

Amazonia Security Agenda

Strengthening the water, energy, food and health security nexus in the region and beyond

Summary of Findings and Initial Recommendations

Authored by



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1. A new security agenda for Amazonia

A nexus of securities under threat

Amazonia's abundant natural resources underpin water, energy, food and health security for the people and economies of the region and far beyond. At the heart of this nexus of securities is water. So abundant in the region, but now under increasing threat as industrial and agricultural pollution increases, and extreme droughts reveal a once unthinkable water vulnerability.

Huge wealth continues to be generated from Amazonia's vast natural resources, but with high environmental and social costs. And even as many of its nations seek to produce more energy, minerals, metals and agricultural commodities from the region to meet increasing national and global demand, Amazonia's own citizens do not share equitably in the benefits.

This large-scale economic development in Amazonia has always been predicated on deforestation. But by compromising Amazonia's ecosystems, deforestation is now threatening not only the wellbeing and rights of the region's people, but also the economic sustainability of the very industries that it has enabled.

Climate change as a threat multiplier

Climate change will multiply these threats, as increasing temperatures, changing rainfall patterns and more frequent and intense extreme events further impact water, energy, food and health security.

The droughts, floods and fires of the last decade could provide an early indication of the challenges and opportunities that lie ahead.

A new security agenda

This calls for a new security agenda for Amazonia. Not one focused only on national security in a traditional sense, but rather one that acts to strengthen the fundamental underpinnings of a flourishing society – sustained access to water, energy, food and good health for all. These 'securities'¹ are under increasing threat, both individually and in combination, creating significant risks for people, governments and industry.

In other parts of the world, the impacts of environmental degradation are already exacerbating human and economic insecurity on a large scale. As a continent, South America has been least affected by this dynamic – perhaps in large part because of its dependence on a healthy Amazonia.

The opportunity for decision-makers

The countries of Amazonia may have differing visions for the region, but they have joint dependence on its natural resources and joint exposure to regional-scale risks. For their leaders, the opportunity is clear: work together to mitigate threats to water and the other securities, and incentivise the transition to a more sustainable and equitable economy that will flourish in a changing Amazonia.

Given overlaps with existing regional processes and priorities, the political and logistical difficulties are many. A new perspective on the problem is urgently needed – one that recognizes that fundamental issues of national prosperity and regional security are at stake, and can offer a new platform for action.

Initial policy recommendations are therefore laid out in section 6, to serve as building blocks for nationally-focused discussions that are planned in Bolivia, Brazil, Colombia, Ecuador and Peru.

2. Abundant Amazonia

Greater Amazonia

Amazonia is a heterogeneous mosaic of ecosystems and populations without clear geographical boundaries. Definitions vary widely between countries and contexts², and have been based, among other things, on ecological criteria, altitude, watershed, and political-administrative boundaries. This study follows ACTO-UNEP's definition of 'Greater Amazonia', derived by including the maximum possible area across hydrographic, ecological and political/administrative criteria³.

	AREA KM ²	% SHARE OF AMAZONIA	% OF COUNTRY IN AMAZONIA
BOLIVIA	724,000	9.8	65.9
BRAZIL	5,034,740	67.9	59.1
COLOMBIA	477,274	6.4	41.8
ECUADOR	115,613	1.6	40.8
PERU	651,440	8.8	50.7

Based on ACTO-UNEP (2009). Country data are not available for the Greater Amazonia region and therefore are presented using the political-administrative defined region.

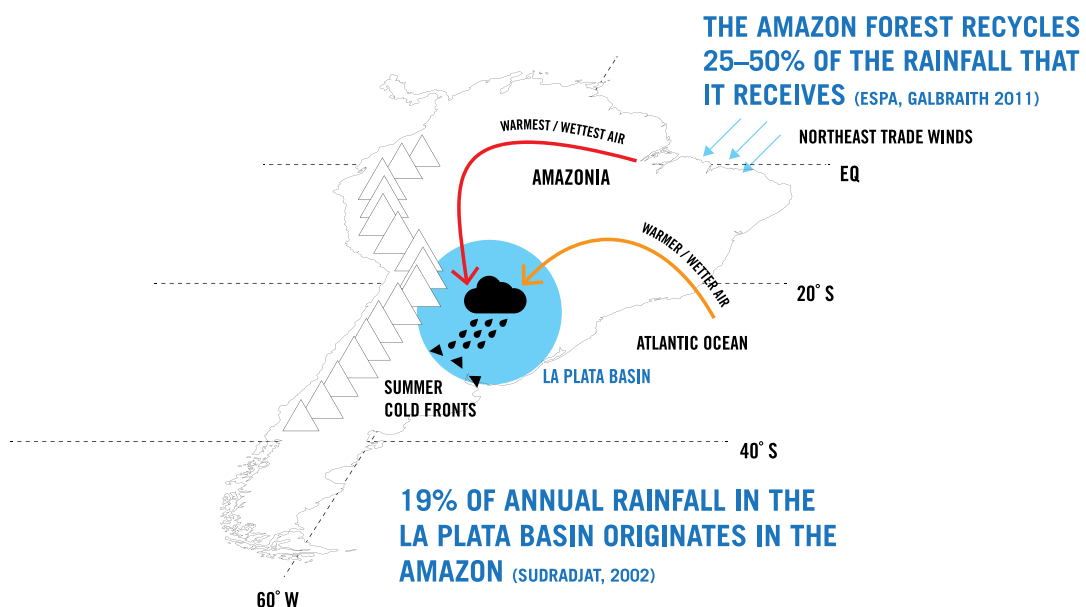
Ecosystem services underpin security

Rainforest is the most extensive among Amazonia's ecosystems, but rivers, lakes and wetlands, and savannas are also significant⁴. Together, these ecosystems, with their rich biodiversity, provide a wide range of services which underpin water, energy, food and health security for the people of the region and beyond.

Water security in particular is dependent upon the forest's rainfall recycling and water regulation and purification services⁵. Other forest ecosystem services that are vital at different scales include the provisioning of food and medicinal resources; nutrient recycling, erosion regulation, and moderation of extreme events; climate regulation and carbon sequestration and storage⁶.

Amazonia not only supports the economy and human wellbeing within the region itself, but also those far beyond its boundaries. The Amazon releases 8 trillion tonnes of water vapour into the atmosphere each year⁷, recycling water from the Atlantic across the forest and

FIGURE 1: AMAZONIA UNDERPINS REGIONAL WATER SECURITY



Source: Based on Marengo, J.A. et al 2004

transporting it over thousands of kilometres⁸. Around one fifth of the rain that falls in the La Plata Basin, a region which generates 70% of the GDP for the five countries that share it⁹, comes from the Amazon¹⁰. In other words, Amazonia’s ecosystem services underpin water security far beyond the forest, feeding agriculture and hydropower, and providing water for industry and people. The estimated value of this is in the order of tens of billions of dollars annually¹¹.

Interdependence

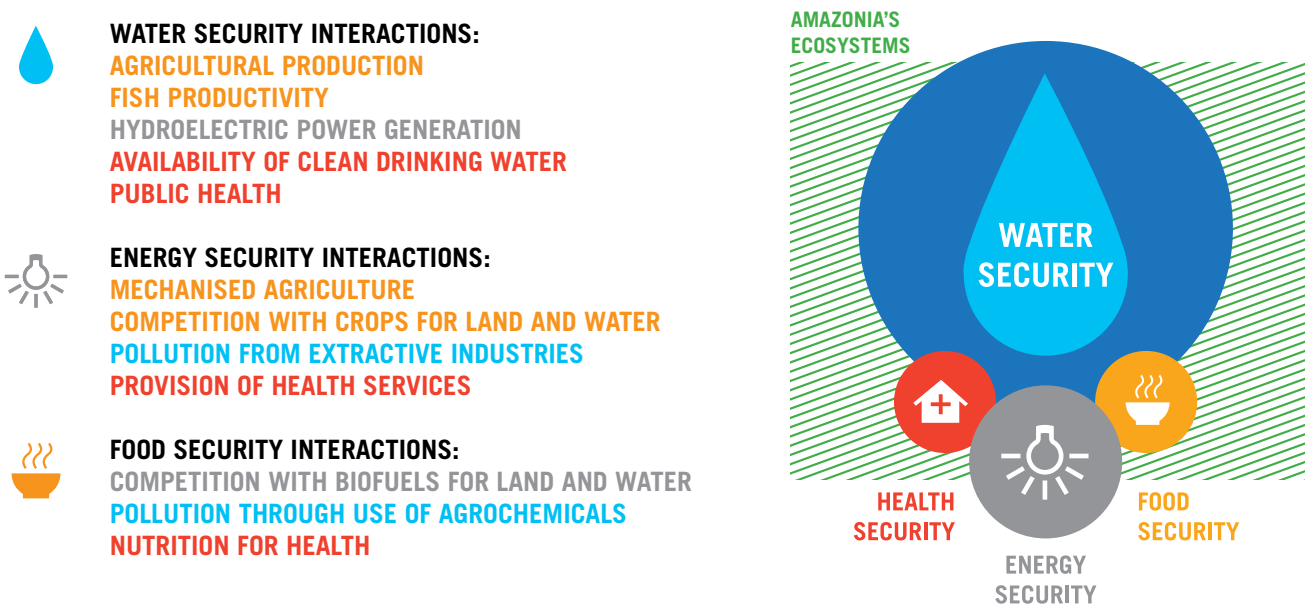
Water, energy, food and health security are interdependent in Amazonia, and ultimately all depend on its ecosystems.

Water security is central to this nexus. It is essential for hydroelectric power generation and the riverine transport of liquid fuels to rural communities (supporting energy security); for agricultural production and fishery productivity (supporting local and regional food security); and the provision of clean drinking water, mitigation of droughts and floods, and regulation of water-borne diseases (health security).

In turn, both large-scale agriculture and energy generation in the region negatively impact water security through pollution and flow disruption, with further impacts for food and health security of local populations.

Today, this interdependence between the securities multiplies threats. If better understood and accounted for, this could inform and strengthen strategic policymaking at sub-national, national and regional levels.

FIGURE 2: WATER, ENERGY, FOOD AND HEALTH SECURITY IN AMAZONIA ARE INTERDEPENDENT



3. The economic and human landscape in Amazonia

3.1 Huge wealth is being generated for the countries of Amazonia

The scale of current economic activity in Amazonia is often underestimated. The region's natural abundance in resources is being monetised on an industrial scale. Its direct financial value is in the order of magnitude of many \$10s of billions annually. Some key points:

- **Oil and natural gas** are mainstays of the economies of Bolivia (45% of total national exports¹²), Ecuador (55%¹³), and Peru (11%¹⁴). In Ecuador 99% of the country's oil¹⁵, enabling \$8.9 billion of crude oil exports¹⁶, comes from Amazonia. In Colombia, 23% of the country's oil comes from Amazonia¹⁷.
- **Amazonian hydropower** supplies a high percentage of national electricity needs: 39% in Ecuador, 35% in Bolivia, 22% in Peru, and 11% in Brazil¹⁸.
- **Amazonian produce** feeds the region: 37% of Brazil's beef herd is in Legal Amazonia¹⁹ (83.5% of all Brazilian beef is consumed domestically²⁰). 24% of Colombia's fresh-water fish catch is from Amazonia²¹, and 22% of Bolivia's rice²².
- **Amazonian agricultural commodities** are exported at scale. Soyabean grain and beef from Brazil's Legal Amazonia generated \$7 billion and \$1.6 billion respectively in export revenues in 2012²³.
- **Amazonian metals** generate huge revenues: Brazil's Pará state alone produces iron ore worth c. \$8.8 billion annually, 28% of the country's total²⁴. Madre de Dios region of Peru produces 14% of the country's gold²⁵, a key national export worth \$9.5 billion in total in 2012²⁶.

Demand for these commodities is increasing as national and global populations grow larger and richer. Chinese demand in particular has driven the expansion of Amazonian soya in recent years²⁷, accounting for some 70% of Brazil's soyabean exports in 2012, up by almost a factor of ten since 2000²⁸.

And national plans and concessions aim towards accelerated development in the region. For example:

- 30 new dams are planned for the Brazilian Amazon by 2020²⁹, and 59 across the Andean Amazon³⁰. The potential for new hydropower in the region is gigantic (in the Peruvian Amazon, which already supplies 22% of the country's electricity, less than 1% of technical potential has been exploited³¹).
- Bilateral agreements to meet Brazil's growing energy needs have been proposed or agreed with other Amazonian nations (Bolivia for gas, and Bolivia and Peru for hydropower³²). These are proving controversial.
- Brazil plans to increase national soya exports by 39% and beef exports by 29% by 2021³³.
- 21% of Amazonia is under some form of mining exploitation or concession, and 14% under some form of oil exploitation or concession³⁴.
- Amazonia is being integrated into national and international transport networks. This includes 57 transport projects supported by the IIRSA initiative valued at more than US\$ 6 billion³⁵.




This export economy is dependent on Amazonia's water and energy security. Hydropower generation and agricultural commodity production, rely directly on the region's abundant rainfall. Similarly mining, oil extraction and thermo-power generation all require abundant and clean water.

Today's industrialised Amazonian economy also relies on energy supply at scale. Mechanised agriculture, oil extraction and mining all have high energy needs. Energy provision for industry in the region is often closely tied to hydropower (and thus water security) – the Tucuruí dam, for instance, was in significant part developed to power the energy-intensive mining and metallurgical industries in the region³⁶.

FIGURE 3: AMAZONIA'S EXPORT ECONOMY

BOLIVIA

CONTRIBUTION TO NATIONAL PRODUCTION FROM AMAZONIA





-  **39% ELECTRICITY FROM HYDROPOWER**
-  **41% BEEF HERD BENI AND PANDO DEPARTMENTS**
-  **24% NATURAL GAS FROM COCHABAMBA AND SANTA CRUZ DEPARTMENTS**

INTERNATIONAL EXPORT REVENUES THAT DEPEND ON AMAZONIA




-  **US\$940 MILLION** FOR SOYA, 2012
-  **US\$3.8 BILLION** FOR NATURAL GAS, 2011

BRAZIL

CONTRIBUTION TO NATIONAL PRODUCTION FROM AMAZONIA

-  **17% NATURAL GAS FROM AMAZONAS STATE**
-  **11% ELECTRICITY FROM HYDROPOWER**
-  **37% BEEF HERD**
-  **28% IRON ORE FROM PARA STATE**




INTERNATIONAL EXPORT REVENUES FROM LEGAL AMAZONIA

-  **US\$7 BILLION** SOYABEAN GRAIN, 2012
-  **US\$1.6 BILLION** BEEF, 2012
-  **US\$0.5 BILLION** TIMBER, 2012
-  **US\$8.8 BILLION** IRON ORE FROM PARA STATE, 2012



COLOMBIA

CONTRIBUTION TO NATIONAL PRODUCTION FROM AMAZONIA

-  **23% OIL**
-  **24% FRESHWATER FISH CATCH**
-  **17% BEEF HERD**

INTERNATIONAL EXPORT REVENUES FROM AMAZONIA

-  **US\$94 MILLION** OIL PUTUMAYO DEPT, 2000

ECUADOR

CONTRIBUTION TO NATIONAL PRODUCTION FROM AMAZONIA





-  **35% ELECTRICITY FROM HYDROPOWER**
-  **99% OIL**

INTERNATIONAL EXPORT REVENUES FROM AMAZONIA

-  **US\$8.9 BILLION** OIL, 2010 (US\$3.8 BILLION PRODUCTION VALUE CRUDE OIL AND NATURAL GAS)

PERU

CONTRIBUTION TO NATIONAL PRODUCTION FROM AMAZONIA

-  **73% OIL AND LIQUID NATURAL GAS**
-  **22% ELECTRICITY FROM HYDROPOWER**
-  **14% GOLD PRODUCED IN MADRE DE DIOS REGION**
-  **US\$23 BILLION** FROM CAMISEA NATURAL GAS PLANT OVER 30 YEAR LIFESPAN

INTERNATIONAL EXPORT REVENUES FROM AMAZONIA

-  **US\$166 MILLION** TIMBER 2011
-  **US\$196 MILLION** COFFEE FROM AMAZONAS AND SAN MARTIN REGIONS, 2011

3.2 Human landscape: insecurity in a land of plenty

Water, energy, food and health security are also fundamental to people's right to a good quality of life.

While progress has been made in recent years to improve the standard of living in the region, on numerous indicators Amazonia's citizens remain insecure. The wealth created within Amazonia has enriched few Amazonians. Local people have carried the costs of industrial activity such as pollution, and of increased competition for water and energy both in remote rural areas and in Amazonia's fast-growing cities. This raises critical questions of rights and equity which have for a long time beset the region.

The provisioning of clean water, food, raw materials and medicinal resources is especially important for the wellbeing of indigenous and traditional rural communities of Amazonia. Amongst other populations, and especially the 65% who live in urban centres³⁷, income and thus purchasing power is a key determinant of wellbeing. And despite recent progress in tackling poverty, it remains widespread in the region and a major obstacle to security. As many as 60% of people in the Bolivian Amazon, 37% in Ecuador, 23% in Peru and 17% in Brazil are estimated to be below the extreme poverty line³⁸.

- **Water security:** Water purification ecosystem services are important for the provision of clean drinking water. However, limited access to a proper water supply, treatment and basic sanitation infrastructure across Amazonia³⁹, particularly in rural areas, makes water security of Amazonian populations extremely vulnerable to pollution (section 4). This has knock on effects on food security (fisheries) and health security. In Ecuador 30,000 Amazonian citizens are seeking compensation through the courts at the billion US dollar scale over claims of toxic pollution by oil companies in the region⁴⁰.

- **Energy security:** amongst rural populations there is high reliance on expensive imports of liquid fuel, and unreliable electricity coverage⁴¹, though progress has been made through rural electrification programs⁴². Firewood is still an important source of energy in rural areas, particularly in Peruvian Amazonia⁴³.
- **Food security:** Despite poor soils⁴⁴ the Amazon supports a wide variety of crops, fruits, and other food sources⁴⁵. Fish and livestock are key sources of animal protein for both rural and urban populations in Amazonia⁴⁶. Where these are unavailable, wild meat is often an important element of the diets of indigenous and rural populations⁴⁷. Food insecurity is a major problem in the region, affecting up to one third of Amazonian citizens⁴⁸. 20% of children in Peruvian and Ecuadorian Amazonia are thought to be malnourished⁴⁹.
- **Health security:** Even considering recent improvements, health indicators in Amazonia are still poor, and health services are often basic^{50,51}. The forest plays an important role in the regulation of malaria, leishmaniasis and other infectious diseases which are prevalent in the region⁵². Natural medicinal resources are not only important for indigenous and traditional rural communities but are also widely used in urban areas as affordable healthcare⁵³.

4. Growing threats to the security nexus

The nexus of water, energy, food and health security that both people and economies in the region depend upon is under increasing pressure from both new and evolving threats.

Deforestation

Drivers of deforestation

Historically deforestation rates have been highest in Brazil, although changing patterns associated with improved monitoring and governance have seen a significant decrease from the country's peak in 2004. However, a recent spike raises questions over the permanence of this trend. In contrast a significant increase in deforestation has been seen in the Andean countries, particularly Bolivia, over the past decade⁵⁴.

While deforestation drivers vary amongst and within different countries, the key drivers in Amazonia today are conversion to mechanized large-scale cultivation of monocultures and cattle-ranching; mining and hydrocarbon exploitation; illicit crops, infrastructure projects like hydroelectric dams or roads; and smallholder agriculture by emigrants⁵⁵. The development of transport infrastructure can also facilitate further deforestation by increasing access to land and resources unless strict governance controls are in place⁵⁶.

In the future, climate change is also expected to be a driver of deforestation. Drier conditions and a more fragmented forest will increase vulnerability and precipitate further forest loss⁵⁷. During the extreme drought in September 2010 there were a high number of forest fires, about 200% higher in comparison to September 2009.

Loss of ecosystem services

The loss of ecosystem services through deforestation undermines the securities and particularly water security that is so pivotal. The forest recycles 20-25% of the rainfall it receives⁵⁸, and air travelling over extensive forest cover may generate twice as much rainfall as air over deforested land⁵⁹. Large-scale deforestation is predicted to reduce rainfall by up

to 21% by 2050⁶⁰, although the science is still uncertain. Furthermore, deforestation is likely to affect water quality through increasing soil erosion and leaching of nutrients and heavy metals including mercury⁶¹.

A recent study suggests that the controversial Belo Monte dam in the Brazilian Amazon, which is projected to supply 40% of Brazil's additional electricity needs by 2019, will have a significantly lower power output than expected due to regional deforestation – up to 13% lower than under a fully-forested scenario, and up to 36% lower by 2050 if current deforestation rates continue⁶².

Deforestation and forest degradation reduce resilience to extreme events⁶³ such as fires, floods and landslides with major impacts across the securities (section 5).

Inequity and conflict

Unequal access to resources as well as wide social and economic discrepancies between Amazonia's poor, wealthy rural landowners and national and multinational companies is being further exacerbated by the dominant model of development and deforestation in Amazonia today.

Mining, large infrastructure projects and agricultural expansion which threaten indigenous territories, small farmers and rural communities have already led to more incidents of violent conflict. In 2009, indigenous peoples' protests over land and resource rights in Bagua, Peru, escalated to extreme violence that left at least 30 people dead⁶⁴.

Conflict is likely to increase as competition for land and resources intensifies. 11% of oil blocks overlap with officially recognised Indigenous Territories with 33% already in exploration and 1% in production. 18% of mining concessions also overlap with officially recognised Indigenous Territories⁶⁵.

FIGURE 4: EXTREME DROUGHT IN AMAZONIA

DROUGHTS ARE PREDICTED TO INCREASE IN FREQUENCY AND INTENSITY UNDER CLIMATE CHANGE, BUT WHEN AND WHERE THEY OCCUR IS UNCERTAIN

2005 DROUGHT

1.9 MILLION KM²
IMPACTED (SEE MAP)

US\$139 MILLION
COST OF CROP LOSSES IN THE BRAZILIAN AMAZON

18.5%
RISE IN COSTS OF HOSPITAL ADMISSIONS FOR
RESPIRATORY ILLNESS IN ACRE STATE, BRAZIL

US\$100 MILLION
VALUE OF ECONOMIC, SOCIAL AND ENVIRONMENTAL
LOSSES IN ACRE STATE, BRAZIL

AIRPORT, SCHOOLS AND BUSINESSES SHUT
DUE TO FOREST FIRES IN ACRE STATE, BRAZIL

2010 DROUGHT

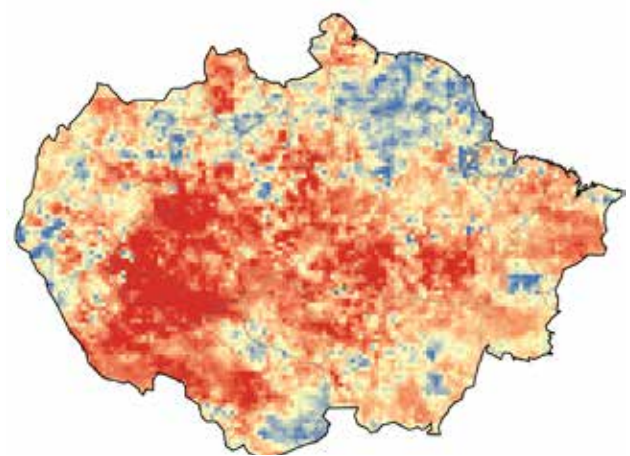
3 MILLION KM²
IMPACTED (SEE MAP)

600 TONNES OF FOOD AID
TO AMAZONAS STATE, BRAZIL






20% OF NORMAL CAPACITY
FOR RIVERINE SOYA EXPORTS, FORCING CARGILL
TO DIVERT EXPORTS 2000 KM BY ROAD

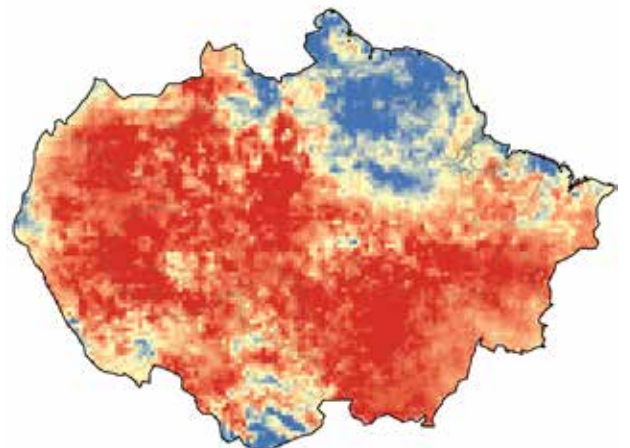
62,000 AFFECTED
IN AMAZONAS STATE, BRAZIL

200%
RISE IN FIRES ON PREVIOUS YEAR



RAINFALL ANOMALY (SD)

-  < -2
 -  -2 to -1
 -  -1 to 0
 -  0 to 1
 -  1 to 2
- Maps from LEWIS, S. et al. (2011) showing satellite-derived standardized anomalies for dry-season rainfall for the 2005 and 2010 droughts in Amazonia.



Pollution

Pollution particularly from mining, agricultural runoff, oil extraction, and sewage is increasingly impacting water security throughout Amazonia⁶⁶. This is exacerbated by the limited water treatment and sanitation infrastructure throughout the region, especially in rural areas. For example only 55% of Peruvians, 49% of Bolivians and 29% of Ecuadorians in the region have access to a treated water supply⁶⁷. This loss of water quality has impacts on local fish stocks, drinking water, and of course human health among others. In the region of Madre de Dios, Peru, where large quantities of mercury have been used in artisanal gold mining, 78% of adults in the regional capital tested for levels of mercury above international safety limits⁶⁸.

While pollution mainly impacts populations local to the point source, it can also have larger-scale regional impacts. A recent oil spill in the Ecuadorian Amazon's Napo River not only contaminated the drinking water supply of cities and local communities in the region, requiring drinking water to be imported, but also contaminated areas downstream in Peru's Loreto region⁶⁹.

Indirect threats

There are also many indirect threats to Amazonia's security, and whilst they are not the main focus of this analysis it is important to recognise their role. These indirect threats include; weak governance and law enforcement, land tenure issues, unplanned urbanisation, and a lack of coordination in national planning.

Water governance has been poor across the region for instance, in part because of historic presumptions of water abundance. The first national water authority in the region was only established in 2000, and until 2005 none of Brazil's Amazonian states had a plan for managing water resources⁷⁰.

5. Climate Change: a threat multiplier for Amazonia

Looking into the future, it is likely that all these threats to Amazonia’s prosperity will be multiplied by anthropogenic climate change exacerbating their environmental, economic and social costs.

The very real impacts of the unprecedented floods and droughts which have hit the region in the past decade offer a useful if still partial view into a climate-challenged future.

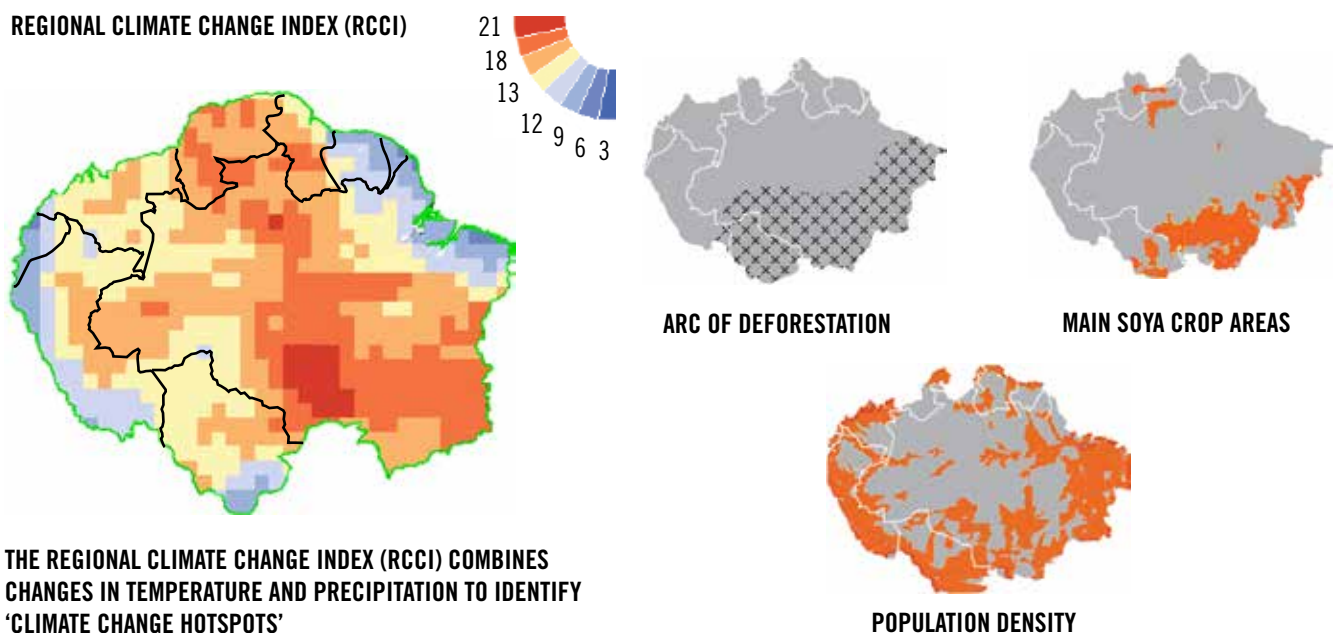
Extreme events in Amazonia

These extreme events have had wide-ranging impacts that underline in very real terms the interdependence of the securities: energy blackouts, destroyed crops, mass displacements of people, and outbreaks of water-borne and respiratory diseases⁷¹. They have also severely disrupted commerce: in August 2010, agricultural giant Cargill’s river transport of soyabean was running at 20% of normal capacity due to low water levels in the Madeira River, forcing a 2,000km diversion to southern ports⁷².

Extreme events can have serious implications for the energy security of local industries, cities and urban centres outside of the region. Hydropower generation is at risk from drought, and vulnerably configured pipelines and cables crossing vast distances are susceptible to landslides and flooding. Heavy rain in 2004 caused a pipeline leak from the Camisea gas project in Peru⁷³, and a fire in a substation in the Brazilian Amazon left 53 million people across the North East of Brazil without energy over several days⁷⁴.

FIGURE 5: CLIMATE CHANGE HOTSPOTS IN AMAZONIA

SOUTH-SOUTH-EASTERN AMAZONIA, AN AREA OF HIGH DEFORESTATION, FIRES AND DROUGHTS HAS BEEN HIGHLIGHTED AS PARTICULARLY VULNERABLE TO CLIMATE CHANGE. THIS COULD THREATEN SOYA PRODUCTION WHICH IS PREDOMINANT IN THE AREA.



Climate change projections

Climate models for the region, while uncertain, converge on a few broad projections:

- Increasing frequency and intensity of extreme events^{75,76}. Amazonia may suffer drought every other year by 2025⁷⁷.
- All-important rainfall patterns are changing and while uncertain, we may expect a wetter western and drier eastern Amazon by 2050^{78,79}.
- Rising temperatures, potentially up by a game-changing 3.5°C on average by 2050⁸⁰.

Such changes would severely impact all the securities, increasing vulnerability and risk for the region's growing economies and populations. Taken together in combination – as experienced on a still relatively small scale during the droughts and floods of the last decade – they will dangerously stretch the capacity of people, governments and industry to cope:

- Higher temperatures in Amazonia, coupled with drier conditions in some areas, could have a major effect on food security and, particularly in Brazil and Bolivia, on agricultural exports. Soybeans, rice, maize and many other staple crops suffer significantly lower yields when average annual temperatures rise above 30°C, and sensitive crops like beans simply cannot thrive in these conditions⁸¹. A recent study suggests that continued deforestation and climate change could lead to a 28% reduction in soybean yields by 2050⁸² and higher temperatures could affect pasture and so livestock grazing⁸³. This would have direct implications for global supply chains.
- Hydropower generation, especially for run of river dams, will be more vulnerable in the dry season, challenging future energy security across the region, especially given plans to invest heavily in new Amazonian hydropower⁸⁴.
- High existing rates of climate sensitive diseases like malaria and dengue increases the vulnerability

of Amazonia's citizens to climate change in certain areas. This will be exacerbated by poor health indicators and limited health services⁸⁵.

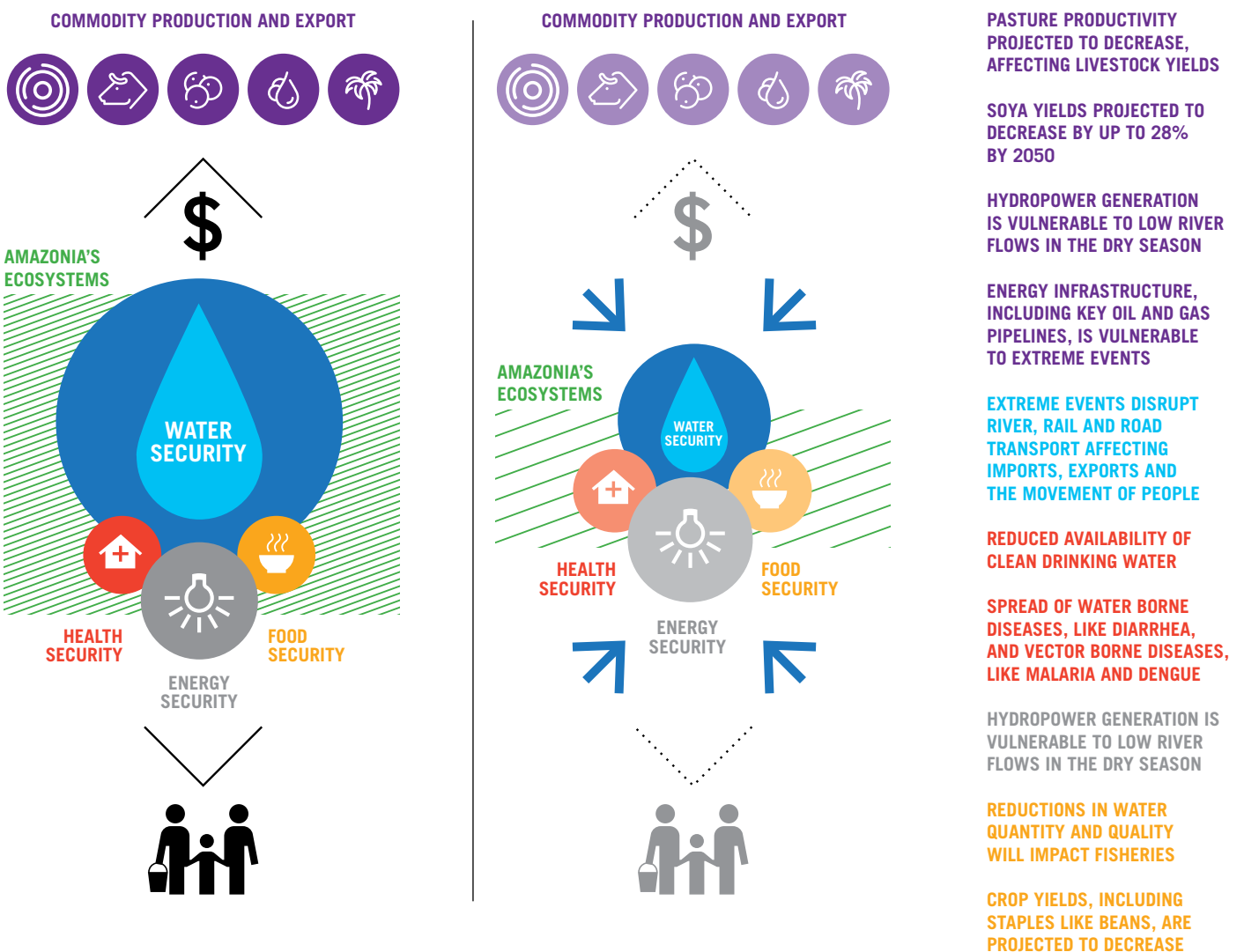
- The unpredictability of droughts, floods and fires increases the risks to human wellbeing and economic activities as discussed above.
- Climate change hotspots, such as SSE Amazonia where drier conditions are predicted⁸⁶ and large-scale agriculture is prevalent⁸⁷, will suffer greater impacts to water and the other securities⁸⁸.

Conclusions

1. Water, energy, food and health security are interdependent, and water security is key. This is a critical nexus for decision-makers, offering new opportunities for impact.
2. Maintaining Amazonia's ecosystems in balance with sustainable economic growth is fundamental to security for people and economies at multiple scales across the region.
3. Already widespread inequity in Amazonia will be exacerbated by threats to the securities, and is likely to lead to increased social conflict unless addressed.
4. Joint dependence on Amazonia's natural resources and joint exposure to regional-scale risk call for greater regional cooperation, alongside decisive action at the national level.
5. Threats to Amazonia's security are increasing and will be multiplied by climate change with high environmental, social and economic costs. Inaction could create unprecedented challenges for South America's political leaders.

FIGURE 6: THE AMAZONIA SECURITY AGENDA

WATER SECURITY IN AMAZONIA UNDERPINS HUMAN WELLBEING AND ECONOMIC PRODUCTION IN THE REGION AND FAR BEYOND. EMERGING THREATS TO WATER AND THE OTHER SECURITIES WILL BE MULTIPLIED BY CLIMATE CHANGE.



6. Opportunity for decision-makers

Achieving the right balance between economic development and safeguarding vital ecosystems in Amazonia is the key to a secure future. Links between water security and a thriving forest ecosystem have long been recognised – but more work is needed to understand the interdependence between water, energy, food and health security in Amazonia, and to quantify the likely impacts to economies and people.

Questions remain unanswered: How do impacts to Amazonia’s water affect the wider region’s economies and what could the costs be? Are there ‘security hotspots’ which critically underpin local communities or industry? Which aspects of development in Amazonia increase security and which most threaten it?

The need for better answers will grow increasingly urgent over the next decade as accelerating climate change in Amazonia multiplies threats to security. But failure to act now on clear early warning signs like the impacts of recent extreme droughts in the region could lead to far greater economic and social disruption in the mid-term, and create unprecedented challenges for South America’s political leaders.

If smartly managed, such a scenario can be avoided. Amazonia’s natural wealth can provide both material goods and essential ecosystem services. With foresight, Amazonia’s industry, infrastructure and cities can evolve to minimise their ‘security footprint’ and flourish in a changing Amazonia.

To achieve this, two major changes are needed:

- i. **A shift in paradigm:** recognition by governments in the region that Amazonia’s ecosystems do not only influence global climate change but also underpin the ongoing wellbeing and prosperity of people across the continent.
- ii. **Better knowledge of risks to inform better decision-making:** a new set of tools encompassing security indicators, threat monitoring, and an analysis of risks and opportunities for governments, businesses and community leaders.

Political and logistical difficulties cannot be underestimated. This agenda overlaps with complex national processes already underway to reduce deforestation, tackle poverty and adapt to climate change, as well as with the financial and trade imperatives that drive development in Amazonia.

The present analysis cannot offer immediate solutions to these challenges. Instead, it aims to provide a new perspective on the problem – one that recognises that fundamental issues of national prosperity and regional security are ultimately at stake, and can offer a new platform for action.

Initial policy recommendations are therefore laid out below to serve as building blocks for nationally-focused discussions that will take place between different stakeholders in each of the five countries considered in this report:

RECOMMENDATION 1: SECURITY HOT-SPOT MAPPING AND MONITORING

To identify areas where water, energy, food or health security are most vulnerable in Amazonia – both individually and in combination – and to quantify with greater confidence the social and financial costs of likely impacts within and beyond the forest. This would entail the following collaborative work across the region:

- **Defining a set of social, environmental and economic indicators** to enable better monitoring, information sharing and communication of water, energy, food and health security across Amazonia.
- **Assessing the vulnerability of different populations and different sectors** both within and outside the forest to quantify likely impacts of changes in Amazonia.
- **Annual Security Hotspot mapping** using security indicators and security threat scenarios to identify geographic ‘hotspots’ of vulnerability for water, energy, food and health.

- **An early warning system** building on the hotspot mapping tool to focus on the impact of extreme climate events, land-use change, and pollution outbreaks on the securities. One such system is that established by MARN in El Salvador.

**RECOMMENDATION 2:
ESTABLISH NATIONAL ‘NEXUS GROUPS’ TO HELP INFORM
DECISION-MAKING ACROSS SECTORS.**

The new security agenda outlined in this report overlaps with many different areas of policymaking and private sector activity, such as regional and national development plans, and national adaptation plans. Its approach would bring critical new information to bear on decision-making in these areas, especially where future vulnerabilities may have a material impact.

Currently, cooperation between ministries and sectors is limited, standardised information is not readily available, and the view some hold of Amazonia as a resource base distant from the economic and political centres of power persists. While these barriers are difficult to overcome, there is a clear need for strong leadership and improved coordination to harness the benefits of a more integrated and systematic approach to regional security risks.

This report therefore recommends that ‘nexus groups’ be established, consisting of senior experts from different ministries and sectors with a high-level mandate to share information, define priorities, identify policy gaps, and highlight opportunities and barriers to achieving water, energy, food and health security for Amazonia and beyond. These could be modelled on the ‘Presidential Task Forces’ adopted within many countries (Indonesia’s UKP4 – Presidential Delivery Unit is one successful example) to address cross-sectorial public policy challenges.

To be effective, these nexus groups will need strong technical capabilities to help strike the difficult balance between economic development and safeguarding vital ecosystems, and be politically empowered to facilitate cross-sector collaboration in planning and decision-making. Compromises are inevitable to ensure that security risks are dealt with before they become a critical social, economic and political issue.

References and End Notes

1. Water security is defined as sustained access to adequate and suitable water; Food security is defined as all people, at all times, having physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO); Energy security is defined as access to a reliable and affordable supply of energy; Health security is defined as widespread access to essential health services, and protection from environmental and behavioural risks to health
2. ACHARD, F. et al. (2005) A proposal for defining the geographical boundaries of Amazonia (EUR 21808-EN). Luxembourg: Office for Official Publications of the European Communities.
3. ACTO-UNEP. (2009) Geo Amazonia. UNEP/Earthprint.
4. HESS, L. L. et al. (1998) Large-scale vegetation features of the Amazon Basin visible on the JERS-1 low-water Amazon mosaic. Geoscience and Remote Sensing Symposium Proceedings, 1998. IGARSS'98.1998 IEEE International. 2. p.843-846
5. MULLIGAN, M. et al. (2013). Water Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
6. HASSAN, R., SCHOLES, R., ASH, N. (eds.) (2005) Ecosystems and Human Wellbeing: Current State & Trends Assessment. Millennium Ecosystem Assessment (MEA), Volume 1. Washington DC: Island Press.
7. NEPSTAD, D.C. et al. (2008) Interactions among Amazon land use, forests and climate: prospects for a near-term forest tipping point. *Phil Trans R Soc B* 363 (1498). p.1737–1746 data from IPCC. (2007) Climate change 2007 - The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. 4. Solomon, S. et al. Ed. Cambridge, UK and New York: Cambridge University Press.
8. MARENGO, J.A. et al. (2004) Climatology of the low-level jet east of the Andes as derived from the NCEP–NCAR reanalyses: Characteristics and temporal variability. *Journal of Climate*. 17 (12). p.2261–2280.
9. WWAP. (2007) World Water Assessment Programme La Plata Basin Case Study: Final Report, April 2007. [Online]. Available from: <http://unesdoc.unesco.org/images/0015/001512/151252e.pdf>. [Accessed: 15th December 2012].
10. SUDRADJAT, A., BRUBAKER, K. L., DIRMEYER, P. A. (2002) Precipitation source/sink connections between the Amazon and La Plata River basins. American Geophysical Union, Fall Meeting 2002, abstract #H11A–0830.
11. CRANFORD, M., TRIVEDI, M., QUEIROZ, J. (2011). Exploring the value of Amazonia's 'Transpiration Service'. In MEIR, P. et al. (2011). Ecosystem Services for Poverty Alleviation in Amazonia. Global Canopy Programme and University of Edinburgh, UK.
12. INSTITUTO NACIONAL DE ESTADISTICA DE BOLIVIA (INE). (2013) [Online]. Available from: <http://www.ine.gob.bo/indice/general.aspx?codigo=50101>. [Accessed: 5 May 2013].
13. PRO ECUADOR. (2013) Guía Comercial de la República del Ecuador 2013.
14. BACA, J.P., GUERRA, L., VILLEGA, M. (2012) Boletín de exportaciones regionales. Elaborado por el Departamento de Inteligencia Comercial – Asociación de Exportadores del Perú (ADEX).
15. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from: BCE. (2012) Reporte del Sector Petrolero II Trimestre 2012. Quito, Ecuador, CONELEC. (2012) Geoportal del CONELEC. Quito, Ecuador & MEER. (2008) Políticas y Estrategias para el Cambio de la Matriz Energética del Ecuador. Quito, Ecuador.
16. BANCO CENTRAL DEL ECUADOR. (2013) [Online]. Available from <http://www.bce.fin.ec/frame.php?CNT=ARB0000766>. [Accessed 18 May 2013 using NANDINA code 2709000000].
17. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from: ACP. (2012) Asociación Colombiana de Petróleo. Informe Estadístico Petrolero 2011. [Online]. Available from: http://www.acp.com.co/index.php?option=com_k2&view=itemlist&task=category&id=6:informe-estad%C3%ADstico-petrolero&Itemid=81.
18. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data for Bolivia from: CNDC. (2010) Comité Nacional de Despacho de Carga. Gross Generation 2010. [Online]. Available from: <http://www.cndc.bo/estadisticas/anual.php>; for Brazil: EPE. (2011) Balanço Energético Nacional 2011. Rio de Janeiro; for Ecuador: CONELEC. (2012) Plan Maestro de Electrificación 2012 - 2021. Quito, Ecuador & CONELEC. Indicadores del Sector Eléctrico. [Online]. Available from: <http://www.conelec.gob.ec/indicadores/>; for Peru: MINEM. (2011) Ministerio de Energía y Minas del Perú. Anuario Estadístico de Electricidad 2010. Lima, Peru & MINEM. (2011) Ministerio de Energía y Minas del Perú. Atlas del Potencial Hidroeléctrico del Perú. Lima, Perú.
19. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). (2013) [Online]. Available from: http://www.ibge.gov.br/english/estatistica/economia/ppm/2011/default_pdf.shtm.
20. ABIEC (2012) Association of Brazilian beef exporters. [Online]. Available from: <http://www.brazilianbeef.org.br/texto.asp?id=9>. [Accessed: 10th May 2013].

21. MINISTERIO DE AGRICULTURA Y DESARROLLO RURAL DE COLOMBIA. (2012) Anuario Estadístico del Sector Agropecuario y Pesquero 2011, Resultados Evaluaciones Agropecuarias Municipales 2011, Edición: Dirección de Política Sectorial - Grupo Sistemas de Información. Noviembre 2012 Bogotá, D.C. ISBN: 978-958-97128-8-7.
22. UPC. (2008) Sistema de Información Productiva Municipal - Unidad de Productividad y Competitividad. [Online]. Available from: <http://www.upc.gob.bo/ipm/>. [Accessed: 14th May 2013].
23. BRASIL ALICE WEB. (2013) Data for 2012. Using HS Code 1201 for soybean and HS Codes 020120, 020130, 020220, 020230, 020610, 020621, 020622, 020629, 021020, 160250 for beef. [Online]. Available from: <http://aliceweb2.mdic.gov.br/>. [Accessed: 10th May 2013].
24. BRASIL ALICE WEB. (2013) Data for 2012. Using HS Code 2601. [Online]. Available from: <http://aliceweb2.mdic.gov.br/>. [Accessed: 10th May 2013].
25. MEM. (2012) Anuario Minero 2011, Ministerio de Energía y Minas, Perú, Abril 2012.
26. INSTITUTO NACIONAL DE ESTADÍSTICA E INFORMÁTICA PERÚ (INEI). (2013) [Online]. Available from: <http://www.inei.gob.pe/web/aplicaciones/siemweb/index.asp?id=003> [Accessed: 10th May 2013].
27. BROWN-LIMA, C. et al. (2009) An Overview of the Brazil-China soybean trade and its strategic implications for conservation. The Nature Conservancy, Latin America Region.
28. BRASIL ALICE WEB. (2013) Data for 2012. Using HS Code 1201. [Online]. Available from: <http://aliceweb2.mdic.gov.br/>. [Accessed: 10th May 2013].
29. FEARNSIDE, P. (2012) Belo Monte Dam: A spearhead for Brazil's dam-building attack on Amazonia? [Online]. Available from: <http://www.globalwaterforum.org/2012/03/19/belo-monte-dam-a-spearhead-for-brazils-dam-building-attack-on-amazonia/> [Accessed 10th February 2013]. Data from: MME/EPE. (2011) Brazil, Plano Decenal de Expansão de Energia 2020. Ministério de Minas e Energia. Empresa de Pesquisa Energética. Brasília.
30. FINER, M. & JENKINS, C.N. (2012) Proliferation of hydroelectric dams in the Andean Amazon and implications for Andes-Amazon connectivity. PLoS One. 7 (4) e35126.
31. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from: MINEM. (2011) Ministerio de Energía y Minas del Perú. Anuario Estadístico de Electricidad 2010. Lima, Peru, & MINEM. (2011) Ministerio de Energía y Minas del Perú. Atlas del Potencial Hidroeléctrico del Perú. Lima, Perú.
32. MME/EPE. (2011) Brazil, Plano Decenal de Expansão de Energia 2020 / Ministério de Minas e Energia. Empresa de Pesquisa Energética. Brasília.
33. SECRETARIA DE COMUNICAÇÃO SOCIAL DA PRESIDÊNCIA DA REPÚBLICA FEDERATIVA DO BRASIL. (2010) Brazil Insights Series: Agriculture and Livestock.
34. RAISG. (2012) Amazonía bajo presión. Red Amazónica de Información Socioambiental Georreferenciada ;coordinación general Beto Ricardo (ISA) . São Paulo: Instituto Socioambiental.
35. INICIATIVA PARA LA INTEGRACIÓN DE LA INFRAESTRUCTURA REGIONAL SURAMERICANA (IIRSA). (2011) Cartera de Proyectos COSIPLAN 2011. UNASUR.
36. LA ROVERE, E.L. & MENDES, F.E. (2000) Tucuruí Hydropower Complex, Brazil. A WCD case study prepared as an input to the World Commission on Dams, Cape Town. [Online]. Available from: www.dams.org
37. AMAZON REGIONAL ARTICULATION (ARA). (2011) The Amazon Millennium Goals. CELENTANO, D. & VEDOVETO, M. (eds.) Quito, Ecuador: ARA Regional.
38. AMAZON REGIONAL ARTICULATION (ARA). (2011) The Amazon Millennium Goals. CELENTANO, D. & VEDOVETO, M. (eds.) Quito, Ecuador: ARA Regional.
39. AMAZON REGIONAL ARTICULATION (ARA). (2011) The Amazon Millennium Goals. CELENTANO, D. & VEDOVETO, M. (eds.) Quito, Ecuador: ARA Regional.
40. AMAZON WATCH. (2013) Ecuadorian Locals Still Seeking Damages from Chevron for Environmental Damage. [Online]. Available from: <http://amazonwatch.org/news/2013/0617-ecuadorian-locals-still-seeking-damages-from-chevron-for-environmental-damage> [Accessed: 17th June 2013].
41. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
42. In Brazil the program 'Luz Para Todos', initiated in 2003, reached 14.4 million rural residents across the country by 2012. In Ecuador between 1997 and 2008 the fund for rural electrification (FERUM) installed a total capacity of 5.2 MW in the country. Around 70% of this power was installed in the Amazon Region using solar photovoltaic technology.
43. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.

44. RAMANKUTTY, N. et al. (2002) The global distribution of cultivable lands: current patterns and sensitivity to possible climate change. *Global Ecology and Biogeography* 11(5). p. 377-392.
45. MAPAZ. (2013) Amazon Initiative Map Server © 2009-2011. Version 1.2. [Online]. Available from: <http://gismap.ciat.cgiar.org/mapaz>
46. LEWIS, J. et al. (ed.) (2002) Alternatives to slash-and-burn in Brazil Summary Report and Synthesis of Phase II. Alternative to Slash and Burn Programme. Nairobi, Kenya: World Agroforestry Centre.
47. NASI, R., TABER, A. & VAN VLIET, N. (2011) Empty forests, empty stomachs? Bushmeat and livelihoods in the Congo and Amazon Basins. *International Forestry Review*. 13 (3). p. 355-368.
48. ORTIZ, R. (2013) Food Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data for Bolivia: ZEBALLOS, H. et al. (2011) Seguridad alimentaria en Bolivia. *Coloquios Económicos* 22, La Paz, Bolivia: Fundación Milenio; for Brazil: ACTO-UNEP. (2009) *Geo Amazonia*; for Colombia: ICBF, PMA. (2008) *Mapas de la situación nutricional de Colombia*. Instituto Colombiano de Bienestar Familiar, Bogotá, Colombia: Programa Mundial de Alimentos; for Ecuador: CALERO LEÓN, C.J. (2010) Seguridad alimentaria en el Ecuador desde un enfoque de acceso a alimentos. Unp MSc Thesis. Facultad Latinoamericana de Ciencias Sociales, Quito, Ecuador; for Peru: ZEGARRA MÉNDEZ, E. (2011) Seguridad alimentaria: una propuesta de política para el próximo gobierno. In RODRÍGUEZ, J. et al (ed.) *Opciones de Política Económica en el Perú: 2011-2015*. Fondo Editorial de la Pontificia Universidad Católica del Perú, Lima, Perú. p. 72-106.
49. AMAZON REGIONAL ARTICULATION (ARA). (2011) The Amazon Millennium Goals. CELENTANO, D. & VEDOVETO, M. (eds.) Quito, Ecuador: ARA Regional.
50. CONFALONIERI, U. E.C. & FONSECA, A.F.Q. (2013) Health Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
51. OPS/OMS, MSD. (2007) Atlas de Salud 2005: Bolivia/Servicio Departamental de Salud. Ministerio de Salud y Deportes/Organización Panamericana de la Salud.
52. PATZ, J. A., CONFALONIERI, U.E.C. et al. (2005) Human Health: Ecosystem Regulation of Infectious Diseases. In HASSAN, R., SCHOLLES, R., ASH, N. (eds.) (2005) *Ecosystems and Human Wellbeing: Current State & Trends Assessment*. Millennium Ecosystem Assessment (MEA), Volume 1. Washington DC: Island Press.
53. SHANLEY, P. & LUZ, L. (2003) The impacts of forest degradation on medicinal plant use and implications for health care in eastern Amazonia. *BioScience* 53 (6). p. 573-584.
54. COCA-CASTRO, A. et al. (2013) Land Use Status and Trends in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
55. COCA-CASTRO, A. et al. (2013) Land Use Status and Trends in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
56. CIAT, TNC, & CBI. (2012) Road impact on habitat loss BR 364 Highway in Brazil 2004-2011.
57. COCHRANE, M. A., & BARBER, C. P. (2009) Climate change, human land use and future fires in the Amazon. *Global Change Biology* 15 (3) p. 601-612.
58. GALBRAITH, D. (2011) Risks to Amazonia: A summary of the past, present and future pressures from land use and climate change. In MEIR, P. et al (2011) *Ecosystem Services for Poverty Alleviation in Amazonia*. Global Canopy Programme and University of Edinburgh, UK. Citing COSTA, M. H. & FOLEY, J. A. (2000) Combined effect of deforestation and doubled atmospheric CO₂ concentrations on the climate of Amazonia. *Journal of Climate*. 13, 18–34; SALATI, E. & VOSE, P. B. (1984) Amazon basin — a system in equilibrium. *Science*. 225, 129–138; ELTAHIR, E. A. B. & BRAS, R. L. (1994) Precipitation recycling in the Amazon Basin. *Quarterly Journal of the Royal Meteorological Society*. 120, 861–880.
59. SPRACKLEN, D.V., ARNOLD, S.R., TAYLOR, C.M. (2012) Observations of increased tropical rainfall preceded by air passage over forests. *Nature*. 489. p.282-285. doi: 10.1038/nature11390.
60. SPRACKLEN, D.V., ARNOLD, S.R., TAYLOR, C.M. (2012) Observations of increased tropical rainfall preceded by air passage over forests. *Nature*. 489. p.282-285. doi: 10.1038/nature11390.
61. PASSOS, C. J. & MERGLER, D. (2008) Human mercury exposure and adverse health effects in the Amazon: a review. *Cadernos de Saúde Pública*. 24. p. 503-520.
62. STICKLER, C. M. et al. (2013) Dependence of hydropower energy generation on forests in the Amazon Basin at local and regional scales. *PNAS* [Online]. Available from: www.pnas.org/cgi/doi/10.1073/pnas.1215331110.
63. DAVIDSON, E. A. et al. (2012). The Amazon basin in transition. *Nature*. 481 (7381). p. 321-328.

64. THE NEW YORK TIMES. (2009) Fatal Clashes Erupt in Peru at Roadblock. [Online]. Available from: http://www.nytimes.com/2009/06/06/world/americas/06peru.html?_r=0. [Accessed: 5th February 2013].
65. RAISG. (2012) Amazonía bajo presión. 68 págs. [Online]. Available from: www.raisg.socioambiental.org.
66. MULLIGAN, M. et al. (2013) Water Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
67. AMAZON REGIONAL ARTICULATION (ARA). (2011) The Amazon Millennium Goals. CELENTANO, D. & VEDOVETO, M. (eds.) Quito, Ecuador: ARA Regional.
68. CAMEP. (2013) Mercury in Madre de Dios, Mercury concentrations in Fish and Humans in Puerto Maldonado. Carnegie Amazon Mercury Ecosystem Project, Research Brief #1 March 2013.
69. ECUADOR TIMES. (2013) Derrame de petróleo llegará a aguas brasileñas. [Online]. Available from: <http://www.ecuadortimes.net/es/2013/06/10/derrame-de-petroleo-llegara-a-aguas-brasilenas/>. [Accessed: 1st July 2013].
70. MULLIGAN, M. et al. (2013) Water Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
71. ANDERSON, L. et al. (2011) Counting the costs of the 2005 drought: A preliminary assessment. In MEIR, P. et al. (2011) Ecosystem Services for Poverty Alleviation in Amazonia. Global Canopy Programme and University of Edinburgh, UK.
72. DTN THE PROGRESSIVE FARMER. (2010) Drought disrupts Amazon river transport: Cargill diverting some soy shipments. Reuters, Sao Paulo. [Online]. Available from: http://www.dtnprogressivefarmer.com/dtnag/view/ag/printablePage.do?ID=NEWS_PRINTABLE_PAGE&byPassCache=true&pageLayout=v4&vendorReference=81adb8a8-9bec-43c0-ac3c-07dea59a884d__1284497391640&articleTitle=Drought+Disrupts+Amazon+River+Transport&editionName=DTNagFreeSiteOnline.
73. LA REPUBLICA. (2004) Ducto de gas colapsa y daña zona del Bajo Urubamba. [Online]. Available from: <http://www.larepublica.pe/28-12-2004/ducto-de-gas-colapsa-y-da-na-zona-del-bajo-urubamba>.
74. REUTERS (2012) Brazil hit by new blackout, infrastructure in spotlight. [Online]. Available from: <http://www.reuters.com/article/2012/10/26/brazil-blackout-idUSL1E8LQ1Z120121026>.
75. COX, P. et al. (2008) Increase risk of Amazonian Drought due to decreasing aerosol pollution. *Nature* 453. p. 212–216.
76. LANGERWISCH, F. et al (2012) Potential effects of climate change on inundation patterns in the Amazon Basin. *Hydrol. Earth Syst. Sci. Discuss.* 9. p.261–300.
77. COX, P. et al. (2008) Increase risk of Amazonian Drought due to decreasing aerosol pollution. *Nature* 453. p. 212–216.
78. MULLIGAN, M. et al. (2013) Water Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
79. OMETTO, J. P. et al. (2013) Climate Change and Land Use Change in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
80. MARENGO, J. et al. (2011) Development of regional future climate change scenarios in South America using the Eta CPTEC/HadCM3 climate change projections: Climatology and regional analyses for the Amazon, São Francisco and the Paraná River Basins, *Climate Dynamics*, DOI 10.1007/s00382-011-1155-5.
81. ERICKSEN, P. et al.(2011) Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS Report no. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.
82. OLIVEIRA, L.J.C. et al. (2013) Large-scale expansion of agriculture in Amazonia may be a no-win scenario. *Environ. Res. Lett.* 8 024021 (10pp) doi:10.1088/1748-9326/8/2/024021.
83. ERICKSEN, P. et al (2011) Mapping hotspots of climate change and food insecurity in the global tropics. CCAFS Report no. 5. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.84. LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
85. CONFALONIERI, U. E.C. & FONSECA, A.F.Q. (2013) Health Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project.
86. TORRES, R. & MARENGO, J. (2013) Climate change hotspots over South America: from CMIP3 to CMIP5 multi-model datasets. *Theoretical and Applied Climatology* DOI 10.1007/s00704-013-1030-x.
87. MAPAZ. (2013) Amazon Initiative Map Server © 2009-2011. [Online].Version 1.2 Available from: <http://gismap.ciat.cgiar.org/mapaz/>
88. COE, M.T. et al. (2013) Deforestation and climate feedbacks threaten the ecological integrity of south–south-eastern Amazonia. *Phil Trans R Soc B* 368: 20120155. <http://dx.doi.org/10.1098/rstb.2012.0155> *Phil Trans R Soc B* 368: 20120155. <http://dx.doi.org/10.1098/rstb.2012.0155>

Figures

Figure 1: Amazonia underpins regional water

MARENGO, J.A. et al. (2004) Climatology of the low-level jet east of the Andes as derived from the NCEP–NCAR reanalyses: Characteristics and temporal variability. *Journal of Climate*. 17 (12). p.2261–2280.

GALBRAITH, D. (2011) Risks to Amazonia: A summary of the past, present and future pressures from land use and climate change. In MEIR, P. et al. (2011) *Ecosystem Services for Poverty Alleviation in Amazonia*. Global Canopy Programme and University of Edinburgh, UK. Citing COSTA, M. H. & FOLEY, J. A. (2000) Combined effect of deforestation and doubled atmospheric CO₂ concentrations on the climate of Amazonia. *Journal of Climate*. 13, 18–34; SALATI, E. & VOSE, P. B. (1984) Amazon basin — a system in equilibrium. *Science*. 225, 129–138; ELTAHIR, E. A. B. & BRAS, R. L. (1994) Precipitation recycling in the Amazon Basin. *Quarterly Journal of the Royal Meteorological Society*. 120, 861–880.

SUDRADJAT, A., BRUBAKER, K. L., DIRMEYER, P. A. (2002) Precipitation source/sink connections between the Amazon and La Plata River basins. *American Geophysical Union, Fall Meeting 2002*, abstract #H11A–0830.

Figure 3: Amazonia's export economy

LUCENA, A. et al. (2013) *Energy Security in Amazonia*. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data for Bolivia: CNDC. (2010) *Comité Nacional de Despacho de Carga*. Gross Generation 2010. [Online]. Available at <http://www.cndc.bo/estadisticas/anual.php>; for Brazil: EPE. (2011) *Balanço Energético Nacional 2011*. Rio de Janeiro; for Ecuador: CONELEC. (2012) *Plan Maestro de Electrificación 2012 - 2021*. Quito, Ecuador & CONELEC. *Indicadores del Sector Eléctrico*. [Online]. Available from: <http://www.conelec.gob.ec/indicadores/>; for Peru: MINEM. (2011) *Ministerio de Energía y Minas del Perú*. *Anuario Estadístico de Electricidad 2010*. Lima, Peru & MINEM. (2011) *Ministerio de Energía y Minas del Perú*. *Atlas del Potencial Hidroeléctrico del Perú*. Lima, Perú.

UPC. (2008) *Sistema de Información Productiva Municipal - Unidad de Productividad y Competitividad*. [Online]. Available from: <http://www.upc.gob.bo/ipm/>. [Accessed: 14th May 2013].

LUCENA, A. et al. (2013) *Energy Security in Amazonia*. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from: MHE. (2010) *Ministerio de Hidrocarburos y Energía de Bolivia*. *Anuario Estadístico Gestión 2010*. Producción, Transporte, Refinación, Almacenaje, comercialización e industrialización de hidrocarburos. La Paz, Bolivia & YPFB. (2012) *YPFB Corporación*. 2012. *Boletín Estadístico Gestión 2011*. La Paz, Bolivia.

INSTITUTO BOLIVIANO DE COMERCIO EXTERIOR (IBCE). (2013) [Online]. Available from: <http://ibce.org.bo/documentos/informacion-mercado/2011-2012/Bolivia-Exp.%20de%20100%20ppales%20prod%20segun%20vol%20y%20val,%2011-12.pdf>. [Accessed: 29 May 2013].

INSTITUTO NACIONAL DE ESTADISTICA DE BOLIVIA (INE). (2013) [Online]. Available from: <http://www.ine.gob.bo/indice/general.aspx?codigo=50101>. [Accessed: 5 May 2013].

LUCENA, A. et al. (2013) *Energy Security in Amazonia*. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from: EPE. (2011) *Balanço Energético Nacional 2011*. Rio de Janeiro; ANP. (2011) *Anuário Estatístico Brasileiro do Petróleo, Gás Natural e Biocombustíveis*. Rio de Janeiro; IBP. *Informação estatística de petróleo e gás*. Instituto Brasileiro de Petróleo e Gás e Biocombustíveis [S.l.]: IBP.

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA (IBGE). (2013) [Online]. Available from: http://www.ibge.gov.br/english/estatistica/economia/ppm/2011/default_pdf.shtm.

IBRAM. (2011) *Information and Analyses of The Brazilian Minerals Economy*, 7th edition. [Online]. Available from: <http://www.ibram.org.br/sites/1400/1457/00000364.pdf>.

BRASIL ALICE WEB. (2013) Data for 2012. Using HS Code 1201 for soybean; HS Codes 020120, 020130, 020220, 020230, 020610, 020621, 020622, 020629, 021020, 160250; and HS Code 2601 for iron ore. [Online]. Available from: <http://alicesweb2.mdic.gov.br/>. [Accessed: 10th May 2013].

LUCENA, A. et al. (2013). *Energy Security in Amazonia*. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from: ACP. (2012) *Asociación Colombiana de Petróleo*. *Informe Estadístico Petrolero 2011*. [Online]. Available from: http://www.acp.com.co/index.php?option=com_k2&view=itemlist&task=category&id=6:informe-estad%C3%ADstico-petrolero&Itemid=81.

MINISTERIO DE AGRICULTURA Y DESARROLLO RURAL DE COLOMBIA. (2012) *Anuario Estadístico del Sector Agropecuario y Pesquero 2011, Resultados Evaluaciones Agropecuarias Municipales 2011*, Edición: Dirección de Política Sectorial - Grupo Sistemas de Información. Noviembre 2012 Bogotá, D.C. ISBN: 978-958-97128-8-7.

DIRECCIÓN DE PROMOCIÓN Y CULTURA EXPORTADORA. (2001) *Putumayo Perfil de Comercio Exterior*, agosto 2001.

LUCENA, A. et al. (2013) *Energy Security in Amazonia*. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from BCE. (2012) *Reporte del Sector Petrolero II Trimestre 2012*. Quito, Ecuador, CONELEC. (2012) *Geoportal del CONELEC*. Quito, Ecuador & MEER. (2008) *Políticas y Estrategias para el Cambio de la Matriz Energética del Ecuador*. Quito, Ecuador.

BANCO CENTRAL DEL ECUADOR. (2013) Available from: <http://www.bce.fin.ec/frame.php?CNT=ARB0000766>. [Accessed 18 May 2013 using NANDINA code 2709000000].

INSTITUTO NACIONAL DE ESTADÍSTICA Y CENSOS DE ECUADOR (INEC). (2013) Available from: http://www.inec.gob.ec/estadisticas/index.php?option=com_remository&Itemid=&func=startdown&id=44&lang=es&TB_iframe=true&height=250&width=800

LUCENA, A. et al. (2013) Energy Security in Amazonia. Report for Global Canopy Programme and International Center for Tropical Agriculture as part of the Amazonia Security Agenda project. Data from MINEM. (2011) Ministerio de Energía y Minas del Perú. Anuario Estadístico de Hidrocarburos” 2010. Lima, Peru.

MEM. (2012) Anuario Minero 2011, Ministerio de Energía y Minas, Perú, Abril 2012.

APOYO CONSULTORIA. (2007) Proyecto camisea: Impacto sobre el Mercado del gas natural y estimación de los beneficios económicos. Documento elaborado para el Banco Interamericano de Desarrollo, Mayo 2007.

BACA, J.P., GUERRA, L., VILLEGA, M. (2012) Boletín de exportaciones regionales. Elaborado por el Departamento de Inteligencia Comercial – Asociación de Exportadores del Perú (ADEX).

Figure 4: Extreme drought in Amazonia

LEWIS, S. L. et al. (2011) The 2010 Amazon drought. *Science*, 331 (6017) p. 554 – 554. doi:10.1126/science.1200807

ANDERSON, L. et al. (2011) Counting the costs of the 2005 drought: A preliminary assessment. In MEIR, P. et al. (2011) Ecosystem Services for Poverty Alleviation in Amazonia. Global Canopy Programme and University of Edinburgh, UK.

BROWN, F. et al. (2011) World Resources Report Case Study. Brazil: Drought and Fire Response in the Amazon. World Resources Report, Washington DC.

REUTERS. (2010) Brazil's Amazon region suffers severe drought [Online]. Available from: www.reuters.com/article/2010/10/26/us-brazil-amazon-drought-idUSTRE69P3NC20101026.

DTN THE PROGRESSIVE FARMER. (2010) Drought disrupts Amazon river transport: Cargill diverting some soy shipments. Reuters, Sao Paulo. [Online]. Available from: http://www.dtnprogressivefarmer.com/dtnag/view/ag/printablePage.do?ID=NEWS_PRINTABLE_PAGE&bypassCache=true&pageLayout=v4&vendorReference=81adb8a8-9bec-43c0-ac3c-07dea59a884d_1284497391640&articleTitle=Drought+Disrupts+Amazon+River+Transport&editionName=DTNAgFreeSiteOnline.

MARENGO, J.A. et al. (2011) The drought of 2010 in the context of historical droughts in the Amazon region. *Geophysical Research Letters*. 38 (12).

Figure 5: Climate change hotspots in Amazonia

COE, M.T. et al. (2013) Deforestation and climate feedbacks threaten the ecological integrity of south-south-eastern Amazonia. *Phil Trans R Soc B* 368: 20120155. <http://dx.doi.org/10.1098/rstb.2012.0155>

MAPAZ. (2013) Amazon Initiative Map Server © 2009-2011. Version 1.2 [Online]. Available from: <http://gismap.ciat.cgiar.org/mapaz/>.

TORRES, R. & MARENGO, J. (2013) Climate change hotspots over South America: from CMIP3 to CMIP5 multi-model datasets. *Theoretical and Applied Climatology* DOI 10.1007/s00704-013-1030-x.

Figure 6: The Amazonia Security Agenda

OLIVEIRA, L.J.C. et al. (2013) Large-scale expansion of agriculture in Amazonia may be a no-win scenario. *Environ. Res. Lett.* 8 024021 (10pp) doi:10.1088/1748-9326/8/2/024021.

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