AMAZALERT Delivery Report

Title	AMAZALERT Final project summary for policy makers
Work Package Number	6
Delivery number	D6.7
First author	Bart Kruijt
Co-authors	Dorian Frieden, Han Dolman, Patrick Meir, Ana-Paula Aguiar, Kasper Kok, Neil Bird and (co-) work package leaders of the AMAZALERT project.
Date of completion	30/11/2014
Name leading Work Package Leader	JOANNEUM RESEARCH
Approved by the Leading Work Package Leader	YES

To complete by the Coordinator

Approved by the Coordinator	YES
Date of approval by the Coordinator	30/11/2014

AMAZALERT

Project summary and recommendations for policy makers

Bart Kruijt, Dorian Frieden, Han Dolman, Patrick Meir, Ana-Paula Aguiar, Kasper Kok, Neil Bird and (co-) work package leaders of the AMAZALERT project.

Updated: 12 December 2014

"The AMAZALERT project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 282664, and was co-funded by many national agencies an institutes."

Contents

Project summaries, products, general information, background, etc . can be downloaded at: www.eu-amazalert.org

Group photo at AMAZALERT kick-off meeting, October 2011. Several people are missing on this photo.

AMAZALERT policy recommendations

1. **Continued protection of standing primary forests is essential.** It is important to maintain the buffering capacity of forests against the impact of climate change on regional water cycles, the carbon cycle, and to conserve the many ecosystem services that depend on the integrity of Amazon forests.

2. **The effectiveness of policies needs to be enhanced in multiple ways.** By improving spatial planning using coherent conservation strategies, formalising land tenure and ensuring effective law enforcement, that overall aims to maximise the ecosystem functions of Amazon forests such as water recycling, carbon storage and as a store of biodiversity.

3. **Long-term monitoring systems need to be sustained and improved**. Due to the uncertainty of the future trajectory of forest degradation, sustained long-term monitoring of the environmental conditions in, and state of, the forest is of crucial importance to detect the possible onset of its instability in a timely manner.

4. **The EU should support regional initiatives.** The most effective policy action available to the EU is to support efforts in Amazonia to towards a sustainable future, including actions to reduce deforestation because of their high likelihood of success and good fit within the national context.

5. **European investments and laws have an impact on Amazonia.** Environmental and social impacts on Amazonia should be considered carefully in European investments and corresponding legal frameworks.

6. **Certification should be stimulated.** Enhancing demand for products from the region that meet high environmental standards may reduce direct negative impacts and will generate momentum towards an overall increase in environmental standards.

7. **The EU can play an important role in the international context.** The EU is most effective in their involvement in strengthening environmental standards in trade on a global level would enhance the impact of other countries and organisations that have a more important influence on Amazonia.

AMAZALERT research recommendations

1. **Investigating ecosystem functioning is still crucial.** Future research on understanding the risks of Amazon forest degradation should focus on the dependence of forest stability on the balance and interactions of CO_2 fertilisation, temperature increase, drought and fire dynamics.

2. **Extensive monitoring of the state of Amazonia should be stimulated.** Furthermore, basin-wide research should emphasise the understanding of regional variability in vulnerability; building of comprehensive time series and databases on the condition of the forests, regional climate and socio-economic indicators; and identifying actions that maximise the resilience to climate change of the ecosystem services provided by forests.

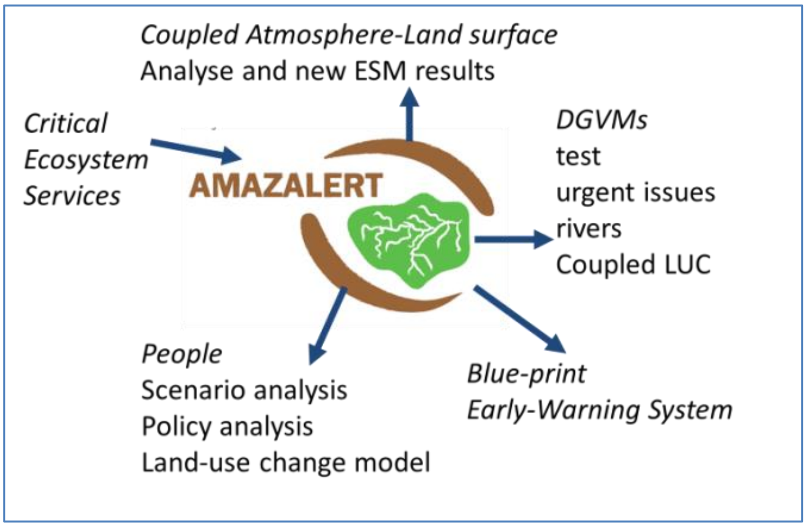
3. **Scientific results need to be shared with policy in an efficient way.** Research is needed on improving the science-policy interface and the uptake of state-of-the-art science in policy making. Novel methods are needed to involve decision makers.

4. **Understanding of land-use change needs to be refined.** The complexity of interactions between multiple drivers acting at multiple scales needs to be studied so as to better understand and model the dynamics of land-use change.

Introduction

Amazonia is under threat through the combined effects of unsustainable regional development and climate change. As summarised in the IPCC reports of 2007 and 2014 studies in the past ten years have indicated that these changes can lead to deforestation, regional disturbance of temperatures and the water cycle, as well as loss of carbon stocks and biodiversity. In turn, these changes can lead to forest loss, droughts, low river levels, floods, loss of hydropower energy and many other ecosystem services and even enhanced risk of diseases and loss of agricultural productivity.

We are only beginning to understand and quantify these threats individually. For example we know that forests are bio diverse, carbon rich and sensitive to climate change and climate extremes, that fire incidence rises substantially in the presence of drought and land use, and that forest loss might affect regional-scale evaporation rates, potentially affecting water supply within Amazonia and beyond its limits, to the bread-basket of South America, the La Plata Basin. We also know that the changing variability of climate can lead to floods as well as droughts in the region, affecting hydropower and agricultural productivity. However, what has been missing until recently has been the capability to combine these different areas of knowledge within one or a few modelling frameworks to understand in an integrated way how the system might respond to coupled global change drivers, and to focus new measurements and new knowledge-gathering processes on our key gaps in biophysical and socio-economic understanding. By combining and developing such model frameworks and data-providing networks, we can develop capacity to predict and identify the possible circumstances leading to loss of Amazonian ecosystem service provision, thereby creating the basis for an 'early warning system' that increases societal resilience and improves our capability to avoid large scale or rapid decline of one of the world's key biomes, the forests of Amazonia.



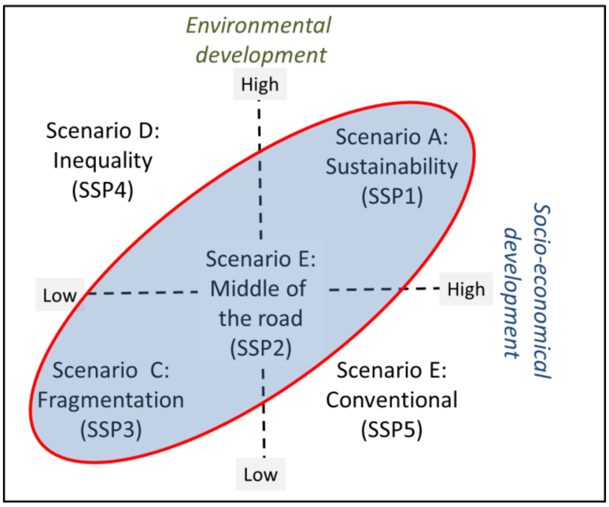
The AMAZALERT project (2011-2014, a consortium of 14 institutes in Europe and south-America, funded by EU-FP7 and national funds) has been pioneering the multi-level integrated analysis needed to address the environmental and societal risks and aspirations described above. The project has i) addressed the uncertainties and provided novel insight into the likelihood of future change in vegetation, water and carbon cycles in the forests of Amazonia as a consequence of climate change and deforestation; ii) developed new land use scenarios and discussed regional and global policies for the region; and iii) analysed the possibilities for identification and prevention of the large-scale loss of ecosystem services.

AMAZALERT research results

The results of the project have been summarised in a number of integrated messages and recommendations. In this summary we provide the key messages and support these with key project results. More detailed project results can be found in project reports and publications, accessible through www.eu-amazalert.org.

Amazon land-use scenarios

Research result 1:
AMAZALERT produced updated qualitative and quantitative land use scenarios for the Brazilian Amazon, capturing the current contrasting trends for the region. Reflecting stakeholder views, scenarios range from having 80% of the original forest preserved, and a large regeneration process, to having 50% deforested by 2100.



This scenario approach was participatory, involving representatives of civil society, the productive sector and government. The workshops also addressed possible (policy) solutions within Brazil and possible strategies from Europe. One of the objectives of the new scenarios was to consider a broader sustainability discussion, while being aligned to global scenarios. The scenarios vary from Low to High Social Development and High to Low Environmental Development, and are aligned to the new IPCC AR5 Socio-Economic pathways. The methods combined exploratory and normative approaches, addressing policy options to build a trajectory towards sustainability, synthesised in Box 1 (see under message 8). Policy options for reducing deforestation even in the worst scenarios were also discussed in some of the workshops (see result 8).

These qualitative scenarios were transformed to explicit land-use models using the open-source platform LuccME (www.terrame.org/luccme). The resulting annual land use maps (2005-2100, fig 1), were used to explore the interactions of deforestation with the dynamics of the vegetation, hydrology and climate, using various Earth system models.

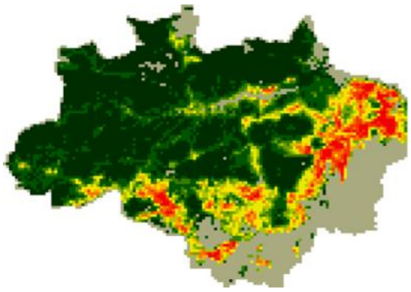
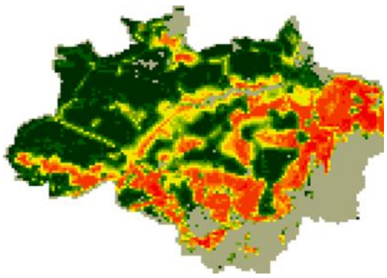


Figure 1a - Scenario a) situation 2050



b) Scenario C— situation 2050

Amazon forest services

Research result 2:
Both stakeholder consultations and AMAZALERT modelling confirm that Amazon forests are of crucial importance for a broad set of services such as safeguarding regional water recycling and carbon storage.

The forests of the Amazon and their biomass are essential to maintain rains, control floods and droughts, store CO2 from the atmosphere, and many other ecosystem services. Stakeholders in particular point out the importance of the practical services 'near to the people' such as food safety, river transportation, hydropower or disease control. Degradation of biomass will lead to degradation of these services.

AMAZALERT has brought together a range of global climate predictions from the CMIP5 studies, improved several atmospheric and land surface models and combined them with new scenarios for regional land-use change to assess the likely impact on vegetation and water in the Amazon, in the 21st century.

Model simulations using scenarios of deforestation developed under AMAZALERT have been carried out to investigate the effects of alternative deforestation futures. In coupled models, the effect of imposing the high land use scenario C in the Amazon basin results in reductions in evapotranspiration and precipitation (Figure 1) in Amazonia compared to the standard CMIP5 projection (RCP8.5).

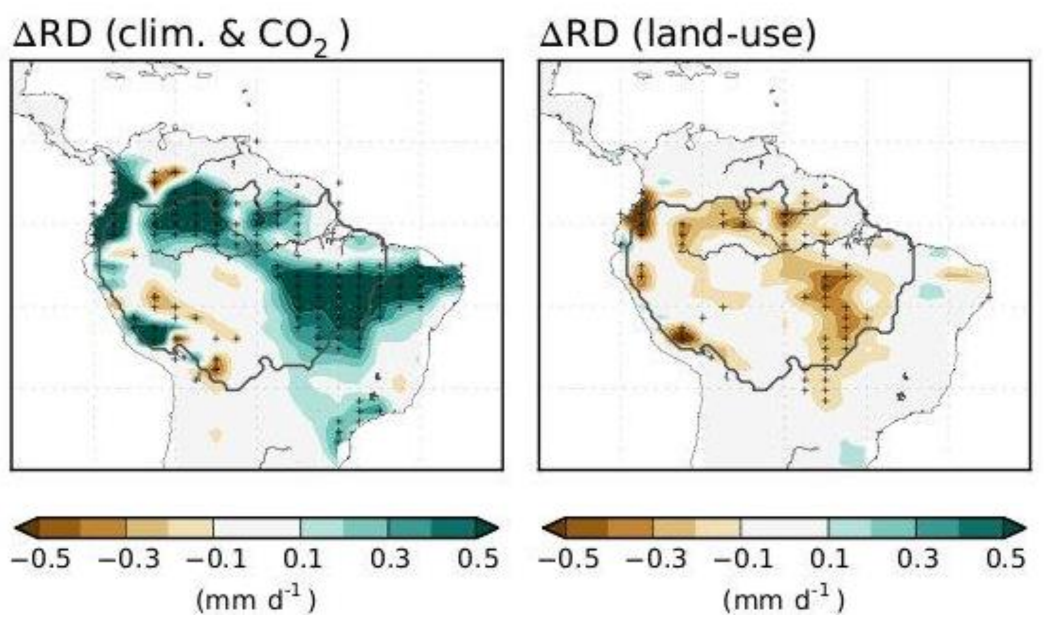


Figure 1 Effects on annual average daily runoff (RD) under high land-use change and climate change (IPSL-CM5A model)

Impacts of climate change and deforestation

Research result 3:
AMAZALERT models show that if deforestation is kept low, it seems unlikely that climate change alone will cause dramatic losses by 2100 in the remaining forest.

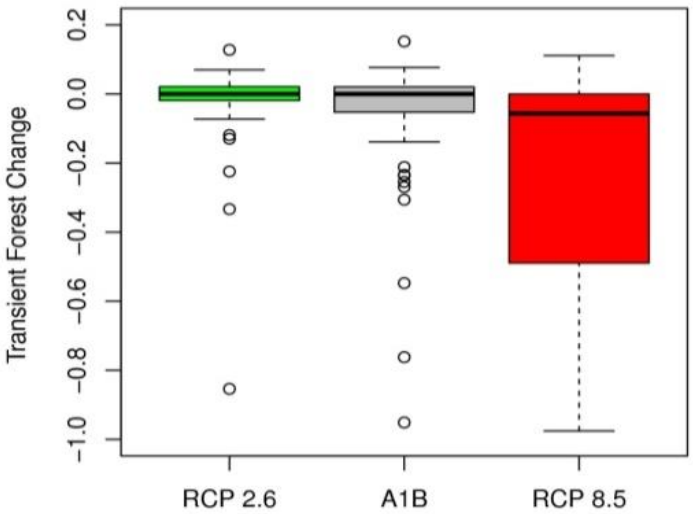


Figure 2. Relative change in Amazon forest area under three different combined development and climate scenarios.

By combining experimental data and simulations using large ensembles of models, AMAZALERT has found that when deforestation is kept to a minimum, projected changes in climate alone seem unlikely to bring about large-scale forest die-back. Figure 2 shows the forest response to climate change by 2100 according to three greenhouse gas concentration scenarios as simulated by an ensemble of the HadCM3C climate-carbon cycle model. Although there is a range of responses, risk of forest loss increases with the emissions scenario severity. On average the forest is projected to remain largely unchanged in extent in the first two scenarios. In the third – and strongest – scenario (RCP8.5), the mean average reduction in forest cover remains marginal but the risk of substantial loss is significant, whilst the probability of forest gain is minimal; in this last scenario, however there is much greater uncertainty in the extent of possible forest loss, ranging from almost no loss to 50% or more.

Unknowns, new evidence and uncertainties

Research result 4:

Uncertainties remain regarding the sensitivity of Amazon forests to climate change, particularly related to CO2 fertilisation, fire dynamics, incidence of drought, as well as to the trajectory of socio-economic development.

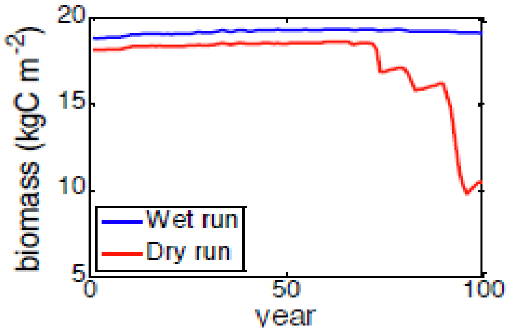


Figure 3. Simulations with a very simple model, showing change of biomass under a wet and a dry climate

Despite its relative resilience if deforestations stays low, AMAZALERT has shown that severe degradation of Amazonia is possible when severe climate change and deforestation progress simultaneously. However the type of change can vary strongly and can be difficult to predict, because signals of change may come only after a biophysical threshold has been passed when decline will already be rapid or irreversible (Figure 3). Early warning for such change will therefore also have to be approached from a broad perspective. Here, basin-wide monitoring of climate change and the frequency of climate extremes, moisture availability, biomass and carbon exchange metrics, will need to make combined use of new and existing networks, both *in situ* and using remote observation (airborne or space borne), to detect large-scale risk of the loss of ecosystem stability, and to help predict likely high-risk scenarios. Thresholds should be defined that account for society’s coping capacity as well as with the uncertainty in prediction of natural ecosystem degradation or instability. In this envisioned early warning system (EWS), new scientific insight and technical capability should be constantly adopted and tested for effectiveness (Figure 4).

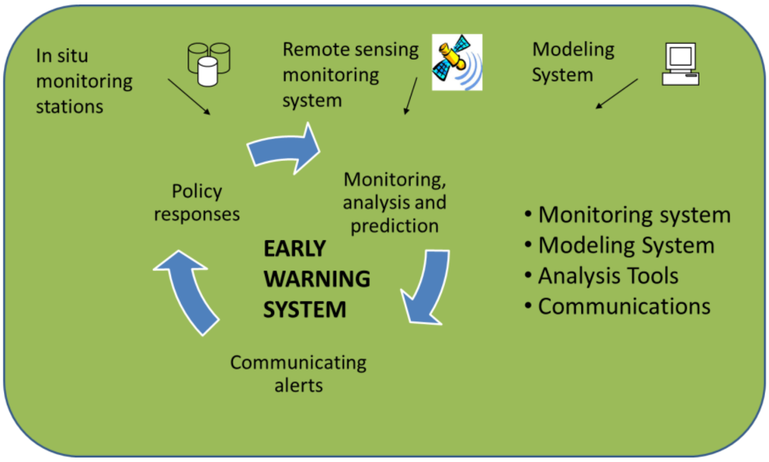


Figure 4 The conceptual basis for an operational early warning data gathering and analysis system (EWS) designed to provide advance warning of abrupt changes (losses) in ecosystem service provision by forest of the Amazon basin.

Research result 5:
New evidence suggests that the carbon gain in the forests is not very sensitive to increasing temperatures, and that some species are surprisingly tolerant of drought, whilst others are not. These findings suggest the resilience of Amazonian forests to climate change may be greater than previously thought, but species composition may change.

Novel field data collection in AMAZALERT has focused on quantifying the effects of increased temperature on photosynthesis and on understanding the processes governing differential species mortality during drought. Leaf warming experiments carried out in the canopy of experimentally droughted and non-droughted forest did not suggest that the maximum rate of photosynthesis changed significantly following warming, and that current vegetation models are generally overestimating temperature sensitivity (Fig 5 and 6). In relation to drought sensitivity, our data from experimentally droughted forest show that some species, and large trees, are particularly vulnerable to drought, potentially risking significant biomass losses. These mortality differences appear to be related with increases in respiration (CO2 emission to the atmosphere) in drought-sensitive species. Overall, these data suggest some resistance to climate stress in carbon uptake, but more sensitivity in respiration. The net effect means that a long-term change in the species composition and structure of the forest under extended drought and warming is likely (if no fire occurs), together with an increase in the amount of dead and decomposing wood.

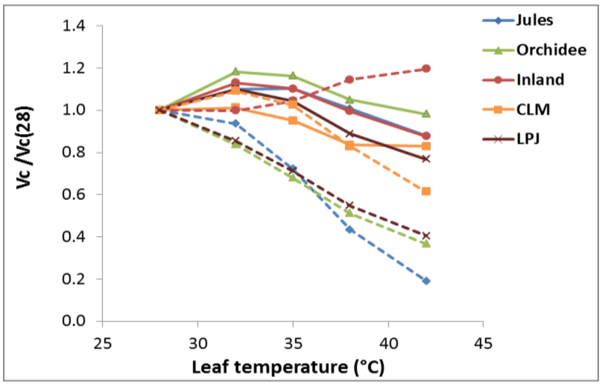


Figure 5. Photosynthesis dependence on temperature as measured (solid) and in models (dotted)

Figure 6. Photosynthesis measurements performed from a canopy tower (left), leaf with heater underneath (right).

Research result 6:
The uncertainties imply that in the worst case, with high deforestation, up to 50% of forests could disappear or degrade, which would promote drying effects on the regional climate. However, in the best case, forest degradation could be limited to the current 20% of Amazonia, with minimal effects on regional climate.

We defined three extreme land use scenarios (A and C, with C2 representing high biofuel targets and C1 no such targets) linking different land use policies to possible impacts on the provision of ecosystem services in Amazonia. The resulting land cover maps were used to estimate the impacts in the provision of key ecosystem services in the region, using four dynamic vegetation models: INLAND (Brazilian), ORCHIDEE (French), LPJml (German) and JULES (British). Figure 7 shows, for the ORCHIDEE model, consequences for the change in evaporation of the three land-use scenarios, relative to natural cover only. There is a clear impact of land use change on the water cycle in the entire Amazon basin, with increasing removal of forest area leading to significant decreases in evaporative flux, increased variability in river flow and lower potential for hydropower (figure 8). However, the magnitude and spatial pattern of the simulated impact depends on the model used, which means there is still substantial uncertainty about the precise magnitude and location of these impacts.

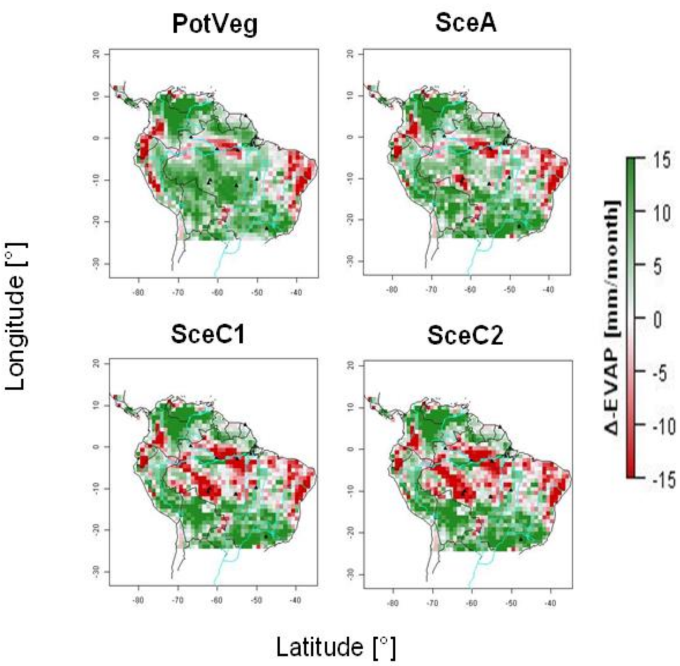


Figure 7. Simulations of change in evapotranspiration under three land-use scenarios, using the ORCHIDEE model

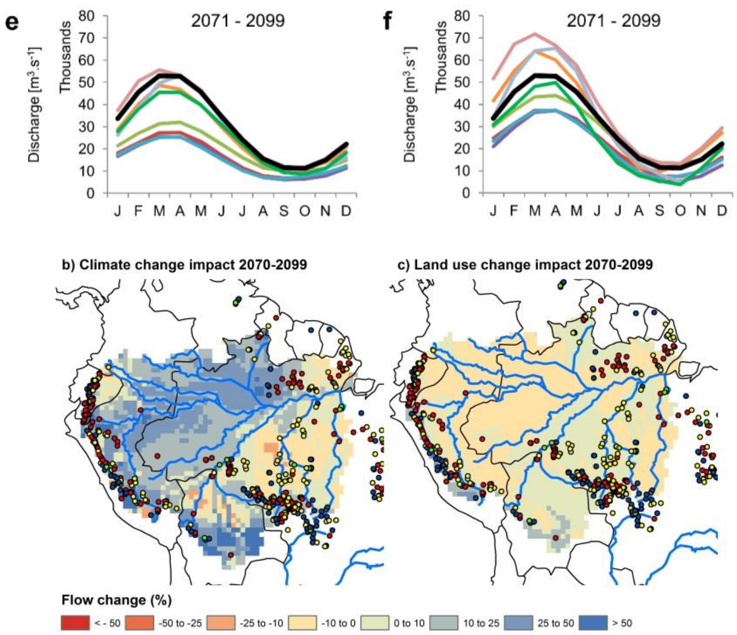


Figure 5 Simulated hydrographs of Rio Madeira (top, Brazilian model) and discharge (bottom, LPJml model), for climate change only (left) and including LUC (right).

Geographic differences in vulnerability

Research result 7:

Observations and modelling studies in AMAZALERT show that the forests of the south and southeast of the Amazon Basin are more vulnerable to forest loss and degradation by droughts than forests in the north and northwest, because of higher pressures in this region from anthropogenic activity and climate change.

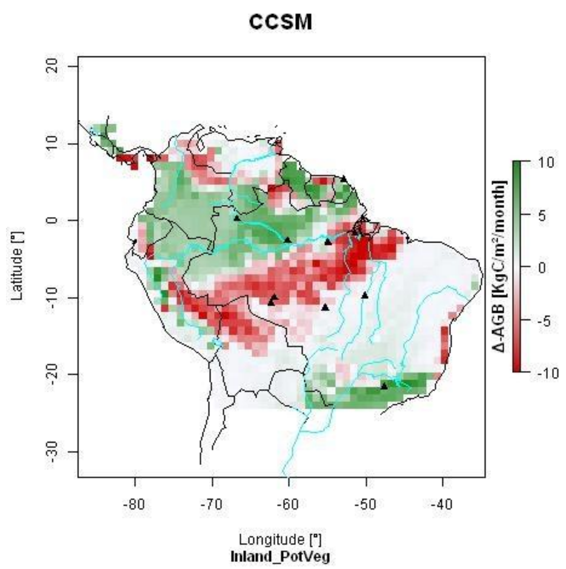


Figure9. Simulated change in biomass without deforestation under extreme climate change (Brazilian INLAND model)

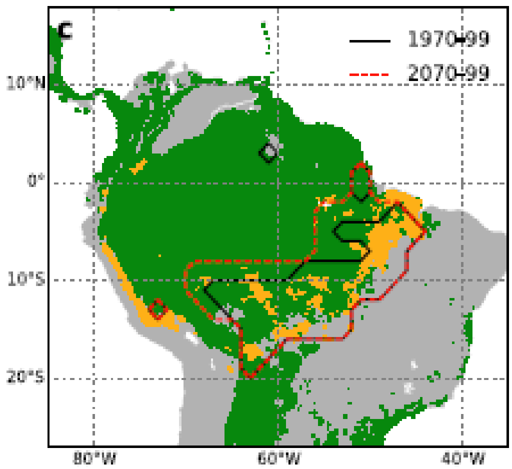


Figure 10. Simulated change in the extent of area with dry season length > 3 months in CMIP5 simulations under high emissions (RCP 8.5)

The work undertaken for AMAZALERT indicates that the southern and eastern Amazon Basin is more vulnerable to changes than the north and northwest. In coupled model HadGEM2-ES, it was found that underlying conditions can affect the drying impacts of deforestation. In areas with a long dry season – the south and east – deforestation caused a bigger reduction in evapotranspiration than areas where the dry season is short – the north-west. The range of deforestation scenarios along with three climate scenarios were used to drive four Dynamic Global Vegetation Models to 2100. Results (figure 9) show that biomass increases in the northern Amazon but in the vulnerable south-east it declines, even in intact forests. Further, the combined effects of land use change, climate change and fire were investigated in a land surface model (the Brazilian Earth System Model, BESM). Results show that impacts of climate change including higher temperatures and increased dry season length are enhanced by including land use change and fire.

The current generation of climate models (CMIP5) simulates annual warming in Amazonia relative to late 20th century levels of between 0.8°C and 7.3°C, capturing the range from a low-sensitivity model under a low emissions scenario (RCP2.6) to a high-sensitivity model under a high emissions scenario (RCP8.5). Although projections of annual rainfall changes are mixed, under RCP8.5 >80% of models project drier and longer dry seasons, especially in the south and east.

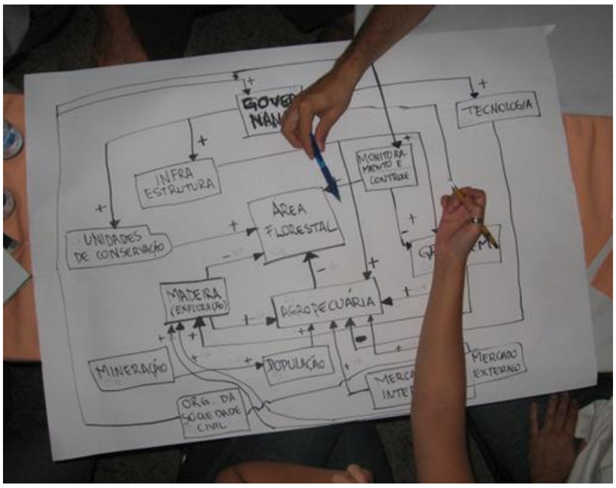
Changes in dry season length have already been observed in Amazonia, with earlier onset and later demise seen in the last decades, such as during the devastating drought year of 2010. Dry season length has a strong relationship with forest area, and the region with long dry season is projected to expand in the future (figure 10). Drought severely impacts the occurrence of fires.

Drivers and policies for deforestation reduction

Research result 8:

Stakeholder consultations suggest that the impact of trade of Amazonian countries with the EU on Amazon deforestation is significant but less than the impacts of (i) trade of Amazonian countries with other regions and (ii) domestic consumption. A strong civil society and social cohesion were indicated by stakeholders as important elements for the prevention of deforestation in different future scenarios.

Beside the scenario participatory process (Research Result 1), interviews and other workshops were held in the scope of AMAZALERT to discuss specifically drivers and actions to decrease deforestation, in any of the giving scenarios.



Currently, the three most important drivers of deforestation are livestock, mechanised agriculture and associated logging, together with underlying causes related to land tenure. These are closely connected to national and international trade of Amazon products. Drivers are projected to change towards 2050, with important drivers now including large infrastructure programmes and mining for oil and gas. However, as before these are strongly related to domestic consumption and interregional trade.

Stakeholders during the European workshop indicated that Europe could potentially have a limited, but significant, impact on deforestation in the Amazon. They suggested that all efforts together could result in a 25% decrease of deforestation rates. Yet, as long as demands for agricultural products and energy from other countries, such as China, continue to increase export might simply shift from Europe to elsewhere. In any case, EU impact is less than from other importing regions and domestic consumption. Stakeholders highlighted the importance of the EU's involvement in international initiatives. These should include the establishment and strengthening of trade standards and certification. It was suggested that EU induced deforestation drivers could be addressed by reduced import through increased efficiency at the demand-side and of production within the EU. At the same time, stakeholders suggested that enhancing demand for products that meet high environmental standards may reduce negative implications and will generate momentum towards an overall increase in environmental standards. One example that was discussed to have shown a positive impact is the soy moratorium.

Besides the influence of trade on deforestation, investments such as in hydropower and mining were mentioned by stakeholders as being important. Stakeholders also perceived the strengthening of the civil society and social cohesion as important given its potentially major role in reducing future deforestation in different development scenarios. Domestic actions within the Amazon nations were stated to be of highest priority due to their proven success in reducing deforestation and the importance of measures coming from within a country (see Research Result 1).

Box 1 – Synthesis of actions towards a sustainable future (AMAZALERT stakeholder scenario workshop results)

(a) MONITORING SYSTEMS: continuation and enhancement of the satellite based monitoring systems initiated at PPCDAM, considered as the key aspect to control deforestation. This includes the development of new systems (based on new sensors, for instance), and expansion to other biomes, to avoid leakages.

(b) INTEGRATED TERRITORIAL PLANNING: consolidation and enhancement of multiple instruments for territorial and land use planning, in order to concomitantly regulate pressure for land, create sustainable economic alternatives and integrate social programs at a territorial basis. This includes private and public lands (such as conservation units, indigenous lands, settlements), rural and urban areas.

(c) CITIES RESTRUCTURING: Strengthening of cities to create an interconnected network of medium-sized cities, with infrastructure, proper network of services and education to meet the demands of sustainability.

(d) LARGE INVESTMENTS PLANNING: Planning for the implementation of large projects (including infrastructure and mining) combined to the integrated territorial planning (item B), avoiding the boom-bust economies of the cities. In the case of infrastructure, planning geared both to the needs of the local population (river transport, for example), as well as market demands (commodities production flow through waterways).

(e) LEGAL FRAMEWORK PROTECTION: enforcement and enhancement of the legislation governing the access to natural resources and land use, creating mechanisms to balance the influence of macroeconomic interests in modifying legal marks at the expense of regional, social and environmental aspects.