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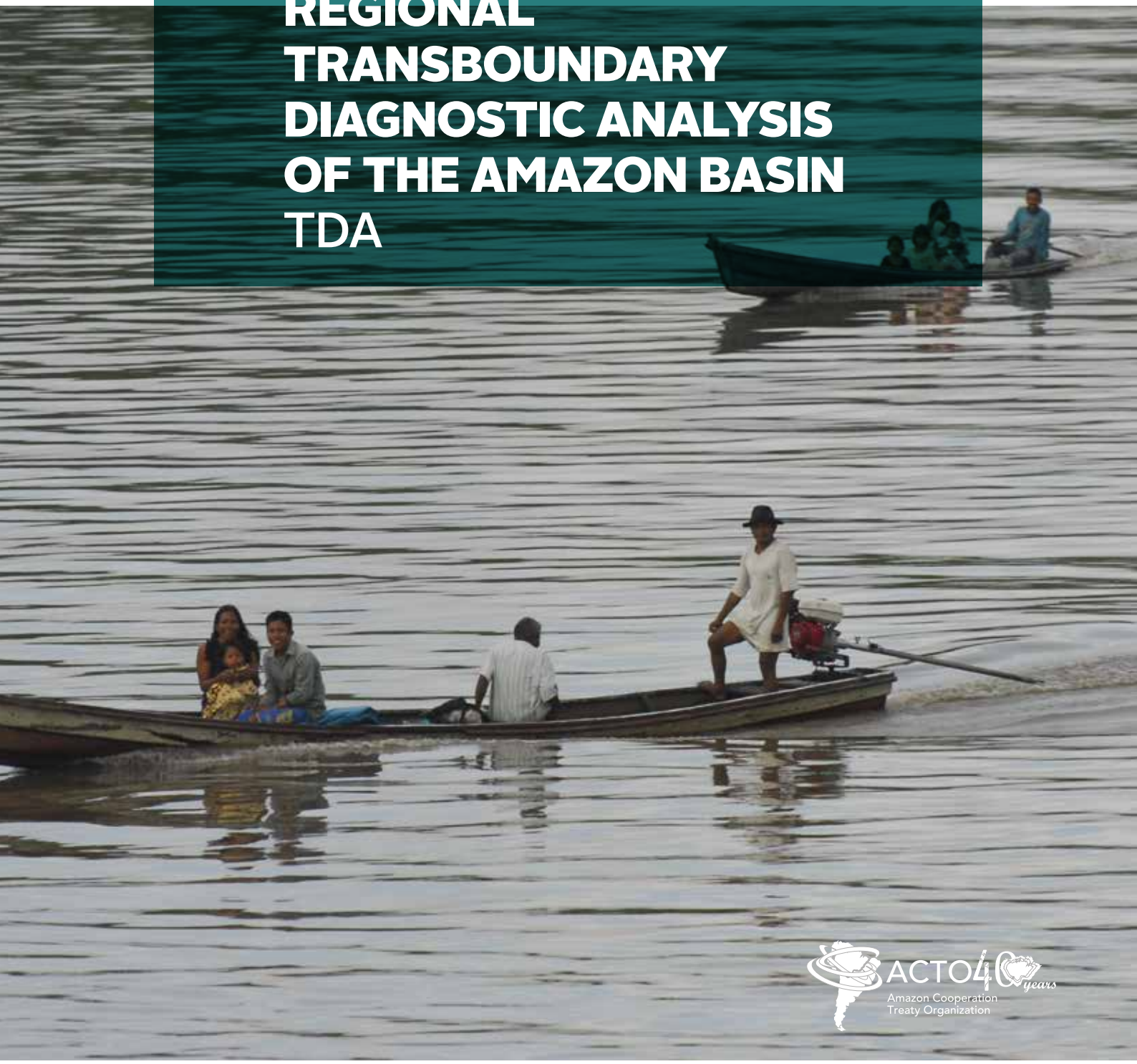
REGIONAL TRANSBOUNDARY DIAGNOSTIC ANALYSIS OF THE AMAZON BASIN

TDA



ACTO 40 years
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REGIONAL TRANSBOUNDARY DIAGNOSTIC ANALYSIS OF THE AMAZON BASIN - TDA

1st Edition
Edited by OTCA
Brasilia, 2018

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A532 Regional Transboundary Diagnostic Analysis of the Amazon Basin –

TDA/ACTO GEF Amazon Project – Brasilia, DF, 2018.

84p.: ill.;color.

Publication in digital format.

ISBN: 978-85-61873-14-1

1. Amazon Basin – GEF Amazon Project. 2. Water Resources and Climate Change –Project. 3. Amazon Region. 4. Amazon Population. I. Amazon Cooperation Treaty Organization.

CDU: 556.18(811)

Graphic Design, Design and Layout:
DUODESIGN Agency

Printed by:
ATHALAIA Gráfica e Editora

Published with the support of:

United Nations Environment Programme

Global Environment Facility (GEF)

INDEX

FOREWORD

Since 1978, the Amazon Cooperation Treaty Organization (ACTO) promotes the protection of the Amazon Basin. The work program of the Amazon Strategic Cooperation Agenda highlights the need to address Water Resources, with a fundamental objective for the region: to support the construction and dissemination of a reference framework for the efficient, integrated and integral management of water resources, aiming at a greater access of the population to water and sanitation, among other issues, in order to improve the quality of life of Amazonian populations.

Pursuant to this mandate, the ACTO / UN Environment / GEF Project - Integrated and Sustainable Management of Transboundary Water Resources in the Amazon River basin, considering Climate Variability and Change, has been in execution for the last five years, representing a successful regional cooperation initiative with the participation of the 8 ACTO Member Countries.

In this area, ACTO reaffirms the sovereignty of its member countries in considering the water resources of the Amazon Basin as strategic and priority resources for the protection of the life of ecosystems and communities.

In this sense, I would like to highlight three essential products achieved by the Project to promote Integrated Water Resources Management (IWRM) in the region, which are framed in the 2030 Agenda for Sustainable Development:

- Shared Vision for the Amazon Basin.
- Regional Transboundary Diagnostic Analysis (TDA).
- Strategic Action Program (SAP).

For this reason, I am pleased to present the Regional Transboundary Diagnostic Analysis of the Amazon Basin, an extraordinary achievement for the region, since it shows the results obtained on water resources management in the basin, based on a wide consultation process with the main national actors (institutions, public and private organizations). Thus, eleven National TDA Workshops were held, with the participation of more than 470 representatives of institutions from the 8 Member Countries, followed by a Regional TDA Workshop on validation of results.

As ACTO Secretary General, I would like to thank all the participants for their diligent work in these meetings, which allowed the identification of Nine (9) Regional Priority Transboundary Problems of the Amazon Basin, the development of Impact and Causal Chain Analyses of the Problems, and the proposal of Regional Strategic Response Lines.

The Regional TDA is a methodological guideline arising from the multi-stakeholder consensus, an invitation to strengthen the institutional capacities of the national entities responsible for the management of water resources in ACTO member countries.

The Regional TDA presented below also enabled countries to assess their internal policies on water resources and to consolidate new mechanisms for transboundary cooperation.

Amb. María Jacqueline Mendoza Ortega
ACTO Secretary General

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INTRODUCTION

BACKGROUND OF THE GEF-AMAZON PROJECT

The Amazon Basin faces numerous challenges in Integrated Water Resources Management (IWRM) pertaining to socio-economic development and human-driven climate change. The basin consists of a continental hydrological system that crosses the national borders of eight countries (Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela), which have identified the need for a multilateral framework on water resource management to meet the needs of the regional population.

In 1978 the eight countries in the basin signed the Amazon Cooperation Treaty (ACT) and later on created the Amazon Cooperation Treaty Organization (ACTO) as a platform for political and regional cooperation.

In 2003, ACTO, on behalf of the countries in the Amazon Basin, along with the United Nations Environment Programme (UN Environment) and the Organization of American States (OAS), asked for the support of the Global Environment Facility (GEF) to pursue a project entitled "Integrated and Sustainable Management of Transboundary Water Resources in the Amazon River Basin Considering Climate Variability and Climate Change" (GEF-AMAZON). The project's main objective was to develop a **Strategic Action Program (SAP)** and create an environment conducive to the implementation of Integrated Water Resources Management **(IWRM)** in the Amazon Basin.

This Regional TDA is organized in four parts: (1) Priority Transboundary Problems in the Amazon Basin, (2) Impacts and Causal Chain Analysis of the Transboundary Problems, (3) Regional Strategic Lines of Response, and (4) Conclusions and Recommendations.

Objectives of the Regional TDA

The **Regional Transboundary Diagnostic Analysis (TDA)** aims to identify and analyze the main transboundary problems, their impacts and causes, to define regional response strategies and develop the Strategic Action Program (SAP).

The specific objectives of the Regional TDA include:

1. Identification, selection and ranking of priority regional transboundary problems.
2. Analysis of environmental and socio-economic root causes of priority regional transboundary problems.
3. Analysis of the causal chain of priority regional transboundary problems.
4. Identification of strategic lines of response for the formulation of the SAP.

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TDA METHODOLOGY AND SUMMARY

The Transboundary Diagnostic Analysis (TDA) of the Amazon Basin[1] is a methodology to (i) Identify and assess priority transboundary environmental and socio-economic issues related to Integrated Water Resources Management (IWRM) in the region, and (ii) Determine their direct, indirect and root causes, in addition to their socio-economic and environmental impacts. Thus, the Regional TDA provides the basis for the formulation of the SAP.

Methodologically, the TDA is a scientific-technical document that is based on two main pillars:

- The **available information** and experiences in various aspects of IWRM in the Amazon Basin.
- **The participation of key national actors** (institutions, public and private organizations) related to IWRM in the Amazon region, identifying their perception of the major transboundary problems and their underlying causes.

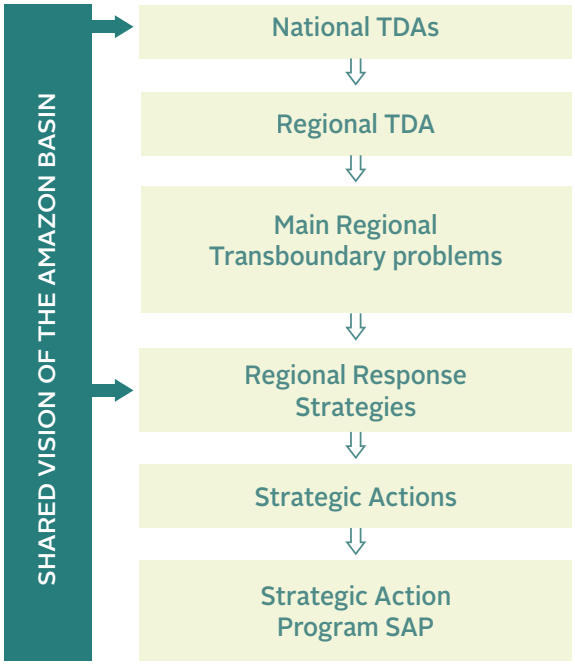
The Regional TDA was the result of 11 national TDA workshops, with the participation of over 470 representatives of institutions from ACTO member countries and the official validation of the results by the National Focal Points in each country. In addition, the TDA received contributions from scientific and demonstration activities implemented in the context of the GEF Amazon Project.

Finally, the proposal for the Regional TDA benefited from the contributions of national TDA consultants (Technical Meeting, Brasilia, 13-14 October 2014) and the contributions of the National Focal Points, at the Validation Workshop: Regional Proposal Transboundary Diagnostic Analysis (TDA) and Base Index for Strategic Action Program (SAP)/IV Meeting of the Project Steering Committee (Brasilia, 20-21 November 2014) and the Regional Workshop on Shared Vision and Strategic Action Program (SAP) (Bogota, 5-6 May 2015).

[1]The scope of the term "Amazon Basin" used in this document considers what is defined in Article II of the Amazon Cooperation Treaty (ACT), which determines the application of the Treaty "in the territories of the Contracting Parties in the Amazon Basin, as well as in any territory of a Contracting Party that, due to its geographical, ecological or economic characteristics, is considered to be closely related to it ". In the case of the Bolivarian Republic of Venezuela, the scope of application of the ACT is the hydrographic that includes the Casiquiare and the Rio Negro basins.

The Regional TDA is a synthesis of national TDAs, identifying (i) priority transboundary problems, (ii) their impacts and causal chain, (iii) the regional strategic lines of response that guide the formulation of the Strategic Action Program (SAP), leading, in turn, to a proposal for implementing the SAP.

The logic of the TDA-SAP process can be summarized as follows:



Thus, the Strategic Action Program (SAP) for Integrated Water Resources Management (IWRM) and adaptation to climate change in the Amazon Basin is based on:

- A shared vision for the integrated management of transboundary water resources in the Amazon basin,
- A Regional Transboundary Diagnostic Analysis (TDA) that consolidates priority transboundary problems identified in the national workshops, and their environmental and socio-economic impacts and the root causes.
- The results and recommendations from the project activities and other regional initiatives by the ACTO.

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GEOGRAPHICAL AND SOCIAL CONTEXT OF THE AMAZON BASIN

THE SOURCE OF THE AMAZON RIVER is located in the Peruvian Andes at 5,597 meters above sea level, and the river flows 6,992 km before reaching the Atlantic Ocean.

THE AMAZON BASIN, the largest drainage basin in the world, occupies more than 6,118.000 km^2 (44%) of the continental area of South America, covering parts of Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela.

The basin is characterized by significant climatic and topographic variability, with elevations ranging from sea level up to 6,500 m in the Andes. Precipitation levels range from 200 mm/year in the Andes to over 6,000 mm/year in some regions of the Amazonian lowlands. Seasonal variations in rainfall resulting from movements in the intertropical convergence zone, produce periods of maximum precipitation between March and June in the Northern Hemisphere, and from December to March in the Southern Hemisphere.

The average discharge of the Amazon basin is about 6,500 km^3/year, representing 70% of Latin America's fresh water discharge and nearly 20% of the global total. (Sterling,1979, Smith, Nigel J.H.,2003, Jansky B. et al.,2008).

The Amazon Countries: Table 1 shows the Amazon areas of ACTO member countries.

TABLE 1. NATIONAL AREAS OF THE AMAZON BASIN BY HYDROLOGICAL, ECOLOGICAL AND POLITICAL-ADMINISTRATIVE CRITERIA

COUNTRY	TERRITORY (Km²)	AREA OF THE AMAZON BASIN (Km²)		
		Hydrological Areas	Ecological Areas	Political-Administrative Areas
BOLIVIA	1,098,581	724,000	567,303	724,000
BRAZIL	8,514,876	3,869,953	4,196,943	5,034,740
COLOMBIA	1,141,748	345,293	452,572	477,274
ECUADOR	283,561	146,688	76,761	115,613
GUYANA	214,960	12,224	214,960	214,960
PERU	1,285,216	967,176	782,786	651,440
SURINAME	163,820		163,820	163,820
VENEZUELA	916,445	53,000	391,296	53,000
TOTAL		6,118,334	6,846,421	7,434,827

Source: "Environment Outlook in Amazonia". United Nations Environment Programme and ACTO. 2009.

Hydrographic Criterion: considers the total extension of the Amazon Basin.

Ecological (or biogeographic) criterion: uses as an indicator the extension corresponding to the South American tropical and subtropical humid forest biome, located east of the Andes mountain range.

Political - administrative criterion: referred to the area covered by the political - administrative limits of different hierarchy established by each country and defined as part of its Amazon region.

THE AMAZON POPULATION, heterogeneous and with different socio-cultural characteristics, was estimated at 33,485,981 inhabitants in 2007 (UNDP, 2008) representing 11% of the total population of the ACTO member countries. Brazil accounts for about 75% of the total Amazon population, followed by Peru with 13%. The Amazon population grew at an average annual rate of 2.3% during 1990-2007; Ecuador with 3.6%, recorded the highest annual average rate.

INDIGENOUS POPULATION: There are about 420 different indigenous peoples (including isolated or recently contacted groups) living in the Amazon, speaking 86 languages and 650 dialects, which are a demonstration of cultural diversity. These people have their own demographic dynamics, rates of fertility and mortality, and various patterns of human settlements. They cross borders, traveling on the basis of social patterns and not according to geopolitical borders. The socio-economic and environmental changes have severely affected indigenous Amazonian populations, forcing them to change their lifestyles and reducing their numbers (ACTO, 2007).

MAIN URBAN CENTERS: In Brazil: Manaus, 1,646,602 inhabitants (IBGE, 2007) and Belem, 1,408,847 inhabitants (IBGE, 2007]); Santa Cruz in Bolivia, 1,545,648 inhabitants (INE, 2008); and Iquitos in Peru, 432,476 inhabitants (INEI, 2014).

REGIONAL SHARE OF THE AMAZON BASIN (%)	NATIONAL COVERAGE OF THE AMAZON BASIN (%)
11.83	65.90
63.25	45.45
5.64	30.24
2.40	51.73
0.20	5.69
15.81	75.25
0	0
0.87	5.78
100	44.99

ACTO

Rui Faquini,

MAIN URBAN CENTERS: In Brazil: Manaus, 1.646.602 inhabitants, (IGBE, 2007) and Belem, 1.408.847 inhabitants (IGBE, 2007). In Bolivia: Santa Cruz, 1.545.648 inhabitants (INE, 2008). In Colombia: Florencia, 137.896 inhabitants (DANE, Censo General 2005) and in Perú: Iquitos, 432.476 inhabitants (INEI, 2014).

HEALTH: The most common diseases are malaria, dengue, tuberculosis, AIDS, and gastrointestinal and respiratory diseases caused by water and air pollution, respectively. Recent studies have shown that malaria transmission is higher in deforested areas (Vittor, Gilman, Tielsch, Glass and Shields 2006). Between 1991 and 2000, infant mortality in children under one-year-old fell by half, from 51 to 36 deaths per 1,000 live births. In the case of infant mortality in children under five, there was a decrease from 67 to 46 deaths per 1,000 (Celentano and Veríssimo, 2007).

EDUCATION: In the Amazon, the illiteracy rate of the adult population is high, ranging from 12% to 93% depending on the region. On average, a drop of 7% in the illiteracy rate was recorded in the major urban centers between 1990 and 2005, and among the population over 15 (Celentano and Veríssimo, 2007).

Rui Faquini

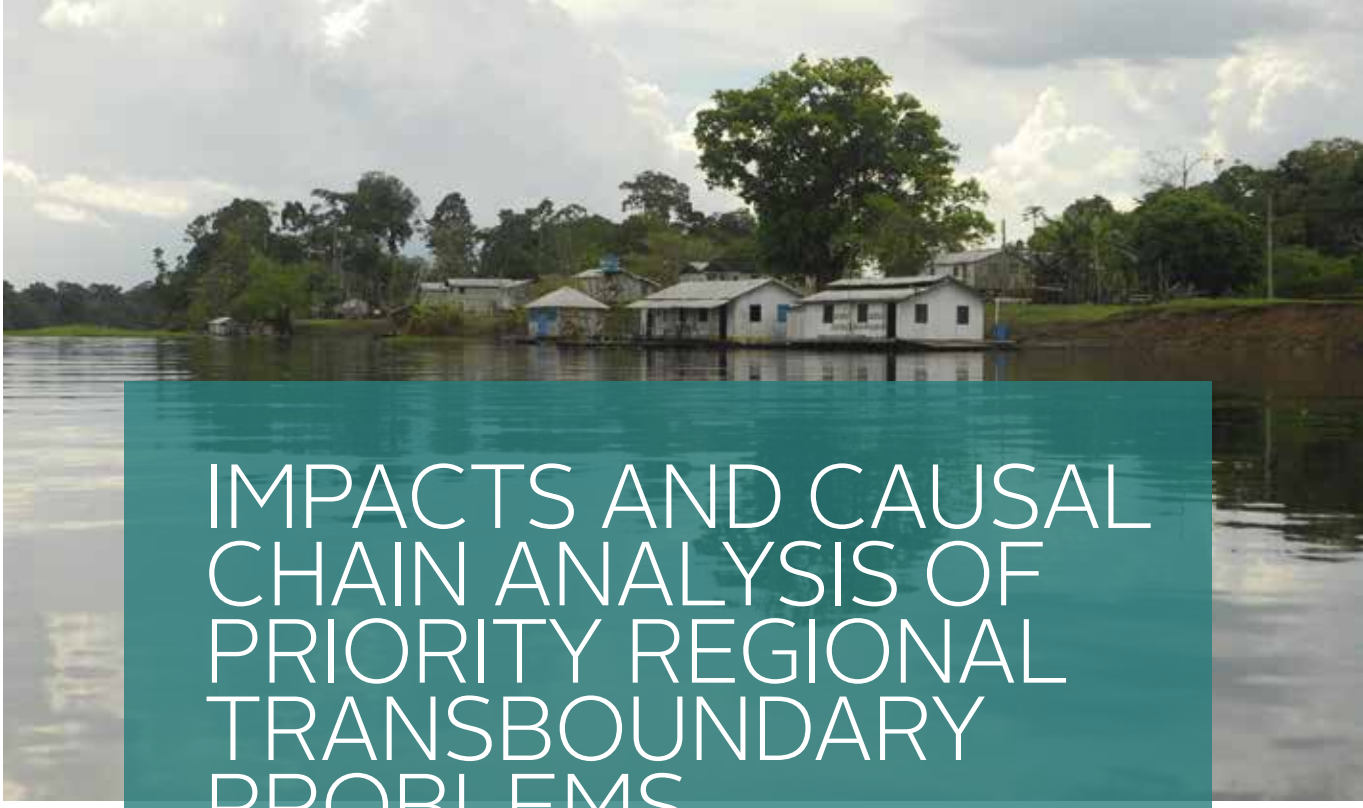
TRANSBOUNDARY PROBLEMS IN THE AMAZON BASIN

The 50 priority transboundary problems identified in the national TDAs were examined in a typological analysis which resulted in nine types of priority regional transboundary problems. To establish the priority of the identified problems, a frequency analysis was done of the 50 problems from the national TDAs.

In this way, the nine priority regional transboundary problems in the Amazon Basin were classified in the following order.

TABLE 2. PRIORITY TRANSBOUNDARY PROBLEMS IN THE AMAZON BASIN.

	PRIORITY REGIONAL TRANSBOUNDARY PROBLEMS OF WATER RESOURCES IN THE AMAZON BASIN
1	Water Pollution
2	Deforestation
3	Loss of Biodiversity
4	Extreme Hydroclimatic Events
5	Erosion, and Sediment Transport and Sedimentation
6	Changes in Soil Use
7	Loss of Glaciers
8	Large Infrastructure Projects
9	Limited Integrated Water Resources Management



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IMPACTS AND CAUSAL CHAIN ANALYSIS OF PRIORITY REGIONAL TRANSBOUNDARY PROBLEMS

For each of these priority transboundary problems, the ***environmental and socio-economic impacts*** and their ***root causes*** have been identified.

This methodological procedure makes it possible to identify the necessary actions to mitigate or resolve the problems caused by harmful environmental and socio-economic impacts.

For the presentation of the causal chains of the problems, tables and figures were used that were created at the national workshops based on the information obtained at those events, and validated at subsequent meetings, meaning that the information therein replicates the proposals made at those meetings. The figures are the graphic presentation of the level of priority, general causes and, in some cases, they provide more detailed information, depending on what was analyzed at the meetings.

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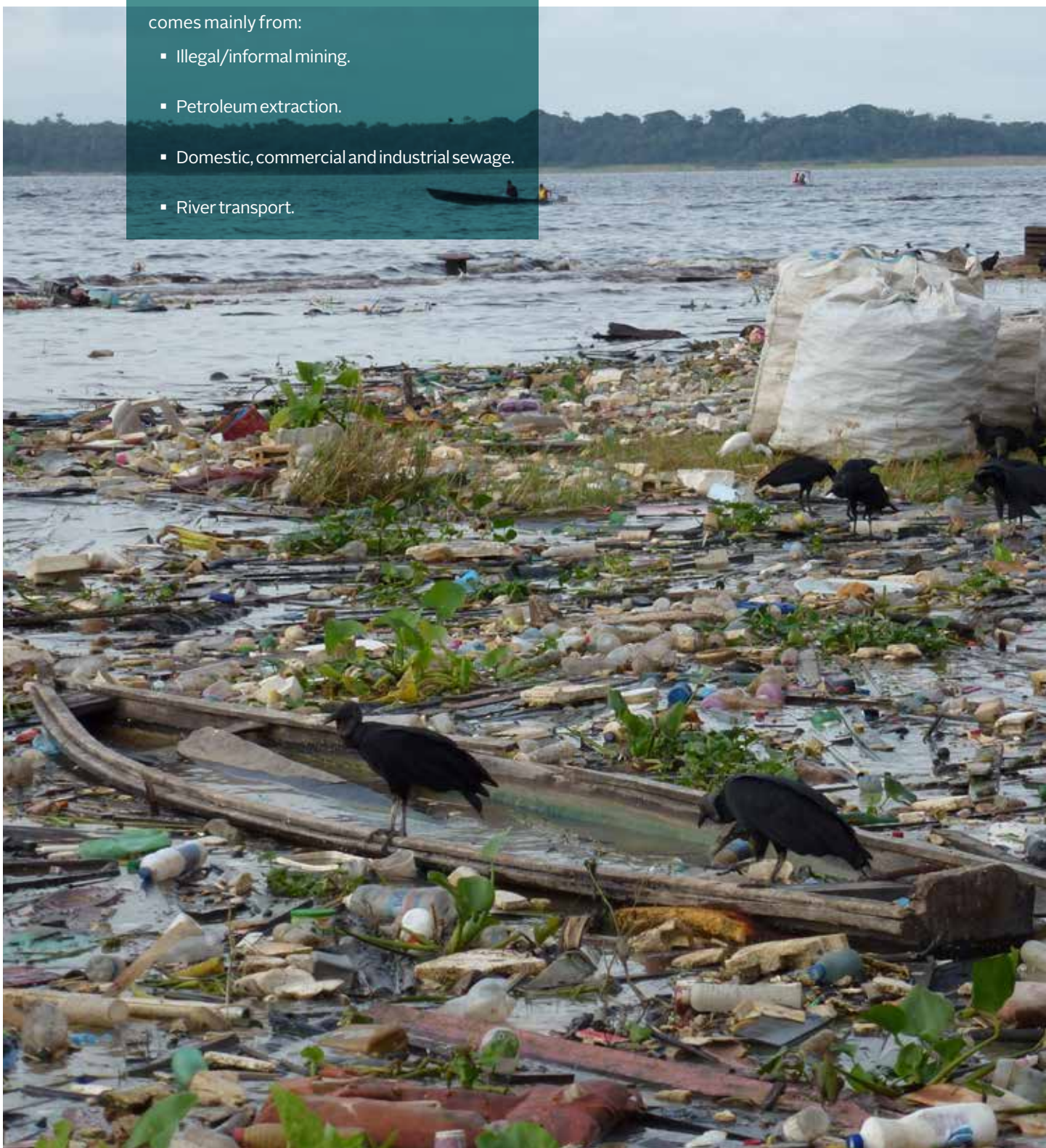
Problem Nº 1

WATER POLLUTION

Water pollution in the Amazon Basin comes mainly from:

- Illegal/informal mining.
- Petroleum extraction.
- Domestic, commercial and industrial sewage.
- River transport.



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Water Pollution from Illegal/Informal Mining

Despite having national laws in place, illegal mining activities have increased in the Amazon Basin during the past two decades, impacting aquatic and land ecosystems, increasing health risks for entire communities, especially because of river water polluted with heavy metals, such as mercury.

Mining is taking place mainly in the Guiana Shield, in the Bolivian (TDA Bolivian Amazon Basin, 2015) and Peruvian Andes, and the foothills of Colombia's Cordillera Oriental. It is estimated that there are between 100,000 to 200,000 informal miners in Colombia, a similar number in Peru and twice as many in Brazil (Socio-Environmental Institute [ISA] 2006).

Illegal mining releases an average of about 24 kg of mercury per square kilometer (of excavated area) into the rivers. It is estimated that as of 1994, 2,300 tons of mercury had been dumped in the Brazilian Amazon, and the rate today is estimated to be around 150 tons/year (Gómez, 1995b and 2000; Sweeting and Clark, 2000; Mann, 2001; Franco and Valdés, 2005; Ibish and Mérida, 2004; UNEP, 2004; FOBOMADE, 2005; ACTO, 2005).

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TABLE 2.1. WATER POLLUTION BY ILLEGAL/INFORMAL MINING

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Water pollution with heavy metals ▪ Contamination of aquatic resources ▪ Soil erosion ▪ Deforestation ▪ Reduction of aquatic resources ▪ Extinction of aquatic flora and fauna ▪ Atmospheric impacts, dust and suspended particles	▪ Decrease in safe food sources ▪ Deterioration of health and quality of life ▪ Destruction of riverbanks ▪ Loss of arable land ▪ Social conflicts ▪ Occupation of indigenous lands ▪ Migration to illegally occupied areas ▪ Land trafficking ▪ Illegal gold trafficking and increase of criminal acts

CAUSAL CHAIN ANALYSIS – ILLEGAL/INFORMAL MINING

Direct Causes (Technical Causes)

Use of chemicals that are hazardous and toxic to aquatic ecosystems; use of dredges in unauthorized areas; improper mining; improper use and poor state of equipment, materials and machinery; mining in protected areas and in close proximity to inhabited areas; lack of knowledge and use of modern, safe technologies; unauthorized mining; dumping of untreated mining waste; mining on riverbanks; community's acceptance of illegal mining because of high unemployment.

Secondary Indirect Causes (Economic Causes)

Illegal, untaxed, sale of low-cost products; low cost of acquisition, transportation and installation of machinery; availability of low-cost unskilled labor; high profits and tax evasion; little social spending and lack of knowledge about environmental functions.

Tertiary Indirect Causes (Institutional Causes)

Inadequate control over the sale of dangerous chemicals; poor supervision and control by the state; lack of effort by the state to implement appropriate methods and enforce labor legislation; limited investment and coordination by the state for environmental monitoring; limited public and private development options.

Root Causes (Socio-political Causes)

Ineffective oversight of the sale, transport and use of hazardous chemicals; lack of sustainable long-term policies to resolve the problem of informal mining; slow implementation of land-use plans; weak coordination and state investment in the sustainable implementation of environmental policies; weak implementation of transboundary policies to conserve and protect aquatic ecosystems.

Water Pollution from Oil Extraction

The largest oil and gas fields are located in the western part of the Amazon Basin, in Colombia, Ecuador, Peru and Bolivia. Pollution accidents occur primarily in the extraction locations and during transportation to the major oil refineries.

Ecuador accounts for about 75% of oil production in the Amazon region, mainly in the provinces of Sucumbíos, Napo, Orellana and Pastaza.

In Colombia, the main oil production area is Putumayo, putting out about 5 million barrels per year.

In the Brazilian Amazon, oil extraction is mainly limited to the Urucú River region in Amazonas State, producing about 16 million barrels per year. It is estimated that the oil industry in this region has produced to date about 40 million tons of sludge (Ministry of Mines and Energy of Brazil, http://www.mme.gov.br; UNEP/ACTO, 2008). The oil and gas reserves in some regions extend into protected natural areas (PNAs).

In Peru, for example, there are oil extraction operations in some PNAs, such as the Pacaya-Samiria National Reserve, the Machiguenga Communal Reserve and the Pucacuro Reserve Zone.

Bolivia also has large reserves of gas, with the potential to supply countries in the region, which in the future will mean major infrastructure projects to extract and sell this product.

In Guyana, oil exploration programs are being carried out in the basin of the Takatu River (Goulding, Barthem and Ferreira (2003a).

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TABLE 2.2. WATER POLLUTION BY OIL EXTRACTION ACTIVITIES

IMPACTS / CONSEQUENCES	
Environmental	Socio-economic
▪ Reduction of aquatic resources ▪ Loss of aquatic biodiversity ▪ Soil degradations ▪ Air pollution ▪ Extinction of flora and fauna ▪ Migration of species of fauna	▪ Deterioration of human health ▪ Increase in operating costs ▪ Displacement of indigenous communities ▪ Conflicts

CAUSAL CHAIN ANALYSIS – OIL EXTRACTION

Direct Causes (Technical Causes)

Inadequate maintenance of pipelines, facilities and transport vessels; vandalism on pipelines; breakage from earthquakes; unregulated transport; lack of training of personnel; thunderstorms and high winds; boats that do not meet safety standards; inadequate management of infrastructure; improper oil extraction practices.

Secondary Indirect Causes (Economic Causes)

Inadequate or nonexistent piers; lack of investment in staff training; little involvement by indigenous and local communities in oil activities; outdated technology in facilities and equipment.

Tertiary Indirect Causes (Institutional Causes)

Little institutional strengthening; little capacity-building; little mitigation control; weak implementation of quality standards; little enforcement of the use of technical standards; encouragement of oil extraction.

Root Causes (Socio-political Causes)

Weak state presence in environmental monitoring; long-term extraction policies.

Water Pollution from Domestic, Commercial and Industrial Sewage

Despite the huge fresh water supply in the Amazon Basin, less than 60% of the population has a safe water supply and sanitation. Most rural communities do not have water and sewage services. Consequently, wastewater from urban centers is emptied directly into rivers and aquatic ecosystems, without any treatment, becoming the main source of endemic diseases in the region (Nippon Koei Lac Co., 2005).

It is estimated that the Amazonian rivers receive 1.7 million tons of solid waste annually and 600 l/s of domestic or municipal sewage (ANA, 2007). Large-scale agro-industrial monoculture is another important source of water pollution because of the intensive use of agro-toxic agents. Because of the climate and the great diversity of insects and microorganisms, the Amazon is the region where the most chemicals are used, such as pesticides, herbicides, insecticides, fungicides and acaricides.

TABLE 2.3. WATER POLLUTION FROM DOMESTIC, COMMERCIAL AND INDUSTRIAL SEWAGE

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Loss of aquatic biodiversity ▪ Reduction of aquatic resources ▪ Degradation of aquatic ecosystems ▪ Eutrophication and pollution by agro-toxic agents ▪ Increase in GHG emissions.	▪ Health problems ▪ Loss of income ▪ Increased water treatment costs

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CAUSAL CHAIN ANALYSIS – DOMESTIC, COMMERCIAL AND INDUSTRIAL SEWAGE

Direct Causes (Technical Causes)

Rainwater mixed with wastewater; inadequate wastewater collection; inadequate treatment of sewage; ignorance of wastewater treatment techniques; failure to comply with sanitation regulations; inadequate rainwater drainage channels; inadequate basic services; wastewater discharge; dumping of solid waste, and new road construction.

Secondary Indirect Causes (Economic Causes)

Little public and private spending on wastewater treatment; little public and private spending on rainwater drainage; not enough wastewater treatment plants; little spending on education and consciousness-raising; low-income families; little spending on sanitation infrastructure, technology and training.

Tertiary Indirect Causes (Institutional Causes)

Inefficient budget management; not enough public spending; absence of land-use plans; inadequate urban development plans; lack of planning for the construction of sewage treatment plants; poor planning in the construction of rainwater drainage systems; ineffective control and oversight of public administration; little interagency coordination, gaps and outdated laws on water quality; weak institutional capacity of the state.

Root Causes (Socio-political Causes)

Population growth because of migration and increasing birthrates; socio-territorial conflicts regarding sewage disposal; political and social groups lack interest in the problem of pollution; centralized management model.

Water Pollution from River Transport

In the Amazon Basin, more than 24,000 kilometers of navigable rivers make up the most important means of travel and integration for the local populations. Local and regional trade flows along the navigable rivers are much more important than international trade flows (ECLAC, 2006).

In Brazil, the National Association of Water Transport (ANTAQ) reported that more than 50 million tons of cargo were transported on the Amazon's rivers in 2012, of which 5 million tons were soybeans, and more than 2.2 million tons of fuels. Work to extend the navigable network of the Amazonian rivers between 2015-2030, should increase the total cargo transported in the Amazon/Solimões Basin to 98 million tons by 2020 (A. Tokarski, 2012).

In Colombia, the intermodal Amazon River corridor is made up of the stretch between Puerto Asís to Puerto Leguízamo-Tarapacá on the Putumayo River, and San Antonio de Ica to Leticia on the Amazon River, for a total of 2,290 km (Neto, Sánchez, Wilmsmeier, CEPAL, 2007).

Bolivia's Amazon region contains the rivers of the departments of Cochabamba, Santa Cruz, Pando, Beni and La Paz, most of them flowing into the main rivers, with 2,900 km of navigability and close to 2,000 km of secondary routes (Neto, Sánchez, Wilmsmeier, CEPAL, 2007).

Although there are no studies or statistics on the exact amount and nature of water pollution caused by river transport in the Amazon Basin, the large volume of cargo and number of passengers, and the lack of regulations and enforcement of the collection of solid waste and hazardous liquids from boats provides an idea of the significance of river transport as a source of pollution in the rivers of the Amazon.

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TABLE 2.4. WATER POLLUTION FROM RIVER TRANSPORT

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Pollution of beaches in the Amazon ▪ Reduction of aquatic resources ▪ Loss of aquatic biodiversity ▪ Eutrophication ▪ Dredging and fuel dumping	▪ Damage to tourism economy ▪ Detrimental to health ▪ Increase in operating costs

CAUSAL CHAIN ANALYSIS - RIVER TRANSPORT

Direct Causes (Technical Causes)

Dumping of fuel and oil; dumping of sewage; dumping of solid waste; people's bad habits; river accidents; inadequate maintenance of machinery; no compartment for collecting waste on boats; worn out transport equipment; unclean boats; fuel spills in water sources; failure to abide by safety regulations.

Secondary Indirect Causes (Economic Causes)

Inefficient river transport service; lack of spending on safety by boat-owners; lack of regulations and adequate systems to collect waste on boats; no regulation fuel sales; informality of the users.

Tertiary Indirect Causes (Institutional Causes)

Informality in cargo and passenger transport; regulations on oil transport are not obeyed; little implementation of environmental education plans; port authorities fail to control transport adequately; absence of local river planning; lack of policies to promote and invest in river ports; boat-owners have little training; poor coordination among the state's institutions in this field and regional oversight and regulatory agencies.

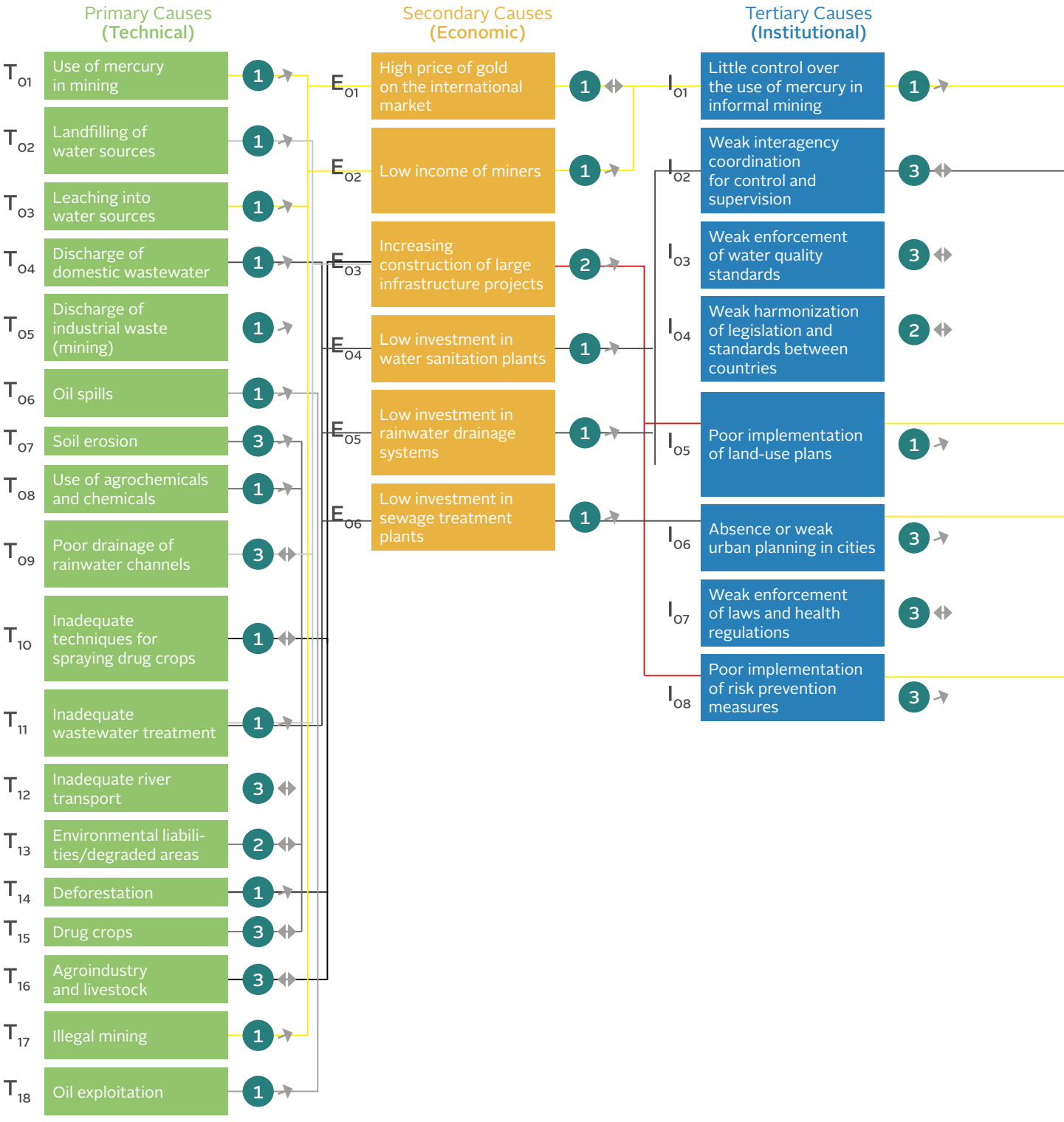
Root Causes (Socio-political Causes)

Inadequate environmental education; lack of civic education and people's inappropriate treatment of public spaces.

FIGURE 1. CAUSAL CHAIN WATER POLLUTION

Problem 1. Water pollution

Causal Chain Analysis



Priority	Tendency
1 High	Growing
2 Medium	Stable
3 Low	Decreasing

Problem Nº 2

DEFORESTATION

Agro-industrial production of grains (soy, rice, sunflower, sorghum and maize) and livestock are rapidly expanding in the Amazon and are the most important cause of rising deforestation rates, together with activities such as small scale mining, logging and infrastructure. For example, in Brazil livestock production grew from 26 million head of cattle in 1990 to 74 million in 2006 (UNEP, 2009).

Monoculture, such as soybeans in Brazil, rice and sugarcane in the Beni region and Santa Cruz in Bolivia, have been an important factor in forest loss.

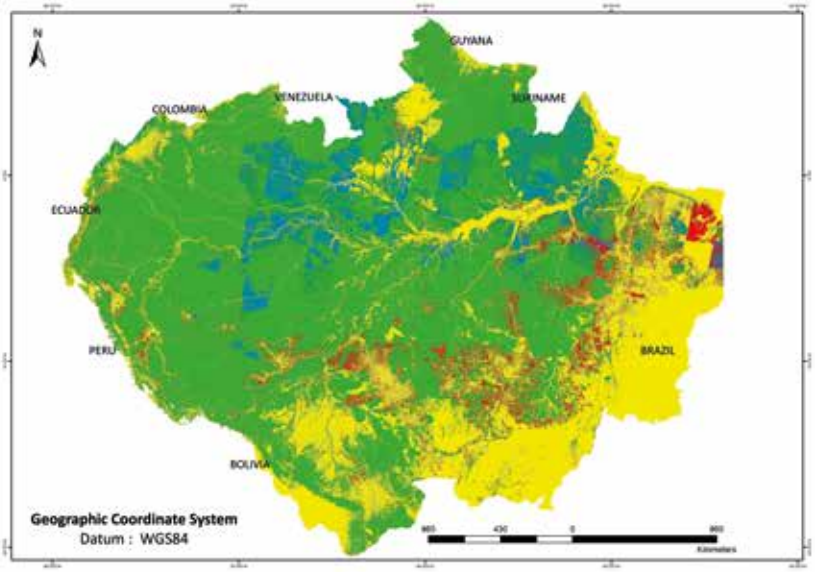
In 2004, Brazil experienced the second highest deforestation rate, 27,772 km/year, ever recorded by the INPE (2016).

The adoption of the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAM), which includes the creation and monitoring of protected areas and federal intervention against organized crime, brought the deforestation rate in Brazil down to 4,571 km2/year in 2012.

The following maps show how deforestation spread in the Amazon Basin between 2010 and 2013 (OTCA, 2015).

Pedarilhos/Shutterstock

Amazon Region Deforestation Map 2013



Legend

Forest: high density forest area and continuous crown cover, forming canopy, native and little change.

No Forest: areas with different features from the forests physiognomy, including hydrography and human activity.

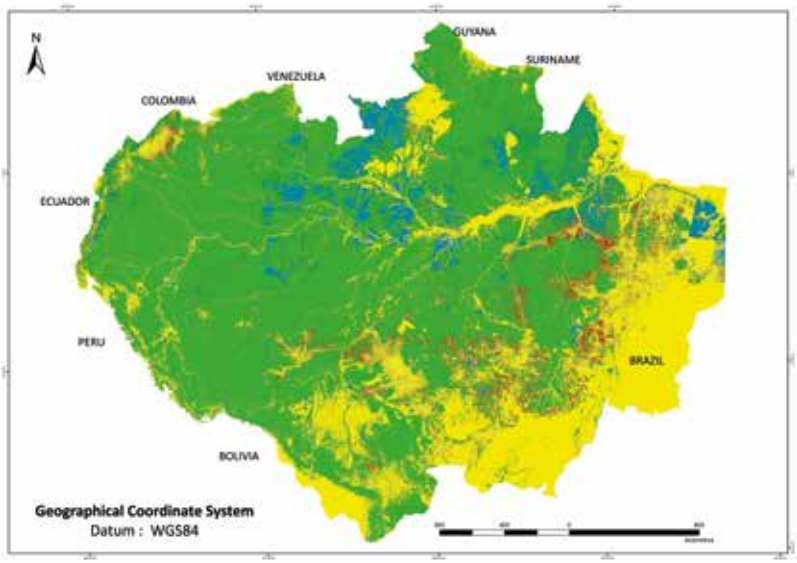
Clouds: areas without information or unobserved due to the presence of cloud cover.

Deforestation 2000-2013: Deforested area within the period of 2000 - 2013.

Localization Map
South America

Data Venezuela 2010
Bolivia historical accumulated deforestation until 2013

Regional Map - Amazon Forest 2010



Legend

Forest: high density forest area and continuous crown cover, forming canopy, native and little change.

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Clouds: areas without information or unobserved due to the presence of cloud cover.

Deforestation 2000-2010: Deforested area within the period of 2000 - 2010.

Localization Map
South America

TABLE 3. DEFORESTATION

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Alteration of the water cycle ▪ Soil erosion and sedimentation of rivers and streams ▪ Alteration of riverbeds and streams ▪ Decreased flow ▪ Loss of groundwater ▪ Reduction of primary forest ▪ Loss of native forest species ▪ Low soil fertility ▪ Desertification and drought ▪ Increase of solid waste ▪ Increased greenhouse gas emissions ▪ Climate change, floods and droughts	▪ Decreased quality of life ▪ Reduction of alternative use of biodiversity ▪ Food security risks ▪ Low-income population ▪ Increased agricultural frontier ▪ Fewer sources of employment. ▪ Population displacement ▪ Socio-environmental conflicts

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CAUSAL CHAIN ANALYSIS - DEFORESTATION

Direct Causes (Technical Causes)

Occupation of areas for infrastructure; expansion of the agricultural frontier; forestry (lumber and plywood); livestock farms; use of firewood and charcoal; mining (legal and illegal); spread of drug crops; road construction; selective extraction of non-timber species.

Secondary Indirect Causes (Economic Causes)

Urban development needs; nutritional needs; agribusiness development; need for goods; profitability of raw materials; energy needs; economic needs; market demand for minerals; access to new markets; high demand for natural products for cultural and/or traditional reasons.

Tertiary Indirect Causes (Institutional Causes)

Authorities' inability to implement land-use plans; little knowledge of sustainable production practices and/or techniques; limited budget when expanding agricultural; no land recovery; no regulations on agricultural loans; few alternative sources of employment; no incentive to preserve the forest; poor coordination and institutional weakness to monitor and control illegal activities; weak or non-existent cross-border laws.

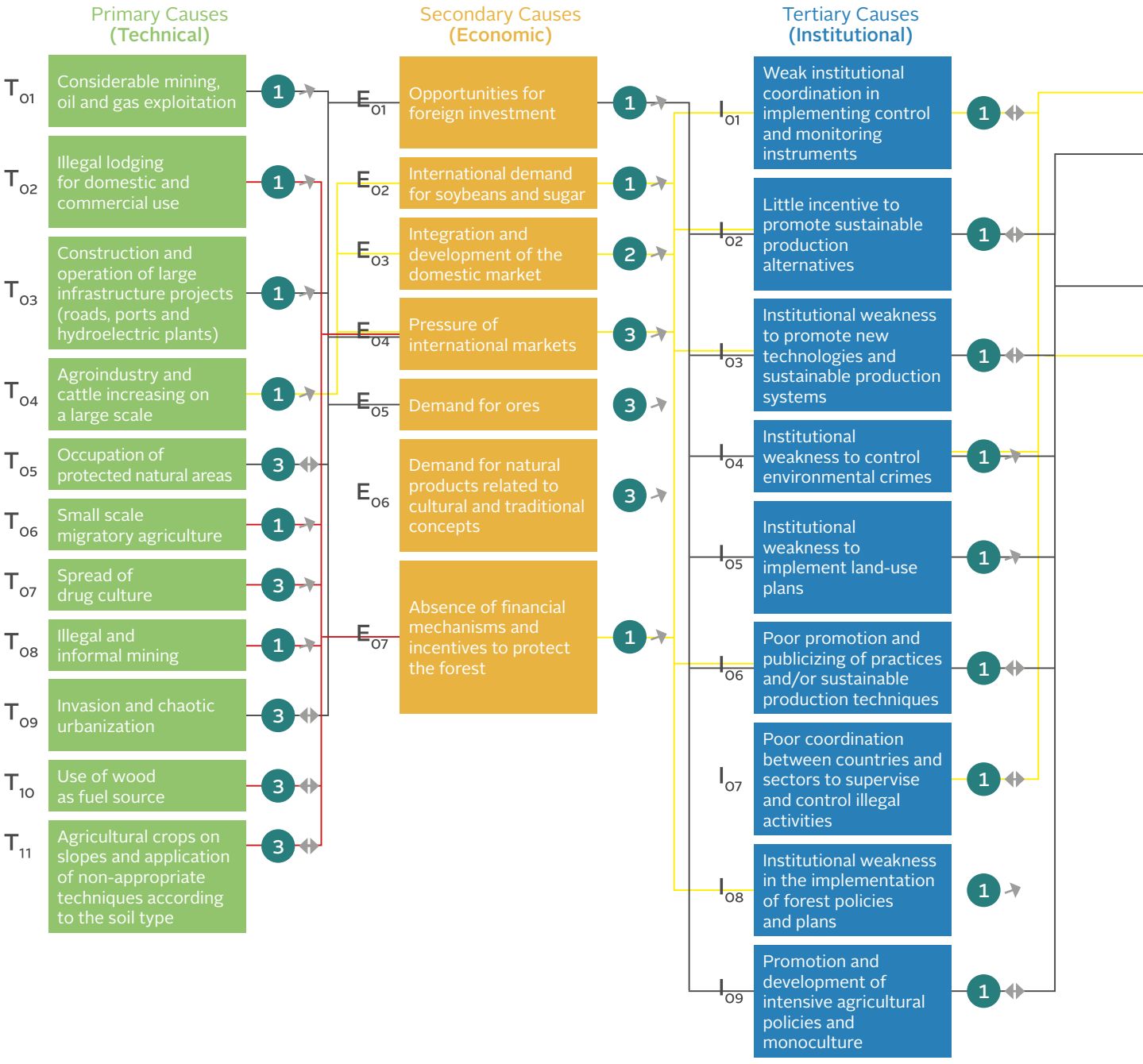
Root Causes (Socio-political Causes)

Poverty; population growth and migration; inadequate education policies; economic and social policies do not meet the expectations and needs of local populations of the Amazon; deficient or poor implementation of environmental policies; limited technical-scientific knowledge of the fragile Amazonian soils.

FIGURE 2. CAUSAL CHAIN DEFORESTATION

Problem 2. Deforestation

Causal Chain Analysis



Actions

Root Causes
(Socio-political)

P_{01}	Migration and demographic growth	1	Encourage the development and implementation of land-use plans
P_{02}	Poverty	1	Encourage multilateral agreements to harmonize environmental laws and regulations on natural resources
P_{03}	Deficient education policies	3	Encourage the development of guidelines for mitigation and/ or compensation of environmental impacts
			Promote improved forest monitoring and effective enforcement of legislation
P_{04}	Macroeconomic extractive models	1	Foster control instruments, monitoring and incentives in forest use
			Encourage environmental audits in forestry areas
P_{05}	Socio-environmental conflicts	1	Promote compensation mechanisms for ecosystem services/functions and forest conservation
			Encourage mechanisms, programs and incentives for conservation of native forests
			Promote a regional information system and monitoring of deforestation
			Strengthen capacity of local governments and communities in planning processes and land-use
			Promote studies for a biophysical diagnosis of the left bank of the Amazon River basin
			Promote education and water culture in local communities and populations
			Promote mechanisms for the participation of local communities and populations in territorial planning processes
			Promote feasibility studies on an adequate “agrosilvopastoril” system according to the type of soil affected by both deforestation and / or forest degradation

Priority	*Tendency*
1 High	Growing
2 Medium	Stable
3 Low	Decreasing

Problem Nº 3

LOSS OF BIODIVERSITY

The loss of biodiversity and ecosystems in the Amazon forest is caused by the destruction of the forest, the spread of the agricultural and livestock frontier, the use of fertilizers, insecticides, pesticides, legal and illegal mining, extraction and illicit trafficking of species, the introduction of exotic species, and other factors.

Illegal trade in timber species, non-timber, and wildlife has been on the rise, despite the efforts of the Convention on International Trade in Endangered Species (CITES).

According to figures from the Brazilian Ministry of Environment (MMA), in 2005 the Amazon region sustained 4,221 known species of animals, 2,500 species of trees and 30,000 species of plants.

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Janossy Gergely/Shutterstock

Jess Kraft/Shutterstock

Leonardo Mercon/Shutterstock

In general, the loss of Amazonian biodiversity is linked to the following activities:

- Extraction of timber, wood and fibers.
- Burning, which depletes the soil seed bank.
- Unsustainable hunting and use of biodiversity.

This process leads to the breakdown, degradation and fragmentation of the ecosystems and loss of the habitat of the original fauna and flora, to physical and biotic changes in the areas that remain and changes to seed banks.

Fotos593/Shutterstock

Tony Moran/Shutterstock

TABLE 4. LOSS OF BIODIVERSITY

IMPACTS / CONSEQUENCES	
Environmental	Socio-economic
▪ Loss of species of flora and fauna ▪ Extinction of species due to trade ▪ Deterioration of rivers and contaminated water ▪ Decreased water availability ▪ Increased risk of natural disasters ▪ Soil loss ▪ Losses because of mining and hunting ▪ Loss of genetic variability and ecosystems ▪ Loss of natural regulation of natural processes and dynamics ▪ Loss of ecosystem resilience	▪ Spread of diseases ▪ High risks for food security ▪ Increased costs of corrective measures and bioremediation ▪ Unemployment in the communities ▪ Reduction of ecotourism ▪ Creates conflicts between communities ▪ Loss of recreation areas ▪ Loss of fish and fishery resources

CAUSAL CHAIN ANALYSIS –LOSS OF BIODIVERSITY

Direct Causes (Technical Causes)

Deforestation, inappropriate farming and agricultural practices, dumping of solid and liquid waste, indiscriminate use of agrochemicals, destruction, degradation and fragmentation of ecosystems; introduction and invasion of exotic species; unsustainable use of biological diversity.

Secondary Indirect Causes (Economic Causes)

Poorly designed agricultural programs; low-tech farming; lack of jobs; social exclusion and inequality; lack of funding for environmental protection; little investment in information and training programs.

Tertiary Indirect Causes (Institutional Causes)

Poor interinstitutional coordination and management; limited pollution control; unusable Land Management Plans; little technical support; shortcomings in the legal system; lack of adequate oversight. Insufficient participation of communities in the execution of programs and projects; outdated environmental legal regulations; lack of resources in public institutions; promotion of introduction of invasive alien species.

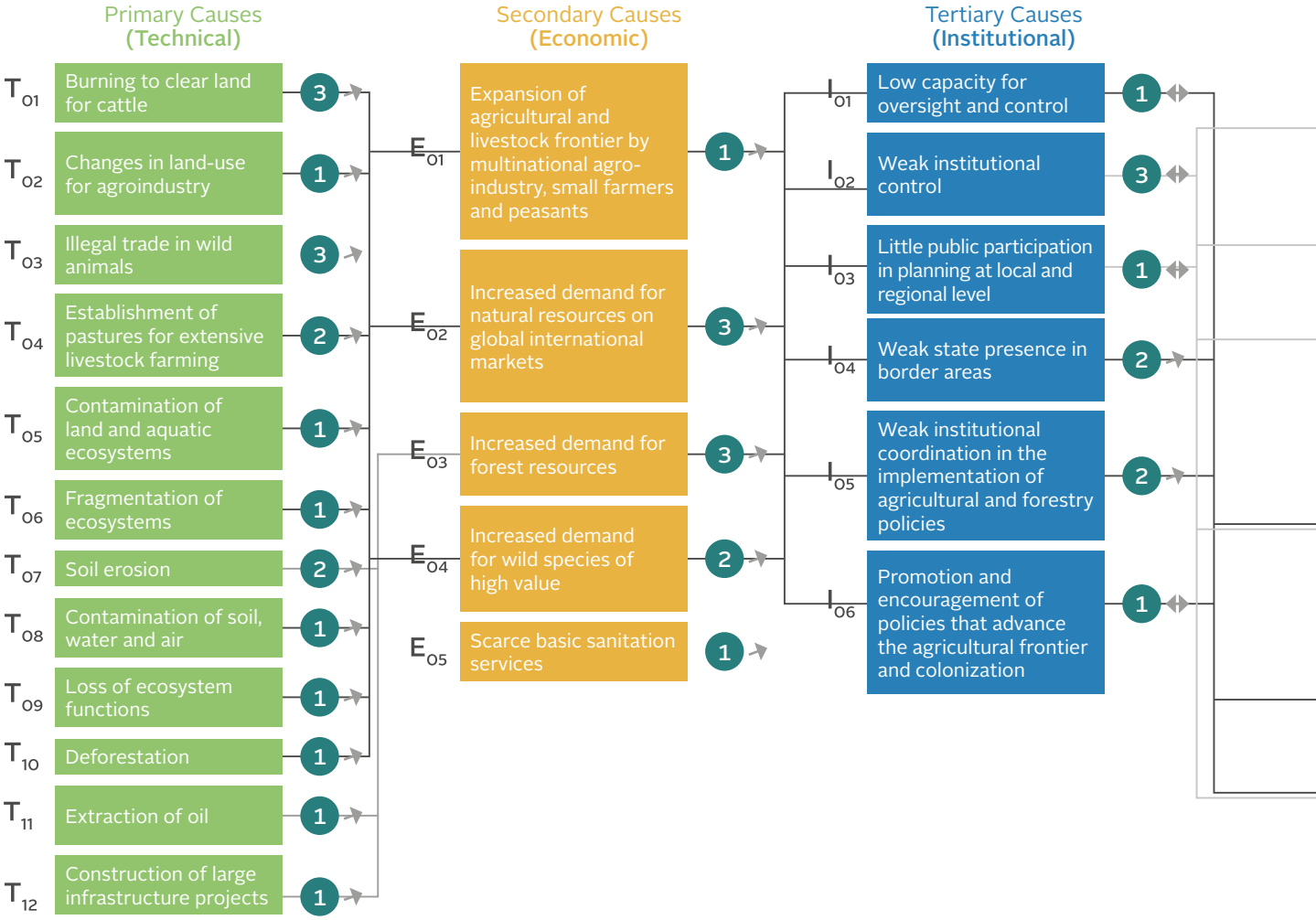
Root Causes (Socio-political Causes)

High population growth in the region and migration flows; inappropriate government policies; little environmental education and conscientiousness. Unsustainable production and consumption; corporate model of production, distribution, waste and food consumption; pattern of knowledge that separates the human being from nature.

FIGURE 3. CAUSAL CHAIN- LOSS OF BIODIVERSITY

Problem 3. Loss of biodiversity

Causal Chain Analysis



Actions

Root Causes (Socio-political)			Actions
P_{01}	Displacement and migration (forced or voluntary) of affected communities	1 ↗	Promote standard systems for monitoring and oversight of biodiversity
			Promote standard systems for monitoring and oversight of hot spots and forest fires
			Strengthen control and monitoring bodies
P_{02}	Demographic growth of urban centers	1 ↗	Promote plans and programs for land-use planning oriented to sustainabledevelopment.
P_{03}	Low demographic density in transboundary areas	1 ↔	Promote regional coordination mechanisms for the flow of information and data on biodiversity
			Promote mechanisms for participation by communities and local populations in programs and projects for the conservation of biodiversity
P_{04}	Poverty of local communities	1 ↗	Promote training programs and projects on biodiversity with local actors
P_{05}	Poor governance for biodiversity protection	1 ↔	Promote programs and training projects, and raise awareness of local communities and populations as well as stakeholders responsible for controlling activities afecting biological diversity.
P_{06}	Cultural practice of slash and burn	3 ↔	Promote agricultural development strategies for medium and small growers
P_{07}	Scarce information about the rights of local communities and populations	3 ↔	Promote creation of centers to breed threatened species
			Promote alternative practices and incentives to reduce the use of agrochemicals
P_{08}	Little technology	2 ↔	Promote solid waste management systems and wastewater treatment

Priority	*Tendency*
1 High	↗ Growing
2 Medium	↔ Stable
3 Low	↘ Decreasing

Problem Nº 4

EXTREME HYDROCLIMATIC EVENTS

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The Amazon Basin is linked to global weather through the water cycle and its carbon reserves which are released through deforestation, droughts and fire, which contributes to the accumulation of greenhouse gases in the atmosphere. In addition,, the Amazon Basin accounts for nearly 20% of the world's total freshwater discharge, affecting major Atlantic currents that are important regulators of world weather.

Floods in the Amazon Basin are common during the rainy season and occur mainly in the lowlands, but their intensity has increased in recent years due to the effects of erosion and climate change, which has had economic impacts in the region. For example, the area that makes up the MAP region (Madre de Dios, Acre and Pando), has recorded a significant increase in the frequency and intensity of floods and rainfall (Brown, 2007).

Droughts are also recurrent events in the Amazon Basin. The drought of 1925-1926, one of the most protracted in the past century, and the severe droughts of 2005 and 2010, have been associated with intense El Niño cycles, causing serious economic losses for more than 1 million people (UNEP, 2007).

Variations in rainfall and river discharge in the Amazon region are associated with fluctuations related to El Niño (ENSO), Pacific Decadal Oscillation (PDO), North Atlantic Oscillation (NAO) and variability in the Tropical South Atlantic. The effects of La Niña (dry periods) have been observed in the Brazilian north, northeast and south; the effects of El Niño, on the other hand, are excessive rain and flooding. With the increase in frequency or intensity of these two phenomena, Brazil will be subject to more droughts, floods and periods of warmer weather (Marengo & Nobre, 2001; NAE, 2005 a, b; Marengo & Silva Dias, 2004a).

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guentermanaus/Shutterstock

Ricardo Hossoe/Shutterstocl

TABLE 5. EXTREME HYDROCLIMATIC EVENTS.

IMPACTS / CONSEQUENCES	
Environmental	Socio-economic
▪ Disruptions in ecosystem food chains ▪ Limited navigation ▪ Water pollution ▪ Changes in the physicochemical characteristics of water because of increased whole solids in suspension ▪ Loss of biodiversity ▪ River fauna poisoned by mercury ▪ Loss of crop area ▪ Loss of landscape diversity	▪ Public health risks ▪ Rising food prices ▪ Economic losses due to transportation costs ▪ Impact on ecotourism ▪ Economic losses related to productive activity ▪ Loss of human life

CAUSAL CHAIN ANALYSIS – EXTREME HYDROCLIMATIC EVENTS

Direct Causes (Technical Causes)

Increase in illegal logging, deforestation of headwaters; IIRSA projects and other megaprojects; loss of glaciers; forest fires; expansion of agriculture; overexploitation of natural resources; infrastructure for moving water (interbasin transfer); inappropriate farming techniques; soil erosion.

Secondary Indirect Causes (Economic Causes)

Increased crop areas; more informal logging companies; increased surface mining.

Tertiary Indirect Causes (Institutional Causes)

Absence of preventive measures to counter impacts of extreme events; poor implementation of plans and programs for adaptation to climate change; absence of land-use plans; little budget to implement the regulations concerning impacts of extreme events.

Root Causes (Socio-political Causes)

Population growth; migration; poverty; urban sprawl on flood plains; increase in greenhouse gases; El Niño.

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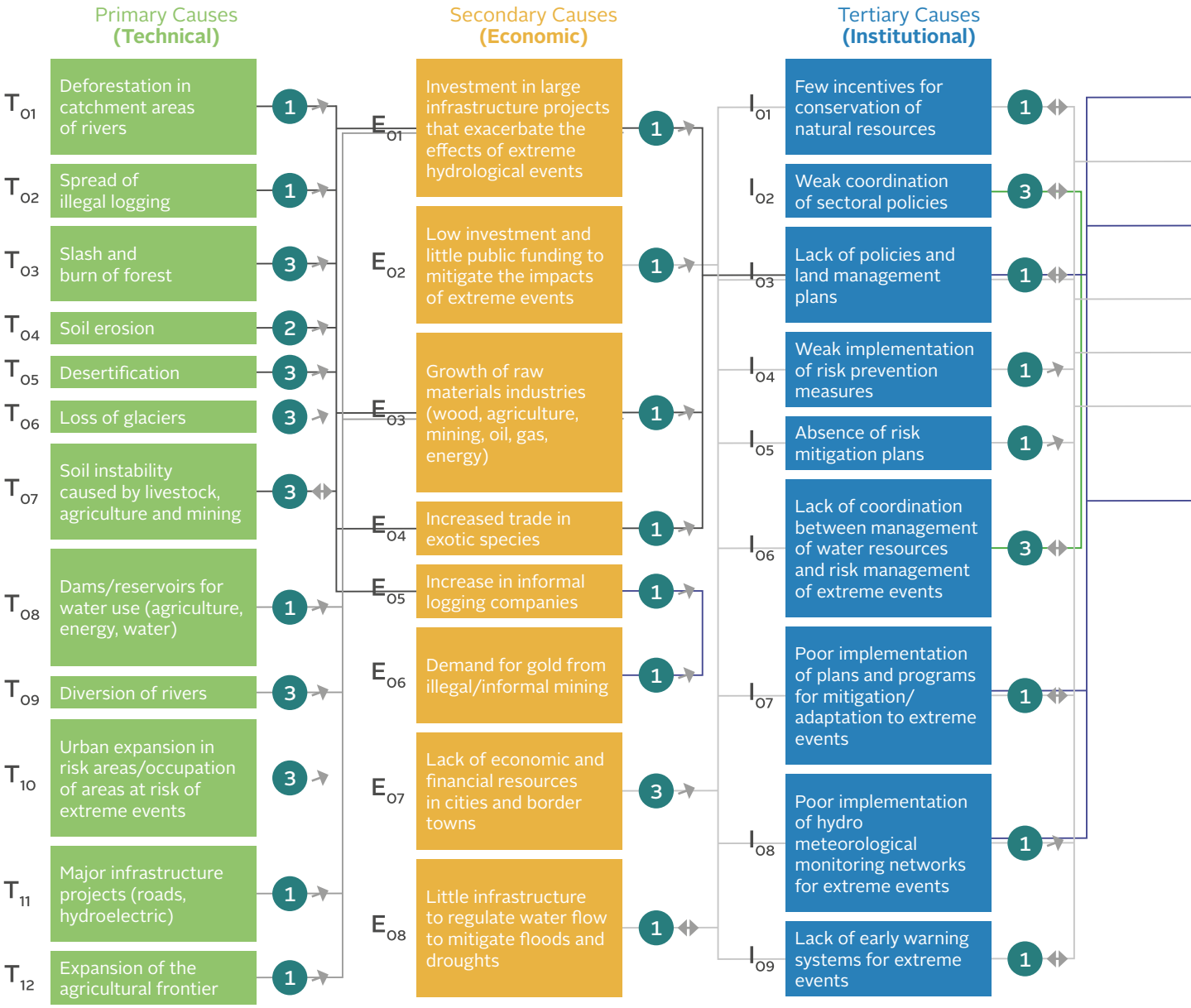
FIGURE 4. CAUSAL CHAIN OF EXTREME HYDROCLIMATIC EVENTS

Problem 4. Extreme hydroclimatic events

Causal Chain Analysis



Actions

Root Causes
(Socio-political)

P_{01}	Migration and demographic growth	1	Promote regional cooperation to mitigate impacts of major infrastructure
P_{02}	Poverty	1	Promote regional cooperation to mitigate impacts of climate variability and climate change
P_{03}	Absence of planning for development	3	Promote programs and projects to monitor hydrological extremes
P_{04}	Little environmental education	3	Promote the improvement and expansion of hydro meteorological network systems
P_{05}	El Niño	3	Encourage the implementation of integrated systems for early warning of extreme hydrological events
P_{06}	Climate variability and change	1	Promote plans and programs for disaster risk management
P_{07}	Little government presence in border communities	3	Promote land-use plans
			Promote training programs for vulnerable populations settled in risk areas.
			Promote programs and training projects, and raise awareness of disaster risk
			Promote incentives for the protection and conservation of water sources in headwaters
			Promote economic incentives for forest conservation
			Promote programs and projects that provide compensation for ecosystem services/functions

Priority	*Tendency*
1 High	Growing
2 Medium	Stable
3 Low	Decreasing

Problem Nº 5

EROSION, SEDIMENT TRANSPORT AND SEDIMENTATION

The Andes are experiencing severe erosion, with large quantities of sediment flowing into the Atlantic Ocean. Measurements done on the upper part of the Madeira River basin reveal that of the 3,200 tons/km2/year of sediment in this river, more than 60% is left in the Andean foothills and the rest goes downstream. The total amount of sediment carried by the Amazon River to the Atlantic Ocean usually varies between 600 and 800 million tons per year (Filizola, 2003).

Under the influence of the Guyana Current, huge amounts of sediment are transported from the Amazon Basin and deposited along the coast of Suriname and Guyana, causing major impacts on coastal ecosystems.

Dr Morley Read/Shutterstock

TABLE 6. EROSION, SEDIMENT TRANSPORT AND SEDIMENTATION

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Loss of arable land ▪ Impact on ecosystems ▪ Silting of riverbeds ▪ Reduction of aquatic resources ▪ Changes in costal marine ecosystems ▪ Increased sedimentation in sea lanes ▪ Decreased water quality in estuaries at the base level of rivers	▪ Increased health risks from deterioration of water quality in rivers and canals. ▪ Effect on food security because of declining aquatic resources. ▪ Increase in price of aquatic resources ▪ Decreased small-scale fishing ▪ Less income for communities dependent on tourism ▪ Navigation risks due to sedimentation of watercourses ▪ Migration

CAUSAL CHAIN ANALYSIS: EROSION, SEDIMENT TRANSPORT AND SEDIMENTATION

Direct Causes (Technical Causes)

Indiscriminate cutting of trees; urban settlements on riverbanks; inappropriate use of land; dumping of solid waste into natural waterways; lack of soil conservation practices; dumping of domestic wastewater; lack of construction of protective structures (control of gullies and river defenses); overgrazing upstream; excessive rainfall in non-seasonal periods; loss of vegetation cover at the riverhead; removal of soil by mining.

Secondary Indirect Causes (Economic Causes)

Increased mining; growth of small-scale informal/illegal mining; sale of quarried materials (sand, gravel, stones) from the rivers; extensive livestock ranching in the central Andes.

Tertiary Indirect Causes (Institutional Causes)

Little enforcement of laws concerning rivers and riverbanks; absence of land-use plans; the absence of grassland and forest conservation policies.

Root Causes (Socio-political Causes)

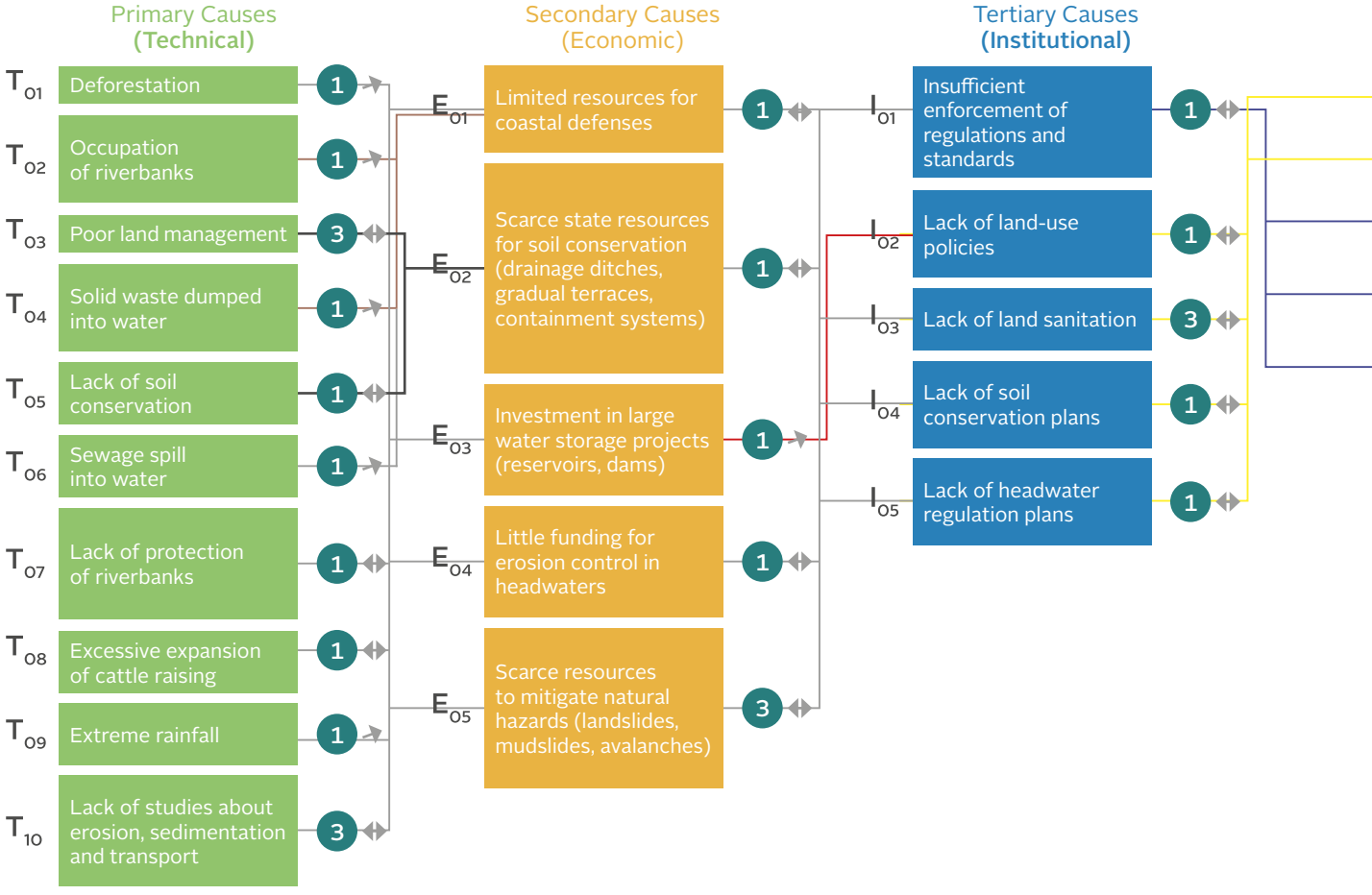
Population growth; land-use tendencies; desertification; climate variability and climate change.

Dr Morley Read/Shutterstock

FIGURE 5. CAUSAL CHAIN OF EROSION, SEDIMENT TRANSPORT AND SEDIMENTATION

Problem 5. Erosion, sediment transport and sedimentation

Causal Chain Analysis



Actions

Root Causes (Socio-political)		Actions
P_{01}	Demographic growth (1, ↗)	Promote plans and programs for land-use planning
P_{02}	Poverty (1, ↗)	Promote programs, projects and research to determine sediment transport and deposition processes and sedimentation in rivers and lakes
P_{03}	Geodynamics and climate change (3, ↔)	Promote studies and research on river dynamics
P_{04}	Lack of knowledge (1, ↔)	Programs and projects to promote soil conservation, river bank protection structures and gully control
		Promote programs and projects for reforestation and forest management
P_{05}	Lack of technology (1, ↔)	Promote health programs and projects related to deforestation and siltation of rivers
		Encourage the construction of plants to treat domestic and industrial wastewater
		Promote capacity-building programs for local governments, local communities and populations
		Promote training, awareness with local communities and populations
		Promote environmental education programs for local communities and populations
		Promote programs and projects related to sediment transport from the Amazon Basin to the coastline of Suriname

Priority	*Tendency*
1 High	↗ Growing
2 Medium	↔ Stable
3 Low	↘ Decreasing

Problem Nº 6

CHANGES IN SOIL USE

In most Amazon countries, land is used mainly for large infrastructure development, agro-industry and cattle ranching, without taking into account the environmental and socio-economic impacts for local populations, especially those with low-income. In many regions of the Amazon Basin, economic policies respond primarily to the demands of national and international markets, to the detriment of the needs of local communities, causing serious social conflicts and the migration of local population to the large urban centers.

Frontpage/Shutterstock

TABLE 7. CHANGES IN SOIL USE.

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Water pollution	▪ Impact on public health
▪ Soil contamination	▪ Less income for families
▪ Soil erosion	▪ Higher value of cleared land compared to native forest
▪ Increased sedimentation	▪ Weak regulation and control
▪ Loss of arable land	▪ Increased demand for timber
▪ Increase in alluvium, avalanches, floods	▪ Increased cost of access to water
▪ Desertification	▪ Loss of arable land
▪ Degradation of ecosystems	▪ Low soil productivity
▪ Loss of biodiversity	▪ Migration
	▪ Poverty

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CAUSAL CHAIN ANALYSIS –CHANGES IN SOIL USE

Direct Causes (Technical Causes)

Expansion of the agricultural frontier, soil impoverishment; monoculture; introduction of exotic species; little technology use.

Secondary Indirect Causes (Economic Causes)

Few alternative sources of employment; low productivity; few incentives and little investment.

Tertiary Indirect Causes (Institutional Causes)

Weak institutional coordination; poor technology transfer and technical assistance; failure to enforce the laws on soil use; lack of land-use plans.

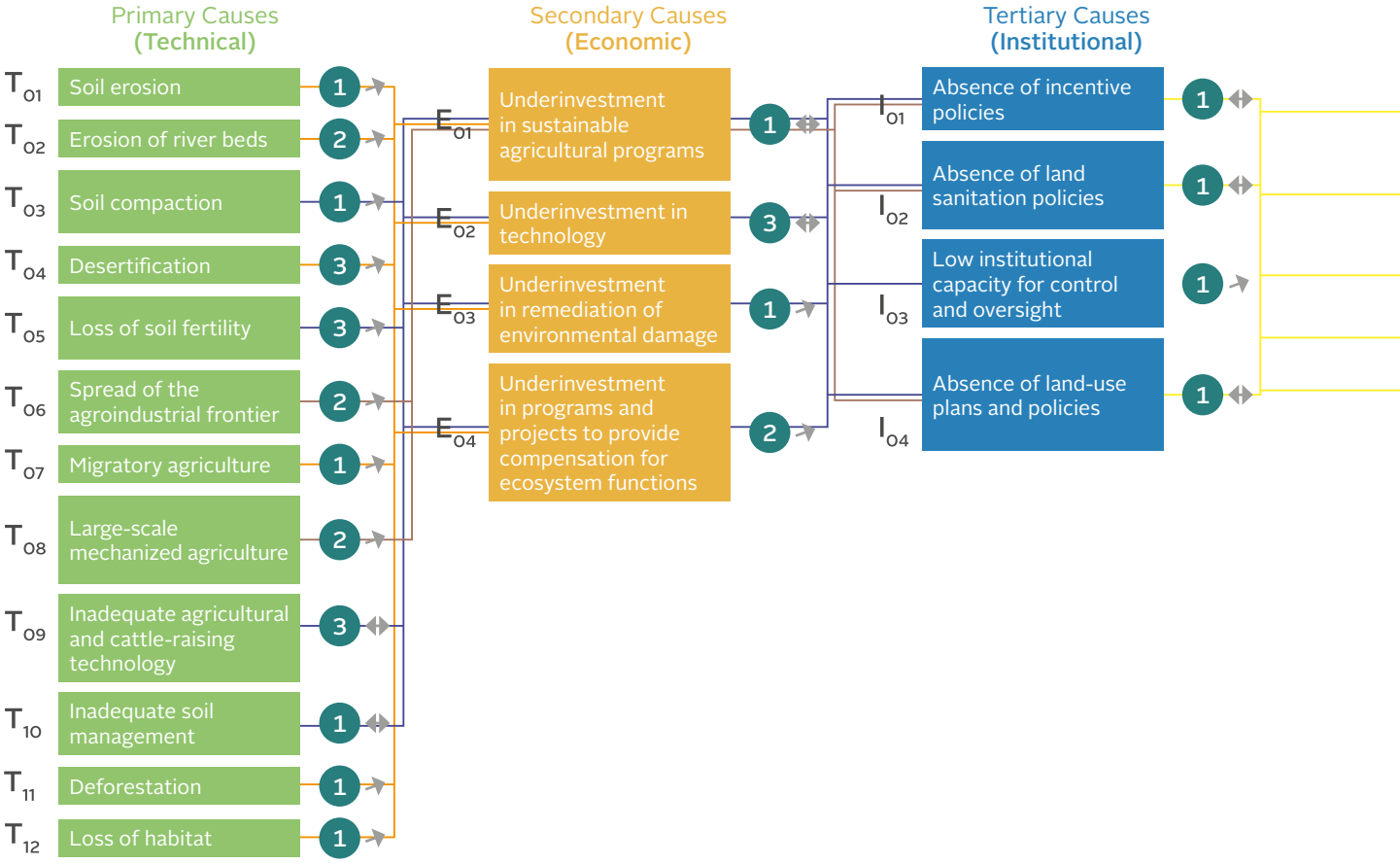
Root Causes (Socio-political Causes)

Population growth; poverty; inadequate land ownership policies; lack of policies for land recovery.

FIGURE 6. CAUSAL CHAIN OF CHANGES IN SOIL USE

Problem 6. Changes in soil use

Causal Chain Analysis



Actions

Root Causes
(Socio-political)

P_{01}	Migration and demographic growth	1	Promote programs and restoration projects for degraded soils and ecosystems
P_{02}	Poverty and unemployment	1	Promote agroforestry on suitable land and recover degraded forests
P_{03}	Little training	2	Promote agricultural programs and projects in floodplains
			Promote programs and projects for agriculture on alluvial soils
P_{04}	Little education	1	Develop programs and projects to combat soil erosion from deforestation on slopes and poor soil management
P_{05}	Little technology	1	Develop programs and conservation projects for the most fertile floodplain soils
			Promote the implementation of a system of classification by soil use capacity
			Promote studies and research on soil water
			Promote studies and research on the characteristics and potential use of non-alluvial soils in restingas, high terraces, hills and mountains
			Promote environmental investments and businesses through the strengthening of local communities and organizations for the appropriation and application of sustainable environmental practices.

Priority	*Tendency*
1 High	Growing
2 Medium	Stable
3 Low	Decreasing

Problem Nº 7

LOSS OF GLACIERS

The increased retreat of the tropical glaciers during the last 50 years is part of a historical process that dates back only two centuries. The current process of retreat began between 1730 and 1750, long before human activities could have had significant impact on climate and global warming (CAN - PRAA - IRD, 2013). The following table shows the changes over time in the extension of tropical glaciers by country.

During the last 40 years, deglaciation has taken place at an accelerated pace, unprecedented in the last three centuries, with the glaciers losing between 30% and 50% of their surface. The most vulnerable glaciers are now practically gone. In early 2000, tropical glaciers covered an area of approximately 1,920 km2, and had a volume of 100 km3.[2] Tropical glaciers are located in the central Andes, mainly in Peru (70%) and Bolivia (20%).

The main impacts of glacier retreat are declining water resources, the formation of new lakes, risk of landslides and mudslides, which could result in prolonged drought and desertification, as well as social conflicts.

TABLE 8. AREA OF TROPICAL GLACIERS

Country	GLACIER COVER (AREA) IN KM2 - YEAR			%	Lost		
BOLIVIA	562.00	393.00		20.47	1975	2006[a]	
COLOMBIA	108.50	76.00		3.96	1950	2006[b]	
ECUADOR	112.80	79.00		4.12	1976	2006[c]	
PERU	2,004.11	1,370.00	1,170.00	71.36	1970	2006[d]	2014[f]
VENEZUELA	2.70	1.80		0.09	1950	2006[e]	
TOTAL ANDES[z]	2,790.11	1,919.80		100.00		2006	

Source: CAN –PRAA –IRD, 2013. Data collected by Kaser (1999), Francou and Vincent (2007),

[z] estimated surface area for 1950-1976 and 2006;

[a] Jordan (1991, data from 1975), estimated loss 30%;

[b] Kaser (1999), estimated loss 30%;c Hastenrath (1981, data from 1975), estimated loss 30%;

[d] Kaser (1999), estimated loss 30%;

[e] Kaser (1999), estimated loss 67% (Kaser, 2006);

[f] ANA (2013).

Jay Boucher/Shutterstock

[2]CAN-PRAA-IRD. Glaciers of the Tropical Andes victims of Climate Change. Project: Adaptation to the impact of the accelerated Glaciers in the tropical Andes. Andean Community of Nations, General Secretariat. Lima, 2013.

worldroadtrip/Shutterstock

TABLE 9. LOSS OF GLACIERS

IMPACTS / CONSEQUENCES	
Environment	**Socio-economic**
▪ Increase in alluvium, avalanches, floods ▪ In the long term, reduced water resources ▪ Risk of landslides ▪ Alteration of hydrological systems ▪ More lakes and ponds	▪ Deterioration of mountain ecosystems ▪ Drought and desertification ▪ Conflicts over water use ▪ Risks for the survival of Andean communities ▪ Increased risk of avalanche ▪ Less water for human consumption ▪ Higher temperatures because of human action

CAUSAL CHAIN ANALYSIS – LOSS OF GLACIERS

Direct Causes (Technical Causes)

Increase in global temperatures; open-pit mining; burning of fields and forest; overexploitation of forest resources; intensification of agriculture; deforestation; expansion of agriculture and ranching near glaciers; land-use change.

Secondary Indirect Causes (Economic Causes)

Little investment in data collection, capacity-building and use of new technologies; insufficient investment in measures to adapt to climate change; lack of economic and financial resources to mitigate physical risks related to the loss of glaciers.

Tertiary Indirect Causes (Institutional Causes)

Limited information, lack of public concern about the issue; poor institutional coordination; inefficient use of resources; few opportunities for dialogue between decision-makers and vulnerable populations.

Root Causes (Socio-political Causes)

Absence of public policies to address the impacts, risks and vulnerabilities related to the loss of glaciers; little environmental education and local population's lack of awareness about the dangers and challenges of loss of glaciers; public has limited access to technical-scientific information about climate variability and climate change.

ACTO

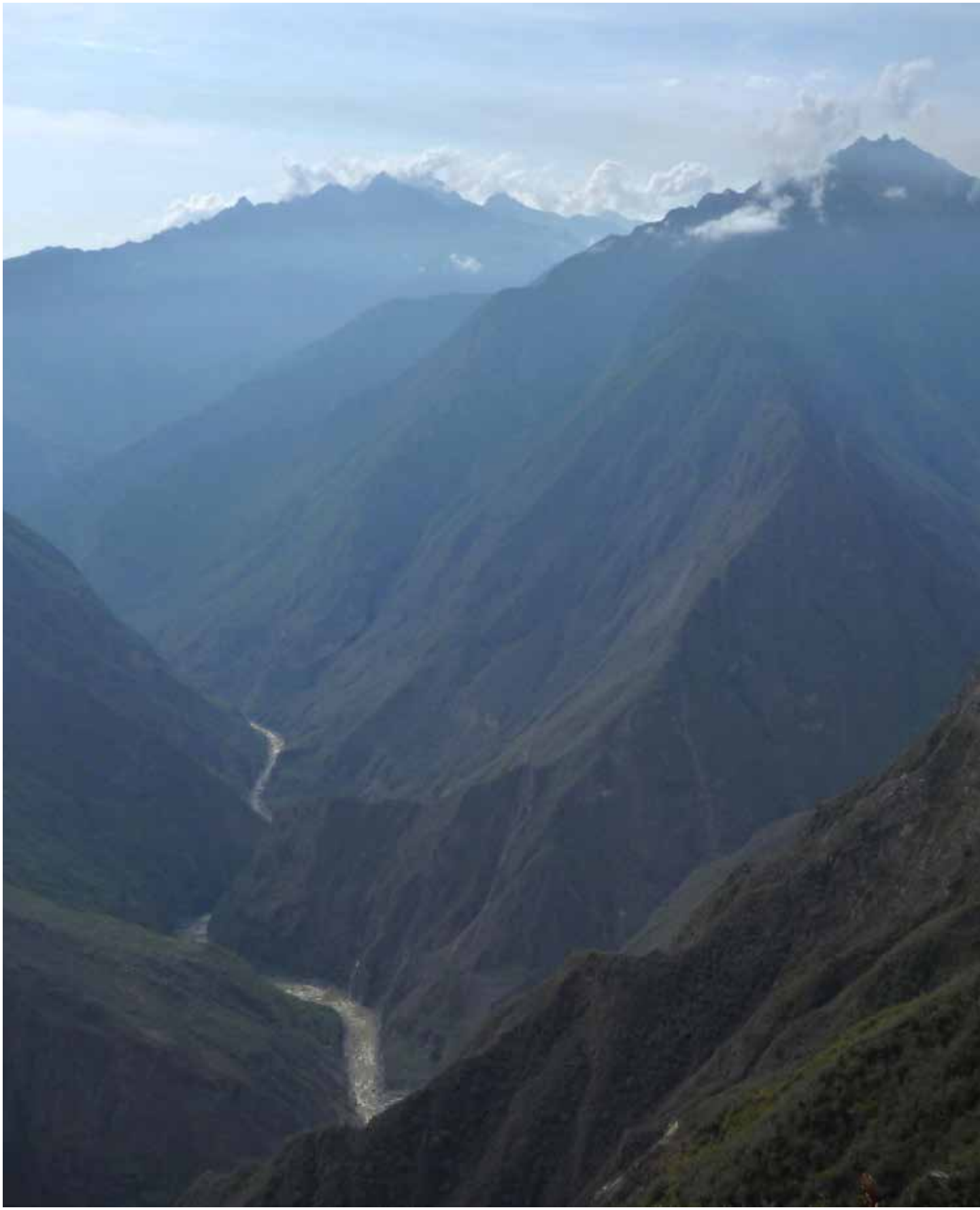


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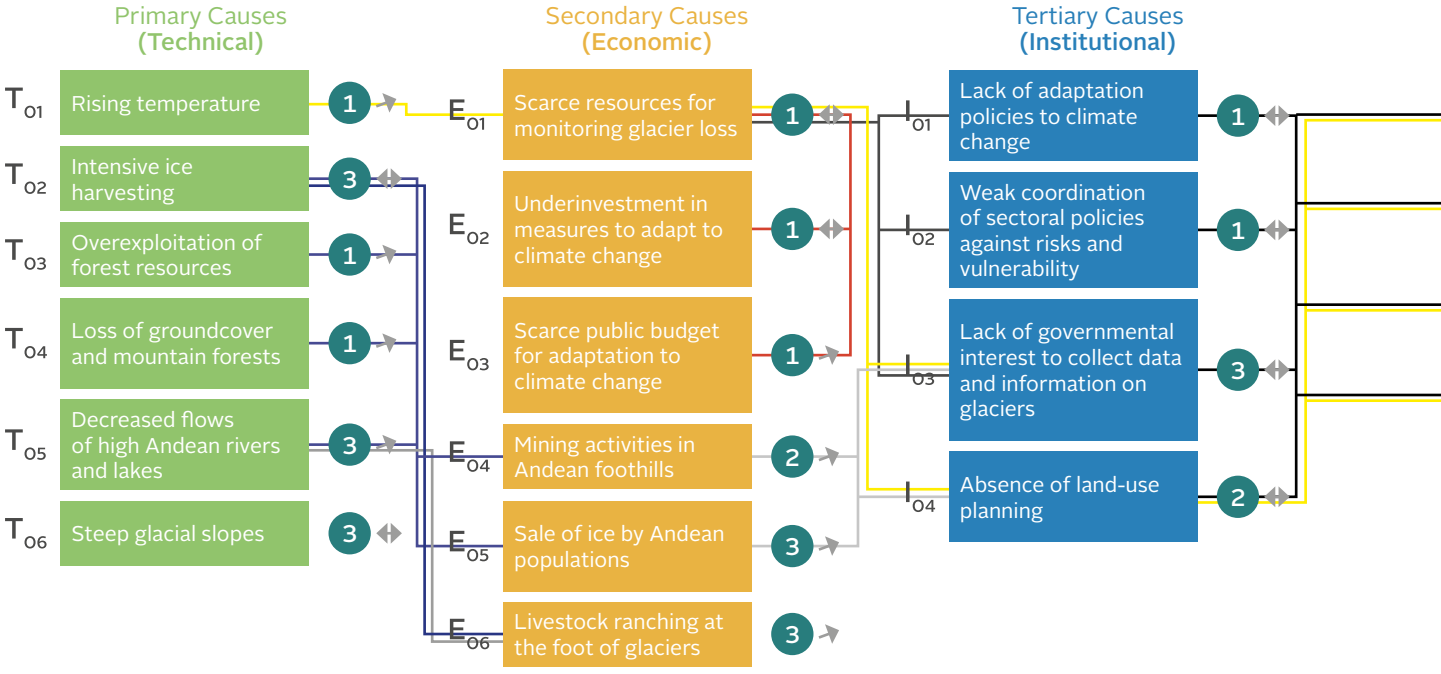
FIGURE 7. CAUSAL CHAIN OF LOSS OF GLACIERS

Problem 7. Loss of glaciers

Causal Chain Analysis



Actions

Root Causes
(Socio-political)

P 01	Risks and vulnerability due to climate change	1	Promote programs and projects in the Amazon Basin for adaptation measures related to the loss of glaciers in the Central Andes of the Amazon Basin
			Promote programs and projects on vulnerability to climate change and glacier dynamics
P 02	Geodynamics and geophysical weaknesses	3	Encourage the creation of the International Center for Glaciers and Lakes in the Central Andes (CIGLAC)
P 03	Greenhouse gases from industrial activity	3	Promote the implementation of financial mechanisms and incentives for conservation and maintenance of ecosystems to mitigate impacts of loss of glaciers
			Encourage the creation of a fund, under the aegis of the United Nations Framework Convention on Climate Change, to ensure the sustainability of adaptation measures to loss of glaciers
P 04	Desertification	3	Encourage the creation of a regional information system on the glaciers and lakes of the tropical Andes
			Promote the dissemination of information to local communities and populations on adaption measures related to the loss of glaciers
			Encourage national and local planning to address the impacts of loss of glaciers
			Encourage glacier monitoring in the tropical Andes
			Promote programs and training projects, and raise awareness of local communities and populations on the impacts of loss of glaciers
			Promote the effective participation of local communities and populations in programs and projects for monitoring and research on glaciers
			Promote the strengthening of the resilience of communities and local populations to impacts of glacier retreat

Priority	*Tendency*
1 High	Growing
2 Medium	Stable
3 Low	Decreasing

Problem Nº 8

LARGE INFRASTRUCTURE PROJECTS

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The implementation of large infrastructure projects in the Amazon Basin has had great social, economic and environmental consequences. The direct impacts include human displacement, economic and social changes, flooding of fertile land, deforestation, death of wildlife, alteration of hydro-biological systems and their adjacent terrestrial ecosystems, plus special problems such as methane contamination, etc.

In terms of the future of the Amazon Basin, the most important major infrastructure program is probably the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA), which aims to develop regional infrastructure to bring about the physical integration of South American countries.

The IIRSA framework proposes 507 infrastructure projects in transport, energy and communications, representing an estimated US$69 billion investment. The Integration Priority Project Agenda (API) includes 31 structured projects and 103 individual projects worth an estimated investment of more than US$21 billion (www.iirsa.org).

IIRSA is organized around 10 Integration and Development Hubs (IDH), of which the Guianese Shield Hub (Venezuela, Brazil, Suriname and Guiana), Amazon Hub (Peru, Ecuador, Brazil, and Colombia), and the Peru-Brazil-Bolivia Hub are significant for the future of the Amazon Basin.

TABLE 10. LARGE INFRASTRUCTURE PROJECTS

IMPACTS / CONSEQUENCES	
Environment	**Socio-economic**
▪ Loss of biodiversity ▪ Fragmentation of ecosystems ▪ Acceleration of deforestation ▪ Impact on Protected Natural Areas ▪ Reduction of wildlife and flora ▪ Increase in solid and liquid waste ▪ Soil erosion ▪ Increased risk of alluvium, avalanches, landslides, and floods ▪ Soil contamination ▪ Water pollution	▪ Spread of diseases ▪ Risks to the survival of indigenous communities ▪ Loss of food security ▪ Loss of arable land ▪ Increased risk of floods ▪ Competition for resources between projects and the population ▪ Increased cost of living ▪ Increased poverty and marginalization ▪ Weak regulation and control by the state ▪ Migration

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CAUSAL CHAIN ANALYSIS – LARGE INFRASTRUCTURE PROJECTS

Direct Causes (Technical Causes)

Little linkage of land-use studies; lack of participation by local people in the development of major projects; interconnectedness of surface and underground water systems not taken into account; hydro-electric projects; use of natural resources; poor knowledge of Amazonian ecosystems; little information available to local population.

Secondary Indirect Causes (Economic Causes)

Extraction of forest resources; change of land-use for infrastructure construction; loss of eco-system operation; little distribution of economic benefits to the population; underdeveloped local river transport; lack of public services; intensification of urban sprawl; degradation of forests because of illegal logging; deforestation for farming; transport of freight from seaports to the interior of the Amazon Basin; export of raw materials (minerals, oil, gas) and manufactured goods from the Amazon Basin to seaports.

Tertiary Indirect Causes (Institutional Causes)

Lack of institutional coordination; weak or no administrative autonomy by sub-national institutions in relation to the centers of power; little implementation of land-use plans; lack of consultation with public at the local/regional level; Initiative for the Integration of the Regional Infrastructure of South American (IIRSA); weak decision-making capacity of public institutions at the sub-national level.

Root Causes (Socio-political Causes)

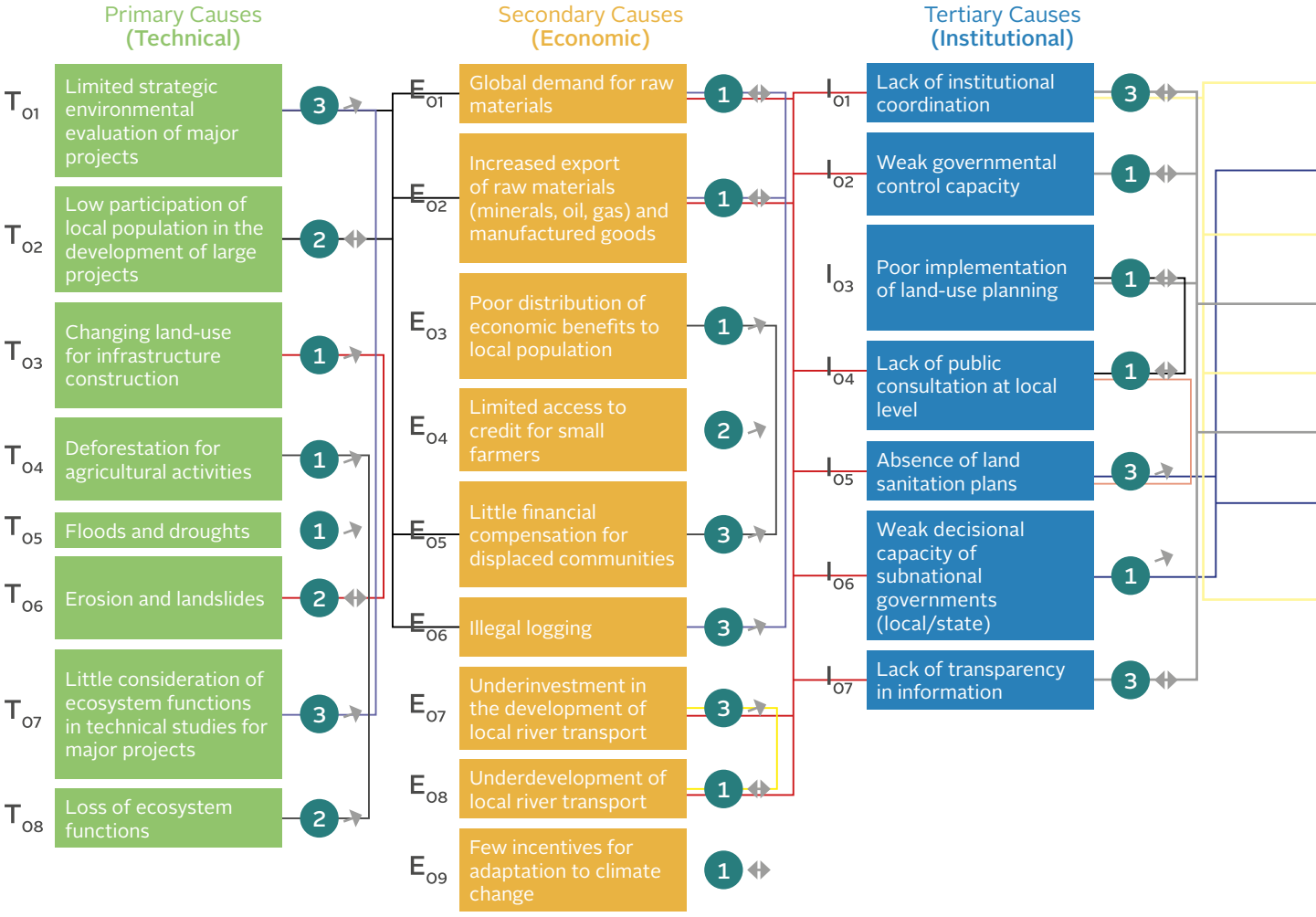
Population growth; migration; forced displacement of communities; poor planning; extractive economic models; development policies to export raw materials; little research for development; geo-political reasons.

Rich Carey/Shutterstock

FIGURE 8. CAUSAL CHAIN OF LARGE INFRASTRUCTURE PROJECTS

Problem 8. Large infrastructure projects

Causal Chain Analysis



Actions

Root Causes (Socio-political)		Actions
P_{01} Poor planning	1 ↗	Establish programs to promote regional planning
P_{02} Migration and demographic growth	3 ↗	Promote programs and projects to control mining, oil and gas environmental damage in the Amazon Basin
		Promote mechanisms for strengthening national agencies and institutions for environmental control, oversight and monitoring
P_{03} Informal urban expansion	3 ↔	Promote national planning of large projects, including reviews and approvals at each stage of the process
P_{04} Extraction-based economic model	3 ↗	Promote mechanisms for coordination and harmonization in regional and national planning instruments
P_{05} Impact on food security	1 ↔	Promote transparency and information sharing about individual megaprojects during their maturation and planning process
P_{06} Poverty	3 ↔	Promote programs and projects for systems to monitor the impact of large infrastructure projects
P_{07} Little education, training and capacity-building	3 ↔	Promote programs and projects to strengthen and increase the number of protected areas in the Amazon Basin
P_{08} Social and environmental conflicts	2 ↔	Encourage financial compensation mechanisms for communities and local populations affected by the impact of large infrastructure projects
		Promote studies and research on the impact of large infrastructure projects

Priority	*Tendency*
1 High	↗ Growing
2 Medium	↔ Stable
3 Low	↘ Decreasing

Problem Nº 9

LIMITED INTEGRATED WATER RESOURCES MANAGEMENT

The issue of IWRM was addressed at the different TDA National Workshops, with emphasis on aspects such as: poor coordination by water resource management institutions; lack of coordination between the different actors; weak governance of water; poor interinstitutional coordination; weak institutions and lack of planning, among others. Water resources management is considered to be an issue that crosscuts other priority regional transboundary problems because it accelerates, triggers or exacerbates them directly. The issue of water resources management at the institutional level was analyzed in the context of the GEF Amazon Project (Montero, 2013).

Rui Faquini/Banco de imagens, ANA, Brasil

TABLE 11. LIMITED WATER RESOURCES MANAGEMENT

IMPACTS / CONSEQUENCES	
Environmental	**Socio-economic**
▪ Water, soil and air pollution. ▪ Unsustainable use of natural resources ▪ Changes in the water cycle ▪ Deforestation ▪ Changes in land-use ▪ Loss of biodiversity ▪ Erosion and sediment transport	▪ Impact on public health ▪ Impact on food security ▪ Loss of cultural values ▪ Social, environmental and economic imbalances ▪ Social conflicts ▪ Little protection and control of water resources ▪ Local populations have little income ▪ Poverty ▪ Increasing migration to urban centers

Michael Zysman/Shutterstock

CAUSAL CHAIN ANALYSIS – LIMITED WATER RESOURCES MANAGEMENT

Direct Causes (Technical Causes)

Control and oversight personnel not trained; lack of planning and implementation of conservation programs in transboundary water resources; little implementation of land-use instruments; little use of tools and techniques to monitor water resources, and anthropic activities.

Secondary Indirect Causes (Economic Causes)

Little investment in transboundary water resources projects; scarce public and private resources at the sub-national level (departments, provinces, districts); low allocation of resources for control and oversight; scarce resources for monitoring and evaluation; scarce state resources to hire professionals with high academic and technical competence.

Tertiary Indirect Causes (Institutional Causes)

Inadequate prioritization of expenditures and resource allocation; few specialized professionals at the agencies for control and environmental assessment; institutional inability to enforce compliance with regulations and management plans; institutional weaknesses in transboundary areas; poor publicizing of environmental standards; weak coordination among the institutions involved; job instability among state officials; poor oversight of public spending; overlap in the actions of state institutions.

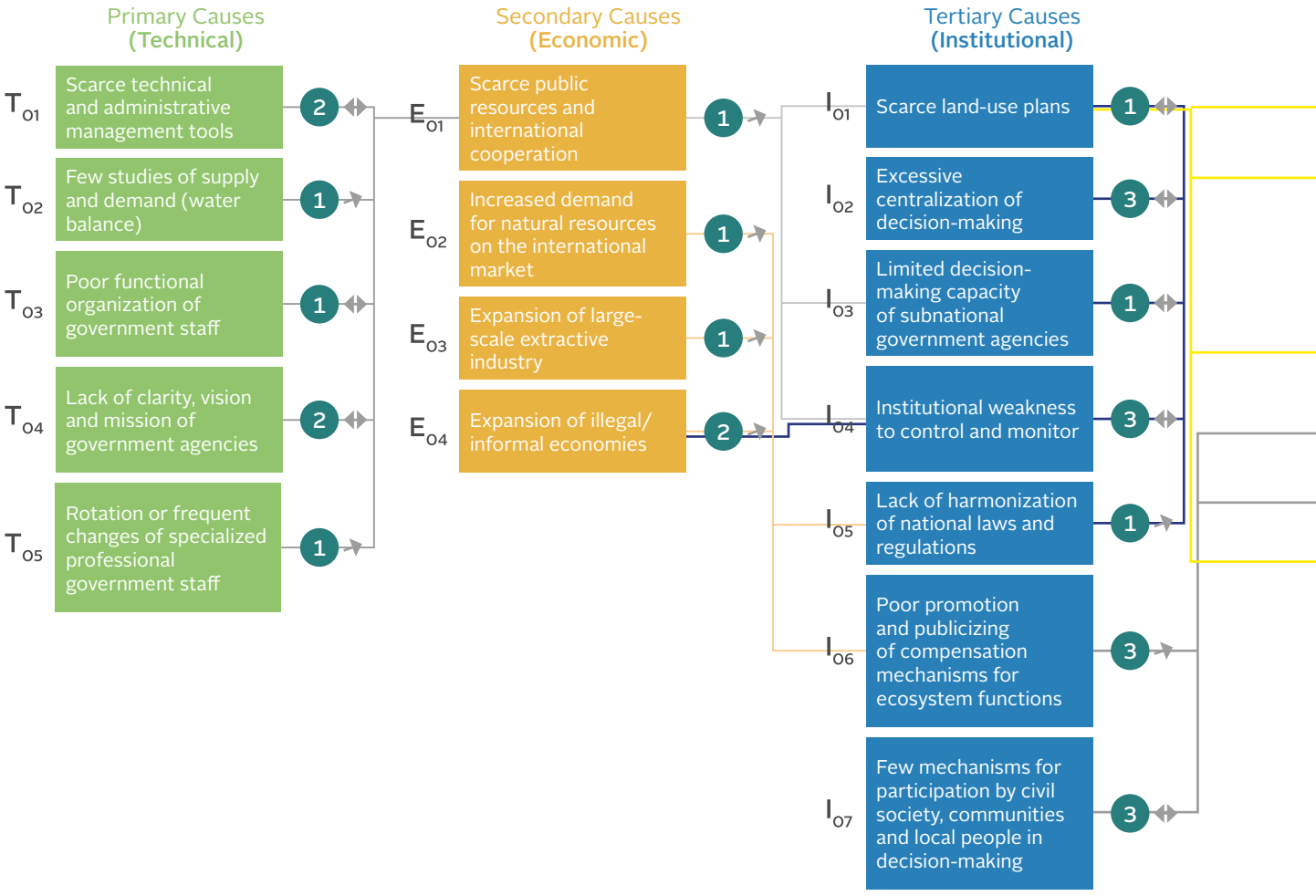
Root Causes (Socio-political Causes)

People have little environmental education and awareness; misinformation about transboundary water resources; absence of state policies on transboundary water resources; lack of social responsibility by business and industry concerning transboundary environmental impacts; little state regulation on environmental issues.

FIGURE 9. CAUSAL CHAIN OF LIMITED WATER RESOURCES MANAGEMENT

Problem 9. Limited water resources management

Causal Chain Analysis



Actions

Root Causes
(Socio-political)

P_{01}	Migration and demographic growth	1	Encourage the establishment of a permanent regional forum for the integrated management of transboundary water resources
P_{02}	Poverty and unemployment	3	Promote regional agreements for scientific and technical cooperation in transboundary water resources
P_{03}	Extractive economic models	1	Promote the strengthening of watchdogs, monitoring and control of transboundary and border environmental issues
P_{04}	Cultural alienation of the native communities	3	Promote regional agreements for obtaining and application of financial resources for the management of transboundary water resources
P_{05}	Little data and information	2	Promote programs and environmental education projects related to transboundary water resources
P_{06}	Little training and capacity-building	1	Promote programs and projects for training local communities and populations in the management of transboundary water resources
P_{07}	Social conflicts	1	Promote participation mechanisms for communities and local people in the management of transboundary water resources
P_{08}	Climate variability and change	3	Promote the dissemination and communication of policies and strategies concerning transboundary water resources management
			Promote the management and the coordinated and planned use of natural resources as well as the establishment and strengthening of basin committees as a mechanism for citizen participation in integrated river basin management.
			Strengthen, update and promote relationship with international or national cooperation agencies in order to obtain technical and financial assistance to incorporate existing best practices in integrated river basin management.

Priority	***Tendency***
1 High	Growing
2 Medium	Stable
3 Low	Decreasing

REGIONAL RESPONSE STRATEGIES

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The Regional TDA document identifies the priority regional transboundary problems, their impacts and their causes, including governance issues, based on the National TDA Workshops.

The Regional TDA document proposes some strategic lines as a first step toward developing strategic actions for the SAP, needed to resolve the indicated priority regional transboundary problems. These are regional strategic lines of a general nature, that are the original and legitimate proposals of the institutions that participated in the National TDA Workshops, which were subsequently consolidated in this Regional TDA, maintaining their original expression, without changing their content. Other valuable contributions, made subsequently, will be considered in the SAP.

Table 12 presents a breakdown of the regional strategic lines by topic, and the specific actions that need to be implemented at the regional level.

TABLE 12. RESPONSE STRATEGIES IDENTIFIED AND SYSTEMATIZIED AT THE REGIONAL TDA

RESPONSE STRATEGIES IDENTIFIED AND SYSTEMATIZIED AT THE REGIONAL TDA
Capacity- building of Key IWRM Stakeholders
▪ Strengthen water resources management institutions in the countries. ▪ Create technical, financial, and institutional capacity for water pollution mitigation. ▪ Strengthen capacity of local actors and their participation in IWRM. ▪ Create a regional participative monitoring and oversight system of water resources.
Financing IWRM
▪ Create a fund to finance water resources management in transboundary basins.
Legal Framework for IWRM
▪ Establish guidelines at the regional level and harmonize criteria at the national level for IWRM in transboundary basins.
Adaptation to Extreme Hydroclimatic Events
▪ Promote monitoring of extreme hydrological events. ▪ Encourage the expansion of hydrometeorological network systems. ▪ Promote the implementation of early warning systems and disaster risk management plans.
Information and Knowledge Management
▪ Create a Regional Amazon Observatory made up of public and private entities and civil society, with the aim of promoting investigation, information flow and knowledge generation for water resources management in transboundary basins. ▪ Promote applied scientific investigation and knowledge for IWRM in transboundary basins. ▪ Establish an Integrated Information System on water resources, considering early warning systems in transboundary basins.
Education and Culture
▪ Promote water culture and environmental education, giving value to traditional and local knowledge for water resources management in transboundary basins.

CONT. OF TABLE 12. RESPONSE STRATEGIES IDENTIFIED AND SYSTEMATIZIED AT THE REGIONAL TDA

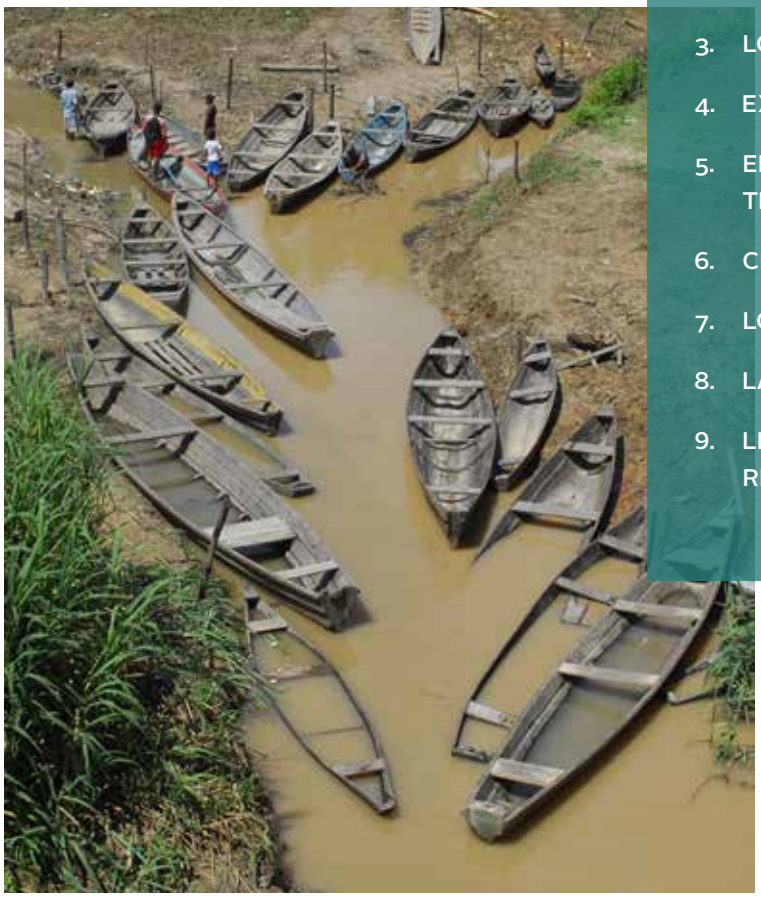
RESPONSE STRATEGIES IDENTIFIED AND SYSTEMATIZIED AT THE REGIONAL TDA
Public Policies
▪ Establish regional public policy guidelines to foster IWRM at the country and basin level in the Amazon. ▪ Promote public policies on water pollution, land-use planning, soil use, forest management, water ecosystems management; Promote sustainable production practices, economic analysis and development of economic instruments for water resources in accordance with each country's laws.
Adaptation and Impact Evaluation
▪ Promote instruments and measures for adaptation to climate change as part of IWRM in transboundary basins. ▪ Promote tools for the economic evaluation of the environmental impact of large infrastructure projects in transboundary basins, according to each country's laws.
Communication, Promotion and Publicity
▪ Publicize public policies and strategies on water resources in transboundary basins. ▪ Promote scientific and technical cooperation on water resources in the Amazon Basin through multilateral agreements among Amazon countries.

ACTO

REGIONAL TDA RECOMMENDATIONS

As mentioned in the previous chapter, the Regional Transboundary Diagnostic Analysis (TDA) of the Amazon Basin identified impacts and root causes for the following nine priority regional transboundary problems related to the management of water resources:

1. WATER POLLUTION
2. DEFORESTATION
3. LOSS OF BIODIVERSITY
4. EXTREME HYDROCLIMATIC EVENTS
5. EROSION, SEDIMENT TRANSPORT AND SEDIMENTATION
6. CHANGES IN SOIL USE
7. LOSS OF GLACIERS
8. LARGE INFRASTRUCTURE PROJECTS
9. LIMITED INTEGRATED WATER RESOURCES MANAGEMENT



ACTO

Based on the national TDA workshops held in the member countries and the results of activities carried out under the GEF Amazon Project, the Regional TDA provides a factual basis for the formulation of the Strategic Action Program (SAP).

The TDA preparation process in the member countries made it possible to bring together a wide range of different actors involved in the management of water resources at the national, regional and local levels, with the aim of cooperating on the Amazon Basin. At the same time, the TDA represents a contribution to the discussion on water resources management in the Amazon, which will be an input for future negotiations at ACTO and other international forums. This interaction has produced the first proposals for regional strategies in response to the challenges of IWRM in the Amazon Basin and to promote measures to adapt to the impacts of climate change.

The strategic actions proposed by participants at the national workshops and in the process of consolidating the Regional TDA, are summed up in the following recommendations:

FINAL RECOMMENDATIONS

- **Strengthen the administrative and technical capacities of the national institutions** in charge of managing water resources in the eight countries, in accordance with their national institutional contexts.
- **Strengthen the technical, financial and institutional capacities of the key stakeholders** by giving them the skills to mitigate water pollution and ensure effective participation in the management of water resources in the region.
- **Promote regional systems for monitoring and surveillance** of water resources and strengthen the Integrated Information System on Water Resources, with the participation and engagement of public and private institutions and civil society, to promote research, information flow and the generation of knowledge for IWRM in transboundary basins.
- **Create a Water Fund** to support the implementation of IWRM projects in transboundary basins.
- **Establish regional guidelines and harmonize national standards** for IWRM in transboundary basins.
- **Establish guidelines for public policies at the regional level** to make IWRM in the Amazon Basin possible, addressing water pollution, promoting land-use planning, soil use, forest and water ecosystem management, and promoting sustainable production practices.
- **Promote water culture and environmental education,** based on information and knowledge of water resources issues.
- **Establish early warning systems and promote tools and measures for adaptation to climate change** in transboundary basins.
- **Strengthen communication,** promotion and dissemination of public policies and strategies on water resources in transboundary basins, and strengthen technical and scientific cooperation in the field of water resources through multilateral agreements among the ACTO member countries.
- **Strengthen institutional coordination mechanisms** for IWRM in the Amazon Basin countries at the national, regional and local levels, by implementing, updating and/or creating guidelines and/or regulations.
- **Strengthen mechanisms for communication and exchange of information** between the national institutions responsible for the management of water resources in each country for a better understanding of this subject. At the regional level, the definition and implementation of mechanisms for the exchange of information and communication between government agencies of the eight ACTO member countries should be considered.
- **Consider the creation of a Permanent Steering Committee for the Coordination of IWRM** in the Amazon Basin in order to coordinate water issues among the member countries, with the initial task of funding and implementing the Strategic Action Program.

ACRONYMS

ACT	AMAZON COOPERATION TREATY
ACTO	AMAZON COOPERATION TREATY ORGANIZATION
ANA	AGENCIA NACIONAL DE AGUAS (BRAZIL)
ANA	AUTORIDAD NACIONAL DEL AGUA (PERU)
ANTAQ	NATIONAL ASSOCIATION OF WATER TRANSPORT (BRAZIL)
CAF	DEVELOPMENT BANK OF LATIN AMERICA
CAN	ANDEAN COMMUNITY OF NATIONS
CEPAL	UNITED NATIONS ECONOMIC COMMISSION FOR LATIN AMERICA AND THE CARIBBEAN
CITES	CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
ENSO	EL NIÑO – SOUTHERN OSCILLATION
GEF	GLOBAL ENVIRONMENT FACILITY
IBGE	BRAZILIAN INSTITUTE OF GEOGRAPHY AND STATISTICS (BRAZIL)
IDHs	IIRSA INTEGRATION AND DEVELOPMENT HUBS
INE	NATIONAL STATISTICAL INSTITUTE (BOLIVIA)
INEI	NATIONAL INSTITUTE OF STATISTICS AND INFORMATICS (PERU)
IIRSA	INITIATIVE FOR INTEGRATION OF REGIONAL INFRASTRUCTURE OF S. AMERICA
INPE	NATIONAL INSTITUTE FOR SPACE RESEARCH (BRAZIL)
IRD	RESEARCH INSTITUTE FOR DEVELOPMENT (FRANCE)
IWRM	INTEGRATED WATER RESOURCES MANAGEMENT
MMA	MINISTRY OF THE ENVIRONMENT (BRAZIL)
NAO	NORTH ATLANTIC OSCILLATION
OAS	ORGANIZATION OF AMERICAN STATES
PDO	PACIFIC DECADAL OSCILLATION

PNA	PROTECTED NATURAL AREAS
PPCDAM	ACTION PLAN FOR THE PREVENTION AND CONTROL OF DEFORESTATION IN THE LEGAL AMAZON
PRAA	ADAPTATION TO THE IMPACT OF RAPID GLACIER RETREAT IN THE TROPICAL ANDES
SAP	STRATEGIC ACTION PROGRAM
TDA	TRANSBOUNDARY DIAGNOSTIC ANALYSIS
UN ENVIROMENT	UNITED NATIONS ENVIRONMENT PROGRAMME
UNDP	UNITED NATIONS DEVELOPMENT PROGRAMME

LIST OF FIGURES

LIST OF TABLES

Focal Points of the ACTO / UN Environment / GEF Amazon Project

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- Special acknowledgment to Mr. Humberto Cardoso Gonçalves, co-manager of this regional initiative, current Superintendent, Superintendency of Support and Implementation of the National System for Water Resources Management-SAS / SINGREH, National Water Agency.

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PRIORITY TRANSBOUNDARY PROBLEMS IDENTIFIED IN THE NATIONAL TDA DOCUMENTS

COUNTRY	TRANSBOUNDARY PROBLEMS
BOLIVIA	• Effects on water and hydrobiological migratory resources by hydroelectric dams in border areas • Deforestation • Degradation of habitats by burning and fires • Loss of natural ecosystems due to the advance of the agricultural frontier • Reduction of fish and fishery resources • Mining pollution associated with the exploitation of gold • Extraordinary flood patterns • Use and illegal trafficking of timber and wildlife in border areas
BRAZIL	• Pressures on Biodiversity • Limited Integrated Water Resources Management • Deforestation • Weak Planning for the development of productive activities in the Amazon • Lack of Monitoring of Extreme Hydroclimatic Events
COLOMBIA	• Water pollution • Deforestation • Infrastructure construction • Biodiversity loss • Extreme hydrological events • Weak water governance
ECUADOR	• Water pollution • Deforestation • Water governance • Land planning • Soil use changes • Biodiversity loss • Scarce infrastructure of basic services • Poor application of land use plans • Insufficient inter-institutional coordination
GUYANA	• Pollution by economic activities such as mining, agriculture, etc. • Extreme Hydrological Events: Floods • Water pollution • Deforestation • Solid waste management • Conflicts over the use of water • Groundwater contamination • Excessive water extraction

COUNTRY	TRANSBOUNDARY PROBLEMS
PERU	• Illegal / informal mining • Water pollution by oil exploitation • Pollution from domestic wastewater • Deforestation • Water pollution by river transport • Unsustainable use of hydrobiological resources • Extreme hydrological events (droughts / floods) • Erosion and transport of sediments • Loss of glaciers • Weak institutionality for the management of transboundary water resources
SURINAME	• Contamination by chemicals from agriculture and by mercury from small-scale mining • Solid waste and wastewater management • Land Use Planning • Insufficient legislation and data availability • Climate change • Sediment transport and sedimentation
VENEZUELA	• Water pollution • Migration of indigenous communities • Extreme hydrological events • Loss of biodiversity due to illicit trafficking of wild species • Logging and illegal logging • Soil erosion and sediment transport • Changes in land use • Water resources management

Source: National TDA Documents.


ACTO
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BOLIVIA BRAZIL COLOMBIA ECUADOR GUYANA PERU SURINAME VENEZUELA

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