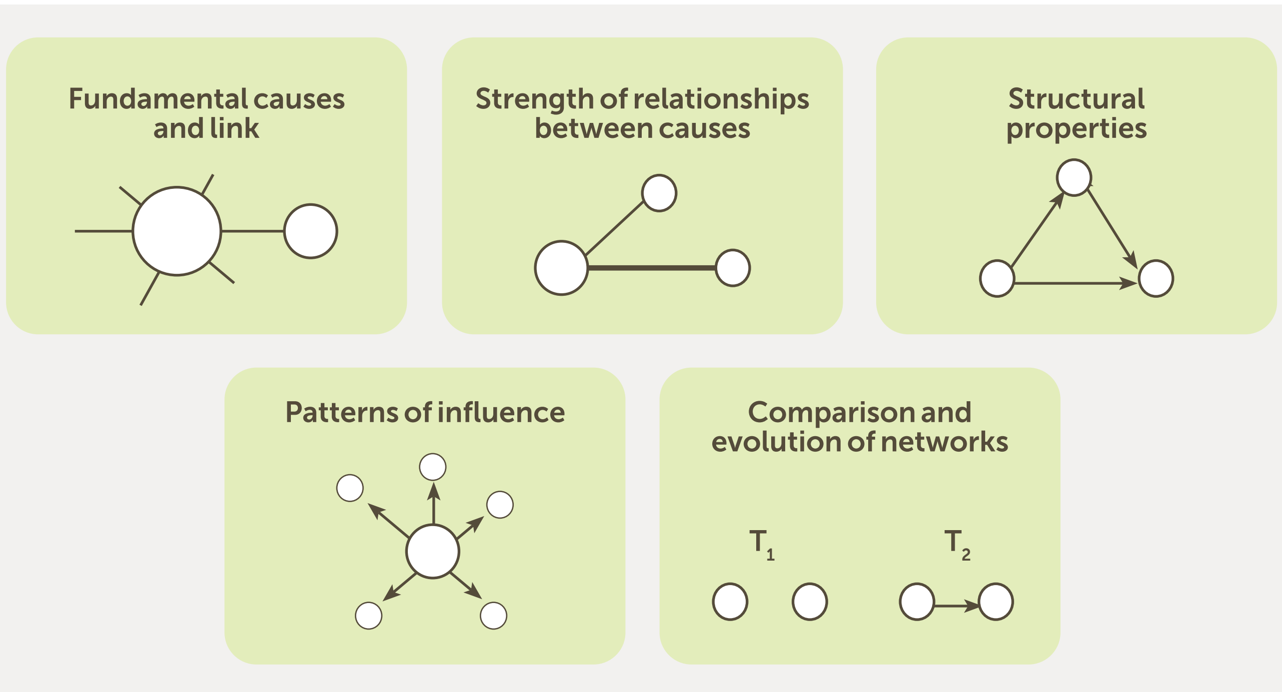
The most important causes are the ones that influence the system. A change in the characteristics of these causes may have a great impact on the system.

Network analysis

The network analysis concludes the final stage of the participatory process of data collection, discussion and analysis and allows the technical team to visualize the system's structure and dynamics based on the causes and their influences. The network allows the information identified through the influence matrix to be validated, displayed, and subjected to statistical analysis based on network analysis metrics.

The network analysis also shows the most important causes in the causal chain, to what extent they are connected (for example, how they relate to each other, whether directly or indirectly, the direction and strength of influence between them), and to what extent they are central or peripheral. It also shows the causal mechanisms and chains, possible feedback mechanisms, and any inverse relations that might help to interpret the impact of possible future actions on one cause, and consequently on the system.

ILLUSTRATION 10. Objectives of network visualization



Source: kateto.net, tutorial on network analysis with R "Static and dynamic network visualization with R", 2017 Katya Ognyanova, Rutgers University.

Network analysis uses visualization programs that calculate the parameters that describe the network structure and its functioning, based on the centrality of the causes and analysis of the links. In some cases, projects may develop their own analysis interface that allows them to quickly digitize datasets and construct networks, estimating the parameters selected for the analysis. In this guide, we show results obtained using the open access R program and its various packages and an interface generated by the project itself, referred to here as "DriveNet Platform".

The DriveNet Platform can at the moment[23] be accessed at https://enketo.ona.io/x/#aNhnv-BoP. It allows the data obtained in stage 3 to be easily recorded as a form. This platform includes a series of customized R commands for each analysis.

For members of the technical team who want to delve deeper, for example by analysing and customizing processes with R code, there are many resources online. We recommend the Rutgers University tutorials.

Table 14 presents the software we used for network analysis in this project, with its main characteristics.

TABLE 14. **Network analysis software**

Software	Target user	Public access	Form of access	Visual attractiveness	Usability
NodeXL	General and researchers	Basic open version and low-cost version	Program download and Excel use	Moderate	Moderate
Package	General and researchers	Open	Download R and necessary packages	Moderate, depending on user skills	Challenging

Adapted from Buckingham *et al.* (2018)

23 CIFOR-ICRAF is working to change the DriveNet Platform.

Stage 5. Analysis of mechanisms and identification of leverage-points

General objective: identify the most influential causes and leverage-points to inform the design of low-emissions rural development strategies.

Duration: 2 weeks.

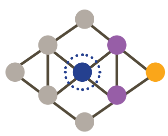
Participants: technical team.

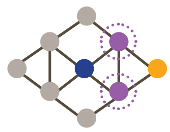
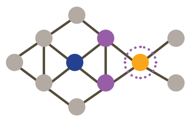
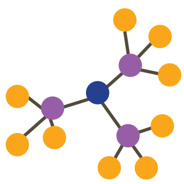
Location: technical team office or work space.

Centrality is a key parameter in understanding a network's structure and functioning. It provides a way of understanding the relative power of the causes and causal mechanisms. By influencing and generating changes in centrally positioned causes we can influence the other causes (Table 15).

Centrality parameters allow us to characterize the ability of one cause to influence the other ones, and the ways in which they influence them.

TABLE 15. Parameters of centrality between causes

Parameter	Image	Description	Function measured	Role in the analysis
Degree of centrality *(totdegree)*		Number of direct causes to which a cause is connected	Connecting	Causes with high values of *totdegree* are **connectors**. They influence the system through their direct effect on other causes. Modification or elimination of connectors can significantly affect land-use change. But it is also important to analyse to what extent the cause is influenced, and by which other causes, since it may not be the cause with the greatest influence on the causal mechanism. Which cause has the most connections in the system of causal mechanisms?

Parameter	Image	Description	Function measured	Role in the analysis
Closeness centrality		Distance, i.e., number of connections between a cause and the rest of the causes	Catalysing	Causes with high values of closeness centrality are **catalysers**. They can quickly reach all the causes in the network, and if modified can produce rapid changes. What cause quickly influences the other causes in a system of causal mechanisms?
Betweenness centrality		Number of times that a cause is the shortest distance away from the other actors	Gatekeeping	Causes with high values of betweenness centrality are **gatekeepers**. They connect groups of causes that would otherwise be disconnected and may affect how these groups influence each other. If not considered, then some indirect effects may be neglected. What are the "bridging causes" in a system of causal mechanisms?
Eigenvector		How connected each cause is to the others and to the most central causes	Influence	Causes with high eigenvector values are **influencers**. Although they do not necessarily exert a strong direct influence, they may have a long-term influence on the core causes. Which cause is the most connected to the central causes of the network?

Modified from Buckingham *et al.;* (2018)

Identification of the most influential cause

If we consider causal mechanisms as part of a complex system, the depiction of the system as a network help to visualize how to change a system: by looking at the values of the various parameters, the degree of intermediation and delays in the feedback nodes (number of intermediate interactions), the rules of influence that govern the different interactions, and the structure of the model and its underlying pattern.

The most important causes are the ones that influence the system, either directly or indirectly. They are identified by interpretation of 1) the influence matrix, where the influence, dependence, and intensity of the causes are calculated by lines and columns, and 2) the metrics generated by the network analysis.

Interpretation of the influence matrix

The technical team leads the analysis by selecting the active and passive forces, and their intensity. This can be done directly by analysing the matrix or preparing a graph in which the X value is the number of other causes influenced, and the Y value is the number of other causes that influence the cause under consideration. The value represented by the size of the circle indicates the intensity, the strength, of the influence. This is an indicator of how fast one cause will influence the others (Illustration 11).

ILLUSTRATION 11. Diagram of influence and dependence of causes

Diagram of causal influence and dependence at the regional level in Amazonas Region, Peru. The causes were coloured to enable them to be distinguished.

To analyse the matrix (Illustration 11), the technical team must answer the following questions:

- Which are the most influential causes (number of other causes influenced)? → X Axis
- What are the most influenced causes (dependent)? → Y Axis
- What are the most "active" causes? The most "passive"? → Balance between X Axis and Y Axis
- With what intensity do they influence the other ones? →Size of the circle

RECOMMENDATION. This information can also be obtained from the position of the cause in the diagram.

According to figure 3:

- If the causes are in the upper left quadrant: they have little influence and are highly dependent.
- If the causes are in the upper right quadrant: they are very influential and dependent. They can guide the system and be guided by the other causes. They are part of the feedback mechanisms.
- Causes in the lower right quadrant are causes with a lot of influence on the others, but they are not easily influenced.
- In the lower left quadrant are the causes that behave relatively independently from the rest of the system.
- The most interesting causes – the potential leverage-points – are those in the upper right quadrant.

The causes that are located close to the limits of two or more quadrants should be discussed by the team, who should revise their definitions and tendencies of influence. Sometimes, the values indicate a high level of influence, which further examination may show to be exaggerated. To be complete, the interpretation needs to be complemented by identifying the size of the circles, which describe the intensity of the influence. Sometimes they represent causes that are not strong. Since these causes depend on other causes, if the system changes their level of influence will change under feedback mechanisms.

RECOMMENDATION. It is important to consider that the most influential and influenced causes are the easiest to modify, but at the same time their dependence on other causes can induce instability and invert the trajectory of change that we want to put in motion to reduce deforestation.

Once we identify these causes, we can examine what type of causes they are, based on the categories considered and also on the scale at which they operate.

How can we know if we are on the right track?

At this point we have obtained and systematized a lot of valuable information that explains deforestation and land-use change processes. But how can we know how to what degree we can rely on the findings to date? Do we need to step back, examine the results of previous stages, and possibly make some adjustments? Three aspects of the results help us decide:

1) Balance between direct and indirect causes:

A good progressive contextualization exercise allows us to identify both direct and indirect causes. At first glance, the latter might not even seem to be causes, but in fact are very important because they trigger change processes. It is usually an indication of a job well done if more indirect than direct causes have been identified. It means that the different categories of causes and the scales at which they operate have been successfully explored.

2) Influence and dependence diagram:

The four quadrants of the influence–dependence diagram must each contain causes. It is important that the upper-right quadrant – which suggests leverage-points – shows indirect causes, such as, in our example, "governance tools", "control and surveillance", "corruption", and "transectoral coordination". Direct causes such as "semi-perennial crops", "illegal crops" and "settlements" usually belong in the left-side quadrants. Although some direct causes may legitimately be located in the upper-right quadrant, this should be justified by strong arguments that reflect the specifics of the territory. If many direct causes are located in this quadrant, the relationships and values entered in the influence matrix should be checked.

3) Scoring of intensity of the influence:

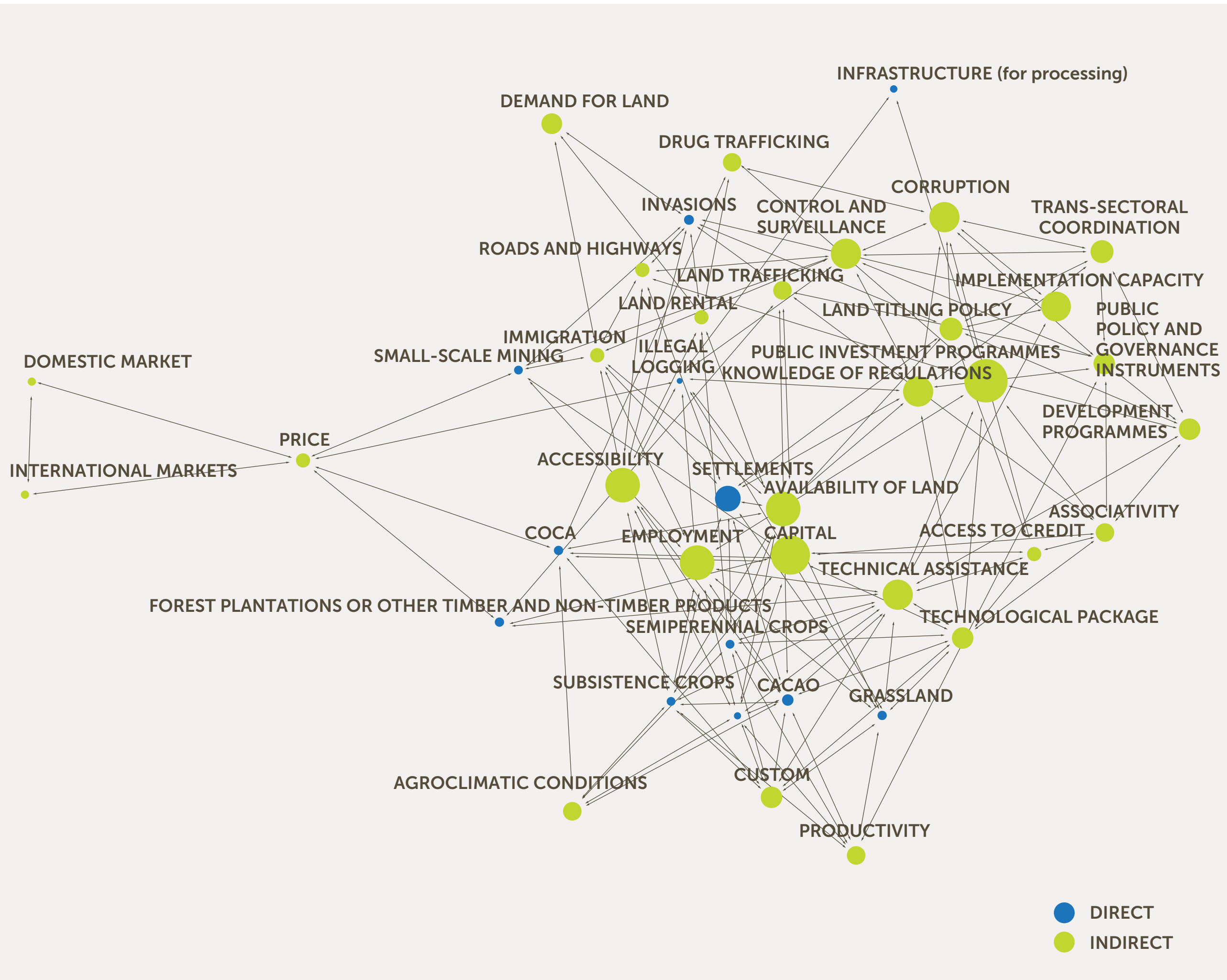
The values used to measure the intensity of the influence go from 1 to 3. As such, the team should try to use all the values without using one much more than the others. There can be a tendency to score too many relationships as intermediate (2), for fear of judging an intensity to be strong (3), weak (1), or non-existent (0). It is important to be rigorous and honest when attributing an intensity value to a direct relationship, and not to hesitate to assign a non-intermediate value when warranted.

Network analysis

The visualization of the causes as a network makes it possible to see the causal mechanisms as part of a complex system. The structure and metrics show how the system works, the rules that define its interactions, the timing of the feedback loops, and their underlying patterns. These elements aid understanding of the variables involved in the concept of leverage-points (Meadows, 1999).

Causal networks can be visualized by **typology** (direct–indirect), **category** (agricultural expansion, cultural factors, social-demographic factors, economic factors, political-institutional factors, infrastructure, other factors), or **scale** (local, regional, national, international). Graphic 12 shows the network of the 42 regional-level causes identified in Amazonas Region, Peru. The size of the node refers to the number of connections with other causes. Public investment programs, capital, corruption, technical assistance, and control and surveillance were the causes with the most direct relations to other causes in the system.

ILLUSTRATION 12. Network of active causal relations



Example of the network of active causal relations at the regional level in Amazonas Region, Peru.

For some elements, it may be important to understand the structure of relationships between the scales of definition of influence of the causes. This can easily be done through the network analysis, considering the classification of causes by scales. Network analysis also shows to what degree the causal chain is structured at the local level or at multiple levels (Illustrations 13, 14, 15), and whether the causal chain is characterized by hierarchical or horizontal relations. Table 16 presents the key elements for network visualization.

ILLUSTRATION 13. Level of influence 1

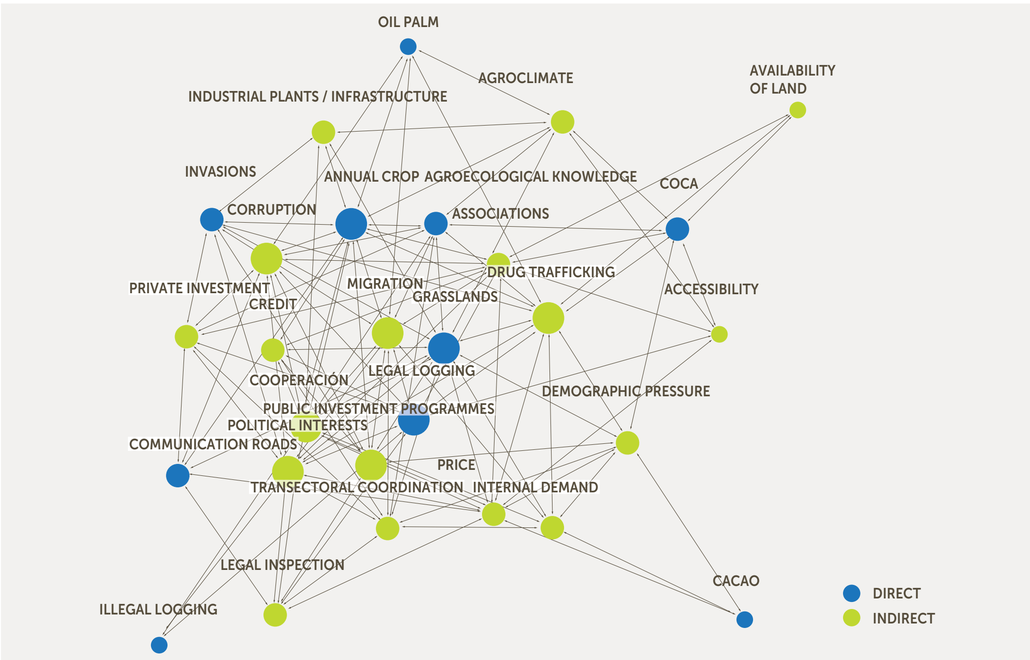


ILLUSTRATION 14. Level of influence 2

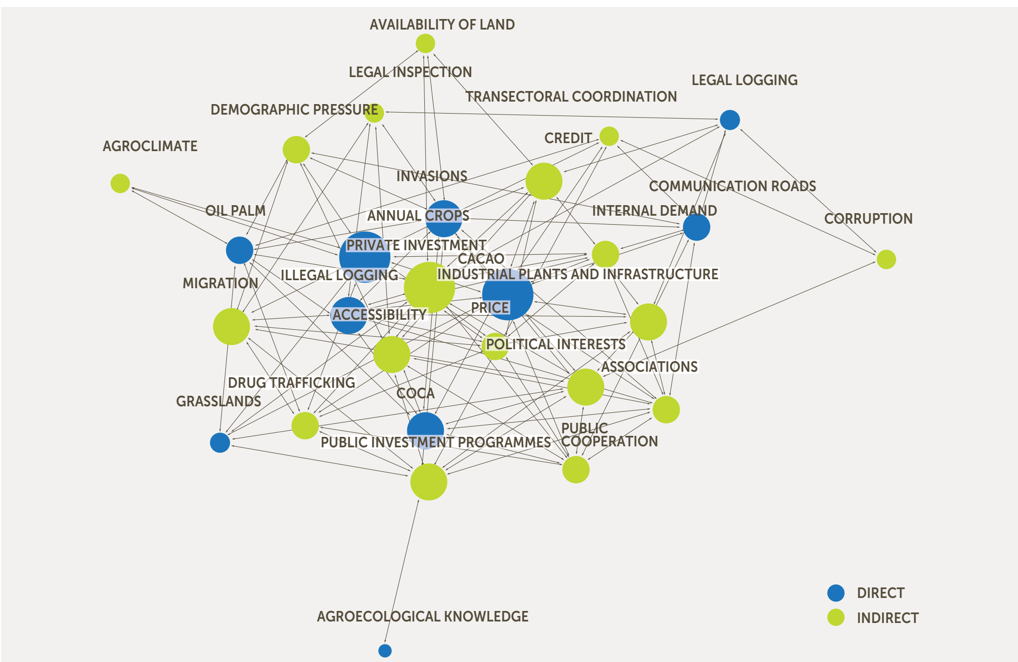
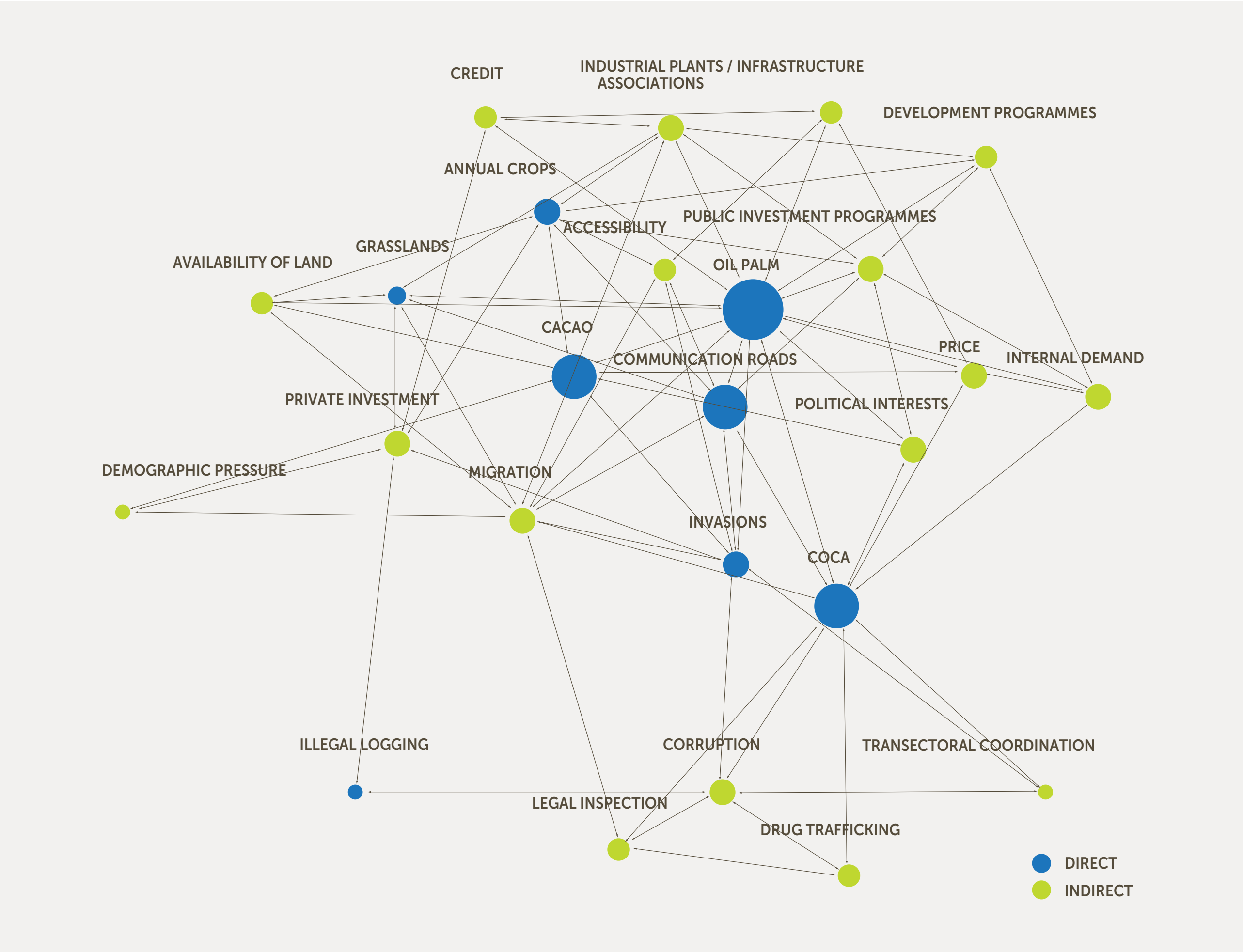


ILLUSTRATION 15. Level of influence 3



Causal networks can be represented graphically by the level of influence of their relations. This provides additional information to interpret the network and identify the leverage points.

TABLE 16. Metrics by causes in Amazonas Region, Peru, at the regional level

Cause	Active influence /Outdegree	Passive influence /Indegree	Totdegree	Betweenness centrality	Closeness centrality	Eigenvector	Intensity
Public investment programmes	12	5	17	115.4256494	0.002849	1	2.25
Capital	11	5	16	139.201443	0.0023866	0.6310321	2.81
Corruption	9	6	15	210.4448385	0.0027701	0.9662303	2.44
Technical assistance	9	5	14	49.3478716	0.0023753	0.6324138	1.55
Control and surveillance	8	6	14	48.2355894	0.0026882	0.8036345	2.62
Technological package	6	7	13	61.1671717	0.0007163	0.6298716	2.66
Land-titling policy	6	7	13	87.9722444	0.0027624	0.8235777	1.83
Settlements	7	5	12	38.8917749	0.0023364	0.5253769	1.71
Semi-perennial crops	1	11	12	2.2361111	0.0005949	0.5100923	1
Availability of land	10	2	12	11.9795094	0.0026247	0.5403754	1.91
Employment	10	2	12	40.5167138	0.0024752	0.5255197	1.74
Governance tool	6	6	12	21.0001804	0.0027548	0.817022	2
Land trafficking	5	7	12	275.4710179	0.0027174	0.6860714	2
Accessibility	10	1	11	23.2122766	0.0026385	0.4334061	2.2
Land rental	4	7	11	274,2143939	0,002611	0,5121773	2

Where:

"totdegree" is the number of relationships of the cause in our example. The most connected causes are political interests, annual crops and market demand. These are the causes that connect the other causes (connectors). Among them are the causes identified in figure 4 as the main leverage-points.

"closeness centrality" indicates the causes that can quickly guide the other causes. Among them are the causes identified in the figure as the main leverage points.

"betweenness centrality" indicates the causes that act as bridges (filters) between groups of causes and causal mechanisms. For example, coca and annual crops are at the center of different causal mechanisms.

"eigenvector" indicates to what degree a cause is connected to the strongest or most central of the other causes. This is important because even if a cause is highly "passive", we may consider intervening in it to generate changes in the others if it is connected to other, very important causes.

Presentation to the group of actors and experts

The final activity of Stage 5 is a closing workshop, aimed at validating the causal analysis and presenting the process and its outcomes. This provides an opportunity to gather feedback on the outcomes and define the causal mechanisms and central causes that will be used in the design of initiatives such as low-emissions development strategies.

Prepare a presentation using the graphics, the causes understood to be leverage-points and their definitions, as well as the maps prepared at the beginning of the process. For each stage, examine the process, outcomes, and list of causes (distribute a printed list or simply show the most important ones, the most influential ones and possible leverage-points, with their complete description, that is, passive or active, intensity, scale, and function in the network (Box 9).

Based on these inputs, present and explain the networks to the participants.

RECOMMENDATION. In making the final selection of the causes and causal mechanisms to be discussed with the experts and local actors in the closing workshop, keep in mind that they will be used as input in the design of strategies. As such, the number of causes and causal mechanisms needs to be manageable. The more causes, the more challenging and complex the discussion of strategy. However, having too few runs the risk of excessive or misleading simplification; the challenge is to strike a good balance.

Combining the causes in causal mechanisms:

One of the strategies that can be used is to reconstruct the causal mechanism, which includes the direct cause under consideration and allows other causes to be included, but only as they relate to the main cause. This makes it possible to combine the causes in mechanisms and discuss with the group how the causal mechanism and causal chain work, based on only a few of the identified causes.

To reconstruct the causal mechanism and chain, begin by identifying the direct cause that explains the land-use change that will be analysed. Next, identify the cause(s) that influence directly this direct cause. The causes that form the causal mechanism must be selected based both on the networks – which show the direct relations between the causes – and on the centrality parameters (metrics). The values of these parameters show which are catalysing causes, the bridging causes, and those that influence the influential causes. A cause that has a direct influence on many other causes will not necessarily form part of the causal mechanism. This exercise requires the technical team to review and reflect on the information systematized in the various matrices, as well as on notes taken during the workshops.

RECOMMENDATION. Arrange the causes in descending order by the value of each centrality parameter, using a spreadsheet (Excel or similar). This makes it easier to identify the causes with the highest values of one or more parameters. Nevertheless, it is also necessary to see what other causes they influence, evaluate how relevant they are, and assess the role they play in the mechanism under construction.

Causal mechanisms include causes from different categories and scales. For each cause selected, keep in mind the definition, the agent or actor involved, the scale of influence, and other elements systematized in the matrices prepared in Stage 2 (see page 74). These inputs are needed to describe the working of the causal chain and mechanisms that explain the land-use change.

The main causal mechanisms can be separated and described independently to be used as input when analysing scenarios and discussing strategies.

Perennial (coffee) and semi-perennial (banana) crops in Soritor District, San Martín Region, Peru.

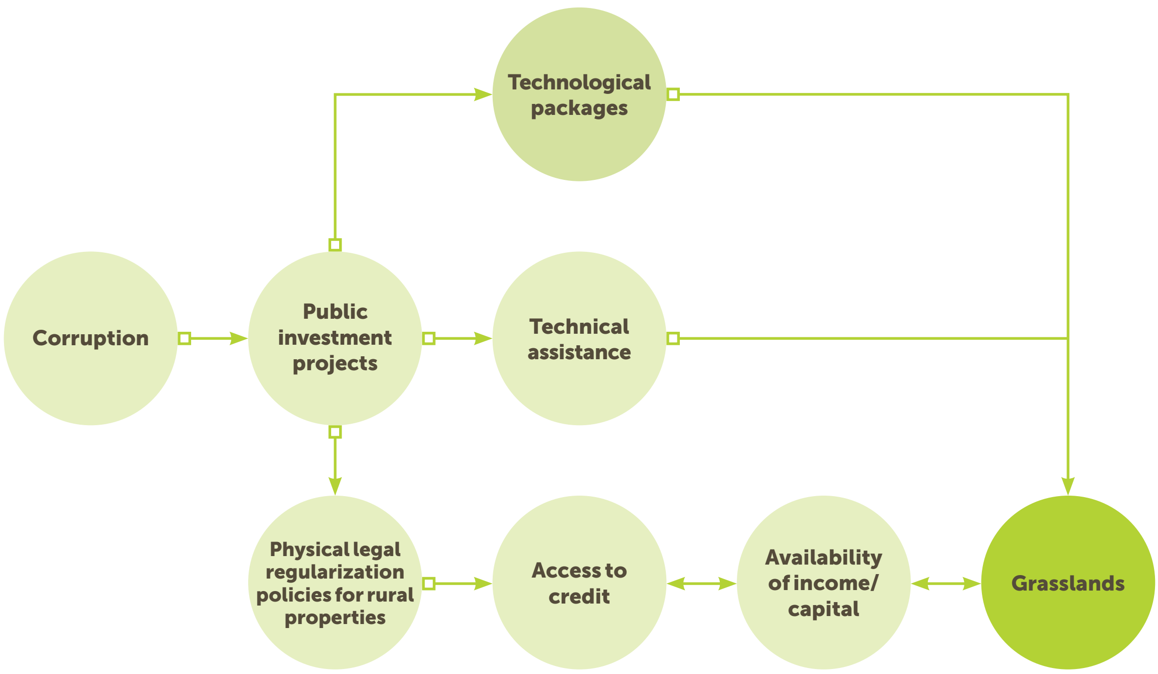
Example of a description of the causal mechanisms that explain land-use change (forest conversion to grassland in San Martín Region, Peru)

Forest conversion to grassland is the result of a combination of economic, institutional, policy, and infrastructure causes. The decision to convert the forest to grassland is directly influenced by three elements.

First, the availability of capital that allows farmers to invest in clearing and preparing the land for grazing and in acquiring livestock. This capital has been accumulated in part from a diversification of income sources and also from greater access to credit, due to more-flexible lending conditions and requirements adopted by financial institutions and other private entities in recent years. Capital invested in grasslands for livestock generates more income for farmers, who then use it as collateral to secure access to new credit and to continue expanding their activities.

The second and third elements consist of increased access to technological packages and technical assistance programs promoted by private entities, respectively.

Greater farmer access to credit has been favoured by land titling and property formalization programs. Titles of occupied and managed lands serve as collateral against the credit offered by financial institutions.



RECOMMENDATION. Choose a maximum of seven causes with their respective causal mechanisms. Write down the workshop outcomes and a description of the causes to use in the final report on the DriveNet process. This allows useful information to be documented and preserved throughout the process.

Finally, systematize all the materials collected and information produced in the different stages and draft the final report. The report should consist of the following sections:

1. **Introduction to the study.**
2. **Description of the methodology, indicating the secondary data used and specifying the workshops and meetings held and their participants.**
3. **Presentation of the context of the territory analysed, justifying its choice.**
4. **Presentation of the outcomes of the analysis of causes.**

   4.1 Description of land-use changes and agents or actors identified in the territory analysed.
   4.2 Description of causes identified by typology, category, scale.
   4.3 Description of causal mechanisms and causal chains for each land-use change, interpreting how they work, the type and intensity of the influence, associated agents or actors, and scales. Specify potential leverage-points. It is important to use the networks and centrality parameters (metrics).

5. **Conclusions.**

This report matters because it provides a way to record and communicate the entire analysis process to those involved in the study or to outsiders. Its analysis of the causes and causal mechanisms of deforestation and land-use change forms the basis for developing initiatives such as low-emissions rural-development strategies.

Final remarks

Annual crops and fallows in Irazola District, Ucayali Region, Peru.

The DriveNet methodology uses a systemic approach, and this allows the development of detailed understanding of the complexity involved in the different deforestation and land-use change processes that occur in a given territory. It provides a way to identify causes and causal mechanisms and, through this, to recognize leverage-points for a series of interventions in the system to produce change and to reduce deforestation.

If appropriately adapted, DriveNet is not restricted to a specific territory or language. It can be deployed in a variety of territories ranging from local political-administrative divisions, such as districts, counties, or municipalities, to larger ones like departments, provinces, regions, or states. DriveNet can also be applied to a territory delimited with purely physical criteria, such as a watershed.

DriveNet is more than just a series of technical steps; it presupposes the existence of institutional commitment from the governments responsible for the territory throughout the entire multi-actor participatory process. At the same time, the successful completion of each stage requires constant effort by the technical team in charge. DriveNet provides the framework for a flexible but constant learning process with the possibility of returning to previous stages to review the inputs and adjust them if necessary.

The amount of information collected with DriveNet is extensive and covers a variety of topics. As a result, it can be used to develop different types of strategic policy documents at the local, regional and even national levels, and be incorporated to land use planning, biodiversity conservation, climate change and restoration agendas, among others.

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Annexes

Annex 1. Land use categories used in the Peruvian Agricultural Census (CENAGRO), 2012

Land use	Description
Lands with hills and forests	Lands covered by trees, shrubs, bushes, etc., that grow together naturally and may have some value for timber, firewood or other uses.
Lands with perennial crops	Lands with plants that are unproductive in their first years and later produce crops for many years at a low maintenance cost. Due to their prolonged production period, they are considered as landed property.
Lands with temporary crops	Lands used for crops with a less than one-year growing cycle that are replanted after each harvest.
Lands with associated crops	Lands occupied simultaneously and equally by different crops.
Lands under short-term fallow	Lands left to rest between harvesting one crop and sowing the next one.
Lands under fallow	Agricultural lands left to rest for a period of less than five years to restore their fertility through the natural growth of vegetation before they are planted again.
Lands with natural grasslands	Lands covered by grass of natural origin that can be managed and used for grazing.
Cultivated grasslands	Lands completely or mostly covered by grass that was sown for grazing or for harvesting as livestock-feed.
Managed grasslands	Areas that can be fenced, irrigated and fertilized, that is, under agronomic management, including livestock rotation.
Unmanaged grasslands	No definition provided. However, the term means grasslands that are not under management.

Annex 2. Metadata form for spatial data

Element	Description
Title	Spatial data name
Name	Name of the file that contains the spatial data (indicate its extension: .shp, .tif, .grd)
Format	Indicate whether vector or raster
How it was produced	Indicate whether created or edited
Spatial reference system	Indicate the Datum and projected coordinate reference (WGS84 UTM Zone 17, 18 or 19 South)
Date	Indicate the date created or last edited - DD MM YYYY
Summary	Write a brief summary of the content of the spatial data
Purpose	Write a brief summary of why the spatial data was created or edited. This should usually include the legal name of the funding organization
Geographic region	Indicate the geopolitical or other spatial unit to which the spatial data refers
Restrictions	Indicate whether the spatial data has any legal restrictions or prerequisites that must be met before sharing or downloading by third parties
Additional information	Write a brief summary with relevant aspects of the methodology used to prepare the spatial data, for example, whether digitized based on images, whether a particular software was used, specific formulae used to calculate certain values, etc.
Source	Indicate the legal name of the institution from which the spatial data was sourced and any link where the data can be accessed
Keywords	Indicate at least three keywords that describe the spatial data
Author	Indicate the name of the author and organization responsible for preparing the metadata

Annex 3. List of causes of deforestation and land use change

	Category	Causes of forest cover removal	Examples, equivalences
DIRECT CAUSES	Agricultural activities (expansion)	Cacao	New farm plots
		Oil palm	New farm plots
		Grasslands	Cultivated, non-cultivated (new farm plots)
		Coffee	New farm plots
		Grapes	
		Subsistence crops	
		Cash crops, annual	Rice, maize, cassava
		Semi-perennial crops	Banana, papaya
		Perennial crops	New farm plot
		Coca and other illegal crops	Marijuana, new farm plots
	Logging	Legal logging	Commercial, small-scale
		Illegal logging	Commercial, small-scale
		Firewood	
		Charcoal	
	Mineral extraction	Small-scale mining	Informal, formal
	Other uses	Forest plantations or other timber and non-timber products	Large-scale plantations
		Land trafficking	Local / major speculators
	Infrastructure expansion	Roads	Highways, unpaved roads, forest roads
		Settlements	Expansion (urban)
		Processing infrastructure	Oil, hydropower plants, mining
		Public utilities	Electricity poles, water supply, sewerage systems
		Storage or processing plants and infrastructure	Sawmills, processing plants, storage facilities
		Invasions	Illegal occupation

	Category	Causes of forest cover removal	Examples, equivalences
INDIRECT CAUSES	Demographic and social factors	Natural population growth	
		Emigration	
		Immigration	
		Population density	Increase/decrease
	Economic factors	National market	Domestic market
		International market	
		Prices	Products / land
		Access to credit	
		Income or capital	
	Technological factors	Technical assistance	
		Incentives	
		Labour	
		Access to technology	Existence of technological packages
		Access to planting material	
		Productivity	
	Institutional and political factors	Political will	
		Public investment and promotion programmes	Public investment
		Private investment programmes	Private investment
		Development programmes	
		Credit and financial inclusion policies	
		Land titling and formalization policies	
		Control and surveillance	Lack of, weak
		Implementation capacity (budget and infrastructure)	Lack of
		Coordination between sectors	
		National budget	Lack of/increase
		Associativity	Associations
		Governance tools	Lack of /weak
	Cultural factors	Knowledge and information	Lack of
		Perception of impunity	
		Corruption	Lack of ethics
		Custom	Cosmovision
	Other factors: biophysical, external, social, social context	Agroclimatic conditions	Agroclimate
		Accessibility	
		Perceived availability of land	
		Availability of crude oil	
		Violent conflict	

Annex 4. Structure of virtual sessions in DriveNet stage 2

DriveNet can be deployed virtually in Stage 2 (Participatory analysis using progressive contextualization) and Stage 3 (Identifying causal relations of influence) as five remote sessions (session 1, 2, 3A, 3B, and 3C). Each session should last from 2 to 2.5 hours (including time to present the study and its goals, and introduce participants and session rules). Longer sessions run the risk of causing participant fatigue and distraction, which could affect the quality of the outputs.

About the sessions:

- Record the virtual sessions through the chosen platform (Zoom, Google Meet, Skype, or other). Let participants know they are being recorded.
- Hold one session per day and leave at least one day between each session for participants to rest. This day is used by the team to go over the information collected and systematize it appropriately, correcting details or clarifying points noted by participants during the session. The number of sessions will also depend on the number of geographical areas being studied and on the complexity of the changes identified by the technical team in advance, during Stage 1. It may mean having only one or two sessions a week. However, the time between sessions 3A, 3B and 3C should be shorter.
- The first session always serves as a pilot, after which the technical team can make time adjustments according to how the session dynamic and amount of information discussed worked.
- Background materials to prepare for the sessions should be shared with participants by email or WhatsApp. It is important to keep these communication channels active, with date reminders before each session and progress updates.
- An example of a short video reminder may include the following message:

> "Good morning, friends, I hope you are well. We are counting on your participation in Session 2 on the 15th of this month. In this session, we will identify the actors and agents linked to the land-use change that we discussed in Session 1. Your presence and contributions will be very important in the analysis of causes and causal mechanisms. See you there!"

The section below provides the structure for the different virtual sessions:

Session 1. What changes?

Session	Background materials	Activity	Note
SESSION 1 What changes?	**Brief summary of the study**	Welcome and introduction to the study of analysis of the causes and causal mechanisms of deforestation and land use change using DriveNet	The technical team presents the goals and explains the importance of the study and its various sessions and activities
		Self-presentations of participants	The technical team asks participants to introduce themselves briefly, giving their name and the organization they represent
		Presentation of session rules	The technical team explains the rules and why they are necessary for the sessions to flow smoothly
	(Coloured) maps of the study area	Geographic description of the study area	The technical team gives a presentation (PowerPoint) on the characteristics of the study area, based on obtained through a synthetic diagnosis of the socioecological context (Stage 1)
	List of questions to identify and characterize the changes in land use	Identification of land-use changes	The structure of the matrix of change that will be completed with the participants' contributions is prepared by the technical team in advance (see page 66). The matrix can be drawn using free apps such as Miro (www.miro.com) or others that fit into the team's budget. The technical team asks the following guiding questions: • What are the most relevant land-use changes that took place in this district? Number them, order them by surface area and characterize them. • Since when have these changes been happening? Have they become more frequent? Is this a trend that will continue or grow? How has the trend behaved in the last five years? • Where is the change taking place? (Describe and name villages, rivers, right or left riverbank). Is the area flat? Where might this occur in the future? • In what legal land-use category is the change taking place? (Examine the map) • What are the characteristics of the change? (Describe how it happens: e.g., "the forest is cut, slashed and burned to grow annual crops (maize, cassava)") • Do you think this change is legitimate? Describe your opinion
		Synthesis and end of the session	The technical team gives a synthesis of the main elements discussed and explains how they will be used in Session 2

Session 2. What agents are producing the changes and what are their characteristics?

Session	Background materials	Activity	Note
SESSION 2 What agents are producing the changes and what are their charac-teristics?	**Brief summary of the study**	Welcome to session 2	The technical team introduces Session 2
		Self-presentation of participants	The technical team asks any new participants to introduce themselves briefly, giving their name and the organization they represent
		Presentation of session rules	The technical team explains the rules and why they are necessary for the sessions to flow smoothly
	Matrix of change	Review of session 1	The technical team gives a brief review, describing the main changes and where they took place, using the complete matrix of change produced from Session 1
	List of questions to identify and cha-racterize the agents/ actors involved in the land use changes	Identification of land use changes	The framework of the matrix of agents (see page 69) that will be completed with the participants' contributions is prepared by the technical team in advance. The matrix can be drawn using free apps such as Miro (www.miro.com) or others that fit into the team's budget The technical team asks the following guiding questions: • Who are the agents/actors that produce this change? • Where do they act? (Describe the physical features, legal land use category) • Where do they come from? (If they are immigrants, indicate whether 1st, 2nd or 3rd generation or temporary migrants and the reasons why they migrated) • Do they own the area they farm? What is the size of the farm or property? Do they have land titles, ownership certificates or others? How did they obtain them? Who do they sell their products to? (local, regional, national market) Do they have other productive activities? What are they? • Since when has the actor been involved in the activity? What made the actor get involved? Did they receive any type of incentives? What might influence the decisions of this agent in the future?
		Synthesis and end of the session	The technical team gives a synthesis of the main elements discussed and explains how they will be used in Session 3

Session 3A What are the causes and how do they relate to each other?

Session	Background materials	Activity	Note
SESSION 3 What are the causes and how do they relate to each other? **Session 3A**	**Brief summary of the study**	Welcome to Session 3A	The technical team introduces Session 3A
		Self-presentation of participants	The technical team asks any new participants to introduce themselves briefly, giving their name and the organization they represent
		Presentation of session rules	The technical team explains the rules and why they are necessary for the sessions to flow smoothly
	Matrix of change Matrix of agents	Review of sessions 1 and 2	The technical team gives a brief review, describing the main changes and where they occur, and the main agents identified using the pre-filled matrix of change and the matrix of actors and agents produced from sessions 1 and 2
	List of categori-zed causes and list of questions to define them	Identification of land use change causes using progressive contextualization	The causal matrix framework (see page 76) that will be completed with the participants' contributions is prepared by the technical team in advance. The matrix can be drawn using free apps such as Miro (www.miro.com) or others that fit into the team's budget The technical team progressively contextualizes each of the changes to identify and define the causes, as shown in the example below: **Change 1: Forest conversion into maize** • Why did the agent/actor clear the forest? To plant maize. Maize is therefore a **direct** cause of the change because the forest was cleared to replace it with maize. • How can we define "maize"? • What is its scale? (Local, regional, national) • What short name can we give it to identify it quickly later? • Why did the agent/actor plant maize? Because he had access to capital. Access to capital is an indirect cause because it influences the agent's/actor's decision to plant maize after clearing the forest. • How can we define access to capital? Does this mean that the agent/actor did not have access to capital before? Or did he have less? • What is its scale? (Local, regional, national) • What short name can we give it to identify it quickly later? Repeat the exercise for each cause
		Synthesis and end of the session	The technical team gives a synthesis of the main elements discussed and explains how they will be used in Session 3B

Session 3B. What are the causes and how are they related to each other?

Session 3B continues the work of session 3A and completes it.

Session	Background materials	Activity	Note
SESSION 3 What are the causes and how are they related? **Session 3B**	**List of categorized causes and list of questions to define them**	Identification of land use change causes using progressive contextualization	The technical team resumes the causal matrix worked on in session 3A and continues the exercise The technical team progressively contextualizes each of the changes identified to identify and define the causes, as shown in the example below: **Change 1: Forest conversion into maize** • Why did the agent/actor cut the forest? To plant maize. Maize is therefore a direct cause of the change because the forest was cleared to replace it with maize • How can we define "maize"? • What is its scale? (Local, regional, national) • What nickname can we give it to identify it quickly later? • Why did the agent/actor plant maize? Because he had access to capital. Access to capital is an indirect cause because it influences the agent's/actor's decision to plant maize after clearing the forest • How can we define access to capital? Does this mean that the agent/actor did not have access to capital before? Or did he have less? • What is its scale? (Local, regional, national) • What short name can we give it to identify it quickly later? Repeat the exercise for each cause
		Synthesis and end of the session	The technical team gives a synthesis of the main elements discussed and explains how they will be used in Session 3C

Session 3C What are the causes and how are they related to each other?

Session	Background materials	Activity	Note
SESSION 3 What are the causes and how are they related? **Session 3C**	**Causal matrix**	Welcome to Session 3C	The technical team introduces Session 3C
		Review of sessions 3A and 3B	The technical team gives a brief recap showing the systematized causal matrix, and reviews and validates the definitions
	List of categorized causes and list of questions to define them	Identifying the causal relations	The technical team prepares the names of the causes in advance in the Miro window distributed in the entire space by levels and coloured by categories The technical team leads the activity of identifying the **direct** relations of influence that exist between the causes. For each **direct** relation, draw an arrow and specify the intensity of the relation (1,2,3). If they are not related, do not draw an arrow
		Synthesis and end of the session	The technical team provides a synthesis of the main elements discussed and indicates how they will be analysed in the following stages of the methodology

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This first English version of the DriveNet manual -revised for international users- provides local, regional, and national actors, and multi-actors platforms in general, with a much-needed methodological framewoek that can be broadly applied to systematically assess the cause and causal mechanism of deforestation and land-use change at geographical or jurisdictional scales.

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