

UN-REDD PROGRAMME



Using Spatial Planning Software to Support REDD+ Decisions: an Application of Marxan

UN-REDD PROGRAMME

13 December 2013

The UN-REDD Programme is the United Nations Collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in September 2008 to assist developing countries prepare and implement national REDD+ strategies, and builds on the convening power and expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP).

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This publication was funded by the National Programme of the Democratic Republic of the Congo.

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Citation: Goodman L., Bodin B., Trumper K., Miles L., Deguignet M., Hallosserie A. (2013). Using spatial planning software to support REDD+ decisions: an application of Marxan. Prepared on behalf of the UN-REDD Programme. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Acknowledgements: With many thanks to the National Programme of the Democratic Republic of the Congo.



1. Executive summary

REDD+ has the potential to deliver multiple benefits beyond carbon, for example through the provision of improved hydrological services from afforestation and cultural benefits from forest protection (Musampa Kamungandu et al., 2012). However, there are also potential risks from REDD+, for example if an increase in fast growing planted forests results from REDD+, natural landscapes low in carbon but high in biodiversity may be cleared as a result. REDD+ safeguards mitigate potential risks from REDD+ while enhancing the potential benefits. Parties to the UNFCCC have agreed to promote and support a set of social and environmental safeguards when implementing REDD+. The UN-REDD Programme has developed various tools to support countries to address the UNFCCC safeguards when planning for REDD+, including UN-REDD Programme Social and Environmental Principles and Criteria.

A strategy to promote and support the UNFCCC safeguards is the use of spatial analysis of the relationship between multiple benefits, to support spatial planning for the location of different REDD+ actions. Highlighting where climate and environmental benefits do or do not overlap or are at risk from REDD+ allows both identification of priority areas for REDD+ implementation, and areas where multiple benefits might trade off with each other. Spatial analysis may also be useful to demonstrate where activities complimentary to existing REDD+ interventions are when choosing where new activities should be implemented. Other considerations countries may have in spatial planning are identifying areas of competing land pressures (agriculture, mining) and understanding the costs of implementing REDD+ interventions.

Marxan (Ball, Possingham, & Watts, 2009) is a type of spatial planning software, originally designed for spatially planning nature reserves and protected areas, particularly in the ocean. Marxan can also be used for REDD+ planning, in particular to demonstrate where priority areas for REDD+ actions could be implemented when there are too many considerations for the solution to be obvious. However the tool may not always be appropriate, given it does not readily deal with socio-economic dimensions, and seeks to meet minimum user targets rather than maximise targets for a given budget. Countries may consider using Marxan for REDD+ under the following circumstances:

- Decisions have been taken on which REDD+ interventions will be used, and/or a REDD+ strategy has been drafted, yet there is still uncertainty on where some or all REDD+ interventions will be located;
- There has been awareness raising on REDD+, and Free Prior Informed Consent (FPIC) on the content of the national strategy, meaning that a stakeholder engagement exercise can be carried out resulting in clearly defined, quantitative REDD+ targets for the climate, biodiversity and ecosystem services;
- There is spatially explicit data available for the area of interest from previous initiatives or studies;
- There is technical capacity in country to carry out the exercise and resource persons available for support;
- Decision makers want to know where targets for a REDD+ intervention can be met at the least cost, rather than how benefits can be maximised while not exceeding a set cost level, or where to achieve the greatest benefits in relation to costs;

- Decision-makers are comfortable in specifying quantitative targets for REDD+ interventions;
- It would not be possible to consider all the important variables for locating REDD+ interventions without software.

In order that the priority areas selected for REDD+ are appropriate and take into account the needs of the stakeholders, several distinct steps should be followed. This is not just good practice, it is an essential component of ensuring that the outcome will be successful and the contribution of spatial planning to the REDD+ strategy useful. There is extensive discussion on the steps for using Marxan in the Marxan Good Practice Guide. A relevant message from the guide is that Marxan will not help to set REDD+ objectives, to ensure that the right stakeholders are involved or to understand whether the datasets being used are robust. This will be achieved through a properly planned exercise, led by informed decision makers and supported by critical analysis.

To demonstrate how Marxan can be used for REDD+ planning, this manual contains an illustration of the steps that the DRC would need to go through with Marxan to identify priority areas for one potential REDD+ action: the expansion of forêts classées – forest inside protected areas such as national parks and hunting concessions. The DRC is an appropriate country for this exercise since it has a draft REDD+ strategy but has yet to identify locations for the REDD+ actions listed in it, and capacity in using this tool is timely given that from 2014 it is anticipated that a World Bank-led forest zoning processes will start in the country. However, the objective of the demonstration contained within this manual is to support the training of technical persons interested in using Marxan for REDD+, not to prioritise areas for REDD+ in the DRC. A draft output, that is based on priorities identified in a policy session organised in collaboration with the National Co-Ordination team, is below:

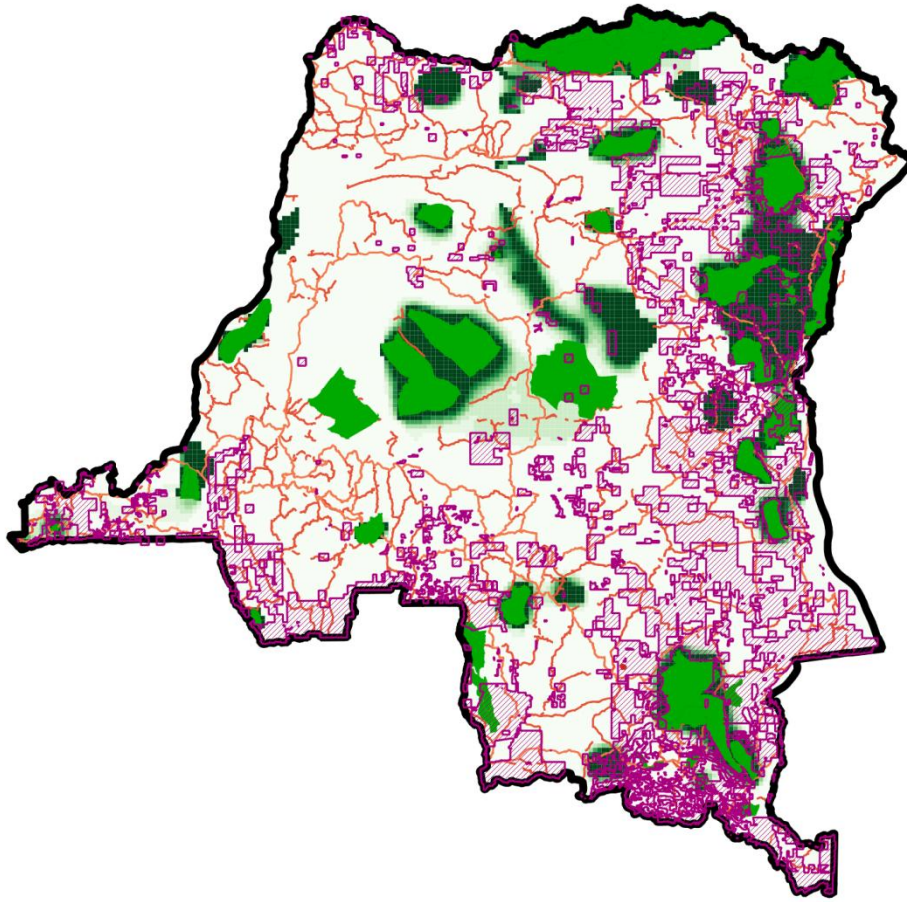


Figure 1 - Draft demonstration output from Marxan. The darker the shade of green, the higher its priority for forêts classées, the roads are in orange and the forest concessions in purple. The light green delineates where forêts classées already exists

Key to the success of using Marxan for REDD+ is communicating the results transparently and in a way that can inform decisions. It is therefore important to display the information so that the inputs can be directly related to the output priority areas for REDD+. It is also important that the format used to communicate results is appropriate, this could be digital or in report form, as long as it can be used to inform for real spatial decisions. It may also be important to demonstrate the impacts of using different datasets for the same target (e.g. the impact of using the IUCN ranges of vulnerable bird species or the Key Biodiversity Areas), and explain why choices were made to include certain datasets. It is anticipated that presentations of results to decision makers will be iterative, in response to reactions to the impact of varying the targets.

A final and important note is that while Marxan may be useful for identifying REDD+ actions, it is not the only tool and may not be the best in a developing country context. Producing the demonstration for the DRC took several months and resources that may not always be available in a developing country context. It is therefore proposed that Marxan be considered only as one of a suite of tools that can contribute to mitigating risks from REDD+, and enhancing potential benefits.

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2. Information on how to use Marxan

This manual contains information on how Marxan can be used for REDD+ planning. It aims to complement the extensive training materials online which can be used to learn how to use the software itself, or the best practices guidance available on how it should be used in systematic conservation planning. The expected audience of this manual are people:

- who would like a basic understanding of planning for multiple benefits from REDD+, and a tool available to support one of the steps involved;
- who want to understand whether or not Marxan is an appropriate tool for use in their REDD+ planning process;
- who are already familiar with Marxan and would like to understand how it could be used for REDD+.

The manual will also serve as a training resource on using Marxan for REDD+. There are also tutorials for applying Marxan for REDD+ available from UNEP-WCMC (email ccb@unep-wcmc.org) which could be used independently or in a workshop by those learning to use Marxan for REDD+.

More general Marxan training resources can be found below:

Marxan software download: <http://www.uq.edu.au/marxan/marxan-software>

Marxan user manual: <http://www.uq.edu.au/marxan/index.html?page=77823>

Marxan online tutorial: <http://www.uq.edu.au/marxan/tutorial/toc.html>

Marxan best practices guide: <http://www.uq.edu.au/marxan/index.html?page=77823>

3. What are the Cancun safeguards and multiple benefits?

Section summary

REDD+ has the potential to deliver multiple benefits beyond carbon, for example through the provision of improved hydrological services from afforestation and cultural benefits from forest protection. Implementing REDD+ safeguards mitigates against risks from REDD+ and enhances these benefits. Parties to the UNFCCC have agreed to promote and support social and environmental safeguards when implementing REDD+. The UN-REDD Programme has developed various tools to support countries to address safeguards when planning for REDD+.

REDD+ (Reducing Emissions from Deforestation and forest Degradation¹) is a mechanism being developed under the UNFCCC² to combat climate change by providing incentives for changing the ways in which forests are used and managed, so that emissions of greenhouse gases from forests are reduced and carbon sequestration is increased.

REDD+ could result in many different interventions in country, such as protecting forests from illegal logging or rehabilitating degraded forest areas.

REDD+ has the potential to deliver benefits beyond carbon, for example, it can promote biodiversity conservation and secure ecosystem services from forests such as water regulation, livelihood generation and non-timber forest products. All benefits from REDD+ including carbon benefits are referred to as “multiple benefits”. REDD+ may also involve some social and environmental risks; for example displacing the factors causing deforestation to other areas. REDD+ safeguards are intended to help guard against risks and enhance benefits from REDD+.

In the “Cancun Agreements” of 2010 (see box 1), Parties to the UNFCCC agreed a set of social and environmental safeguards to be supported and promoted by countries that implement REDD+ activities. These safeguards are necessarily general given that they apply to all REDD+ countries. The following topics are covered by the safeguards:

- consistency with national forest programmes and international agreements;
- forest governance;
- knowledge and rights of indigenous peoples;
- full and effective participation of REDD+ stakeholders;
- no conversion of natural forests to plantations;
- conservation of ecosystem services from natural forest and biological diversity;
- enhancement of social and environmental benefits;
- permanence of emission reductions.
- displacement of emissions from one area to another;

¹ The "+" indicates the inclusion of the following three activities: conservation of forest carbon stocks, sustainable management of forests and enhancement of forest carbon stocks.

² United Nations Framework Convention on Climate Change

Box 1 – The Cancun Safeguards (UNFCCC decision, 2010)

2. When undertaking...[REDD+]... the following safeguards should be promoted and supported:

(a) Actions complement or are consistent with the objectives of national forest programmes and relevant international conventions and agreements;

(b) Transparent and effective national forest governance structures, taking into account national legislation and sovereignty;

(c) Respect for the knowledge and rights of indigenous peoples and members of local communities, by taking into account relevant international obligations, national circumstances and laws, and noting that the United Nations General Assembly has adopted the United Nations Declaration on the Rights of Indigenous Peoples;

(d) The full and effective participation of relevant stakeholders, in particular, indigenous peoples and local communities, in actions referred to in paragraphs 70 and 72 of this decision;

4. Why is REDD+ spatial planning needed for the Cancun safeguards and multiple benefits?

Section summary

Spatial planning is a robust way to enhance benefits and reduce risks from REDD+. Highlighting where climate and environmental benefits and areas important for biodiversity do or do not overlap or are at risk from REDD+ can support the planning process. It may also be useful to demonstrate activities complementary to existing REDD+ interventions when choosing where new activities should be implemented. Other considerations countries may have in spatial planning are identifying areas of competing land pressures (agriculture, mining) and understanding the costs of implementing REDD+ interventions.

What REDD+ intervention is implemented and where will determine whether many of the Cancun agreements in Box 1 are supported, and how a country can get the most out of REDD+ both socially and environmentally. Spatial planning therefore has a large role to play during REDD+ preparedness. The following questions can be considered when locating REDD+ interventions, each will subsequently be outlined in more detail in the latter part of the section:

1. Where are initiatives complementary to REDD+ already being implemented?
2. Where are areas where social and environmental benefits can be enhanced by REDD+ interventions?
3. Where are areas where REDD+ interventions pose social and environmental risks?
4. Where could mutually exclusive REDD+ interventions result in one benefit being lost and another gained (i.e. where are potential tradeoffs)?
5. Where are there potentially competing land demands from other economic sectors not related to REDD+?
6. Where are the costs of REDD+ interventions lowest?

Box 2 - What are REDD+ activities?

There are five REDD+ activities outlined by the UNFCCC:

- Reducing Emissions from Deforestation
- Reducing Emissions from Degradation
- Conservation of forest carbon stocks
- Sustainable management of forests
- Enhancement of forest carbon stocks

These activities are general, and when thinking about where to locate REDD+ activities in country, it may be useful to think about the related interventions. An intervention related to Reducing Emissions from Degradation for example could be community patrolling to reduce illegal logging.

1. Where are initiatives complementary to REDD+ already being implemented?

There are likely to be ongoing initiatives in the country complementary to REDD+. These include but are not limited to protected areas networks, sustainably managed plantations and community conservation initiatives. Retaining these initiatives and expanding them may reduce barriers to REDD+ implementation, such as start up costs, political will and technological capacity. For example, it may be much easier to expand a protected area network adjacent to an area which already has trained park rangers and existing assets such as vehicles and camps.

2. Where are areas where social and environmental benefits can be enhanced by REDD+ interventions?

Retaining some regions of forest may deliver multiple benefits concurrently. For example, the protection of mangroves has the potential to protect the coast from climate-change induced sea-level rise and erosion, preserve fisheries, maintain carbon storage and protect a unique and threatened ecosystem. Maps like Figure 2 below may assist in identifying where critical areas which deliver biodiversity and ecosystem services are. The map shows areas of high carbon, great ape and bird diversity, overlapping benefits on the map represent areas that could deliver multiple benefits at once.

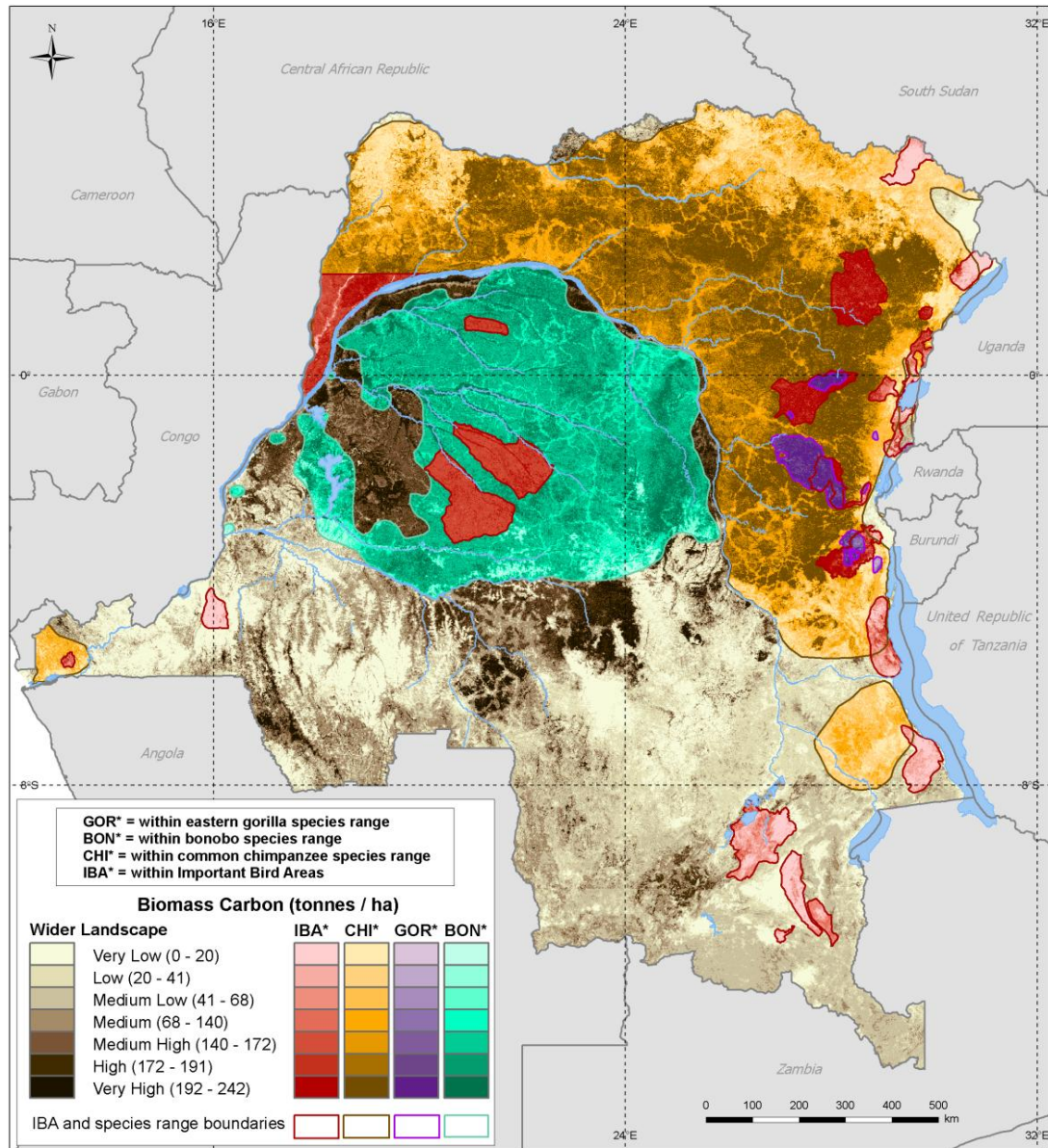


Figure 2 - Biomass carbon, occurrence range of eastern gorilla, common chimpanzee and bonobo and Important Bird Areas (data sources: Caldecott and Miles 2005, BirdLife International 2011), drawn from "Mapping potential biodiversity benefits from REDD+, The Democratic Republic of the Congo", a UN-REDD report published in 2012.

3. Where are areas where REDD+ interventions pose social and environmental risks?



Figure 3 - Fire in dry land savannah woodland, Mozambique

Implementing one REDD+ intervention instead of another in some areas may reduce net environmental and social benefits. For example if a plantation is created on drained swampland, this will result in a negative impact on the climate from organic carbon being released from the soil, and loss of biodiversity and hydrological services. Such an action would also be in conflict with the Cancun safeguard e) which states that “[...REDD+ should...] not used for the conversion of natural forests”.

4. Where could mutually exclusive REDD+ interventions result in one benefit being lost and another gained (i.e. where are potential tradeoffs)?

While one or more REDD+ interventions might both provide benefits in the same area, there may be tradeoffs between the potential benefits they provide. For example, two REDD+ interventions in the same forest could be to 1) fence a forest

and exclude people, or 2) to manage a forest sustainably for timber. There are tradeoffs between the benefits provided by both interventions. Fencing a forest would potentially reduce emissions from deforestation, but might result in forest-dependent communities losing valuable social benefits from harvesting Non Timber Forest Products (NTPFs). Managing a forest sustainably for timber will allow NTFP harvesting but would have lower climate benefits than fencing the forest. There is also a risk that opening an area up for timber extraction and NTFP collection might also enable/encourage unsustainable hunting, which would have a negative impact on biodiversity.

5. Where could mutually exclusive REDD+ interventions result in one benefit being lost and another gained (i.e. where are potential tradeoffs)?

A country planning for REDD+ will have to consider other land use priorities which may conflict with REDD+ interventions, such as mining, hydro-electric dam development and agriculture. Ensuring conflicting activities are considered during REDD+ planning will contribute to REDD+ interventions being permanent, in line with the Cancun safeguards, and reduce social and political conflict. **Error! eference source not found.** demonstrates potential areas where some REDD+ interventions may compete with mining. Either REDD+ could not be located in these areas or competing activities could be done sympathetically, for example tunnel mining rather than open cast mining could be carried out.



Figure 4 - Large amounts of fuelwood from the forests are necessary for small businesses baking bread

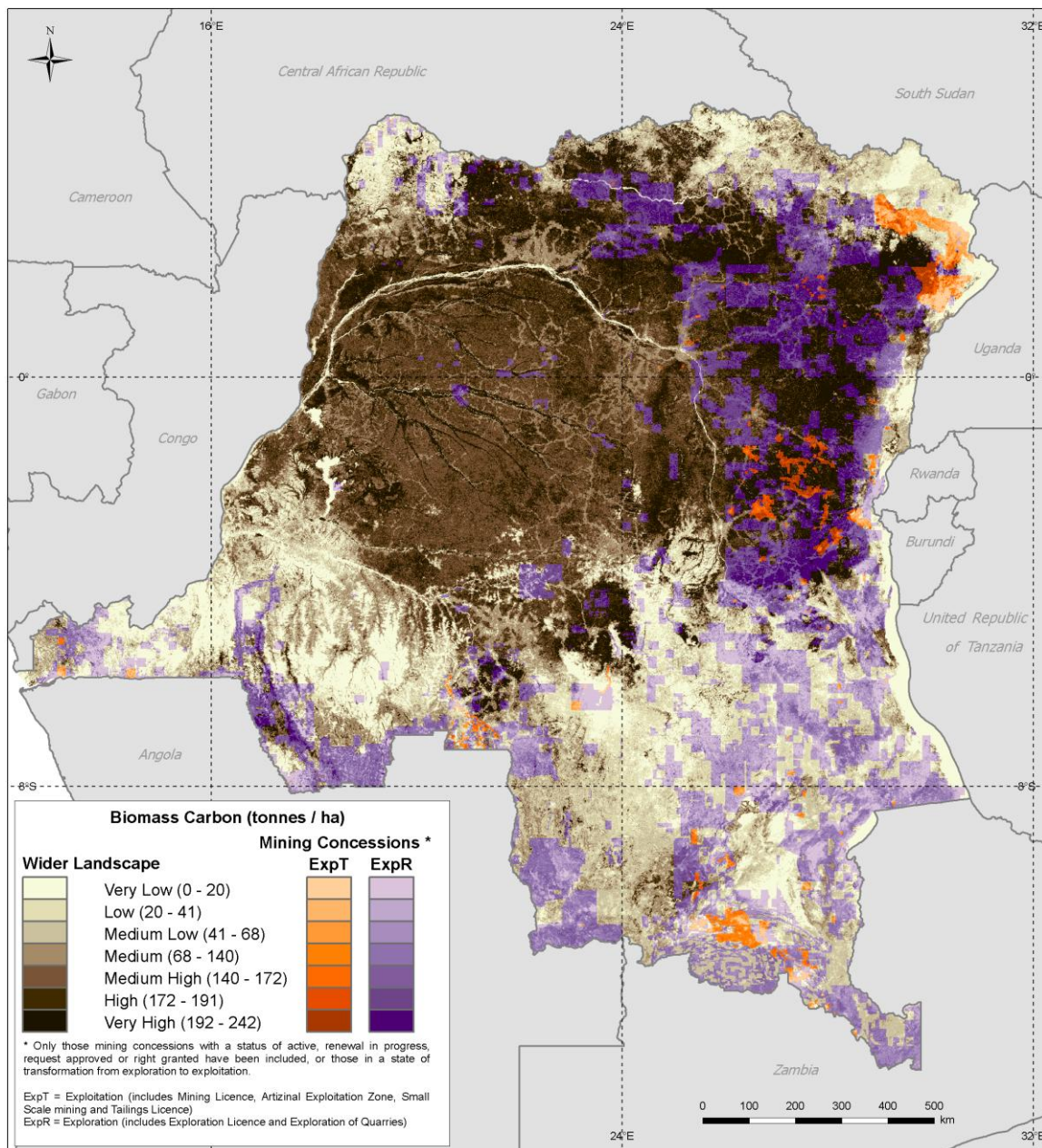


Figure 5 - Biomass carbon and mining in the DRC (data source: Cadastre Minier de la RD Congo 2011)

6. Where are the costs of REDD+ interventions lowest?

The cost of REDD+ interventions is a significant consideration for many reasons in REDD+ planning, and is unevenly distributed through space. A map of this information could inform where REDD+ can be implemented at least cost. Further, a REDD+ intervention is not likely to result in permanent climate benefits if it is not cost effective to implement in an area. This risk has been highlighted in the Cancun safeguards (see f) in Box 1) and can be mitigated by good spatial planning.

5. How and when can Marxan be used in REDD+ planning?

Section summary

Marxan is a type of spatial decision support software. Marxan can be used for REDD+ planning, in particular to demonstrate where priority areas for REDD+ interventions could be when there are too many considerations for the solution to be obvious. However the tool may not always be appropriate; it does not readily deal with socio-economic dimensions, and seeks to meet minimum user targets rather than maximise targets for a given budget, which may not always be appropriate. Countries may consider using Marxan for REDD+ under the following circumstances:

- Decisions have been taken on which REDD+ interventions will be used, and/or a REDD+ strategy has been drafted, yet there is still uncertainty on where some or all REDD+ interventions will be located;
- There has been awareness raising on REDD+, and Free Prior Informed Consent (FPIC) on the content of the national strategy, meaning that a stakeholder engagement exercise can be carried out resulting in clearly defined, quantitative REDD+ targets for the climate, biodiversity and ecosystem services;
- There is spatially explicit data available for the area of interest from previous initiatives or studies;
- There is technical capacity in country to carry out the exercise and resource persons available for support;
- Decision makers want to know where targets for a REDD+ intervention can be met at the least cost, rather than how benefits can be maximised while not exceeding a set cost level, or where to achieve the greatest benefits in relation to costs;
- Decision-makers are comfortable in specifying quantitative targets for REDD+ interventions;
- It would not be possible to consider all the important variables for locating REDD+ interventions without software.

There is an extended discussion by Martin et al. in the [Marxan Good Practices Handbook](#) 2010 on when Marxan should and should not be used in land use planning, which will not be repeated here. This section will instead focus on REDD+ planning and when it might be appropriate to use computer software, specifically Marxan, to support the REDD+ planning process.

When deciding whether or not to use computer software to support land use planning for REDD+, the first considerations should be whether a) the types of REDD+ intervention are known, and b) decisions have already been taken on the location of REDD+ interventions. It will be more informative to run Marxan for planned REDD+ interventions rather than hypothetical ones, and if the location of REDD+ interventions is constrained to some areas, further spatial planning may not be necessary. A timely entry point for a Marxan exercise is therefore after the REDD+ strategy has been drafted, but before REDD+ has been implemented. If some broad regions have been identified for REDD+ interventions, then Marxan may be appropriate for micro zoning within these regions, however the focus of this manual is the macro level.

For a country at this stage there are several software tools which can support the location of REDD+ interventions (see some examples in Table 1) catering to different technical levels and needs. Using software to support the decision making process during land use planning has its advantages. First, software is more efficient when compared to doing a land use planning exercise by hand alone, given it can generate an output that meets several different targets simultaneously, and can measure success against meeting these targets comparatively rapidly. Second, using computer software to select priority areas for REDD+ is an objective and repeatable method, again when compared to doing it by hand.

Table 1 - Land use planning software

Name of software	Description of how it is related to planning for REDD+
Dyna-CLUE	Typical applications of the Dyna-CLUE model include the simulation of deforestation, land degradation, urbanization and land abandonment, and the integrated assessment of land cover change. The model is especially useful for assessments of changes in complex spatial patterns of land use, as it is possible to simulate multiple land use types simultaneously. In a REDD+ context, Dyna-CLUE can be used to simulate land use developments both without and with REDD+ interventions.
The REDD Opportunities Scoping Exercise (ROSE)	At the national level, ROSE assessments provide a rapid qualitative analysis, based on expert opinion, to identify key emissions abatement opportunities across different forest contexts. At the sub-national level, ROSE is a pre-cursor to the process of pre-feasibility and feasibility analysis. ROSE assessments can support a variety of processes towards 'REDD+ Readiness' including (i) development of an R-PP for FCPF funding; (ii) development of a balanced portfolio of sub-national activities and a balanced REDD+ strategy; (iii) quantitative assessments of emissions reductions potential, and (iv) development of demonstration activities illustrative of key project types.
Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST)	InVEST can apply scenarios and models to predict land use and land cover change, as well as impacts of land management plans on ecosystem services. In the context of REDD+ planning, this tool could be useful for assessing impacts on ecosystem services and their economic values under different baseline and REDD+ scenarios. InVEST allows to assess the trade-offs between different ecosystem services under different REDD+ activities. Consequently, it is a useful tool to evaluate where and how to implement REDD+ so as to optimize multiple benefits and to address safeguards.
Zonation	Zonation can link species distribution modelling directly to quantitative reserve planning. Zonation includes species-specific connectivity responses, natural weighting of species and several unique analysis options. It could be used for REDD+ planning to locate optimum or near optimum locations of forest reserves, particularly where species conservation is a critical target.
Marxan	Marxan is a decision-support software originally designed for selecting priority areas for conservation. Marxan can also be applied to other management strategies, such as identifying areas important for REDD+ intervention, as described in this document.

Marxan has advantages over the other land use planning software in table 1 when being used for REDD+. After the initial technical stage to prepare the datasets, it is straightforward to adapt the targets in response to changing stakeholder needs and repeat the exercise. This makes Marxan appropriate for an interactive, consultative land use planning process rather than a one off discussion.

While Marxan may be an appropriate piece of software for REDD+ planning, and can help the questions in section 4 to be answered, it does have limitations. It doesn't support a user to carry out a cost-benefit analysis on two different land use options. This may not appeal to stakeholders who would like to compare the potential carbon revenues from two different REDD+ interventions.

It also requires clearly defined, quantitative figures for the REDD+ targets; ranges for targets, for example, cannot be entered into Marxan. A target for carbon should either be 10GtC or 20GtC retained not 10-20Gt.

This inflexibility may result in intractable discussions to define targets before Marxan can be run, or require multiple runs so that results can be compared.

Marxan also requires input datasets, and if data for key targets are missing or of poor quality, the priority areas which the software produces are, at best, incomplete solutions and at worst, misleading. Other software is needed to prepare and create datasets, for example it may be necessary to create species ranges using modelling software, meaning the user may need to carry out several separate exercises before Marxan can be used. This technical barrier may result in inputs to REDD+ planning not being timely.

Marxan has limited capacity to tackle the social risks and benefits from REDD+. Other tools, such as the UN-REDD Free Prior Informed Consent tool³ may be more appropriate than Marxan and other spatial planning tools for mitigating social risks. It can take into account that some communities may not want to participate in REDD+, by ensuring their land is not selected in the solution. Further if there is a clear link between a REDD+ intervention and a social benefit such as poverty reduction, it is possible to use a poverty target to identify potential intervention locations.

However, Marxan cannot maximise objectives, such as the amount of NTFPs that could be secured by REDD+ or the maximum payments for ecosystem services for a given region. This means that it does not provide the answers to questions like – where should REDD+ interventions be located for the maximum results based payments? Or, where will REDD+ yield the most alternative livelihoods?

³ This tool can be found on UN-REDD.org, the UN-REDD website.

6. What should a Marxan exercise entail?



Figure 6 - Steps for a Marxan exercise

In order that the priority areas selected for REDD+ are appropriate and take into account the needs of the stakeholders, several distinct steps should be followed. This is not just good practice, it is an essential component of ensuring that the outcome will be successful and the contribution of spatial planning to the REDD+ strategy useful. There is extensive discussion on the steps for using Marxan in the Marxan Good Practice Guide. A relevant message from the guide is that Marxan will not help you to set REDD+ objectives, to ensure you have the right stakeholders involved or to understand whether the datasets being used are robust. Following the scheme in Figure 6, which is elaborated below, a wider planning process will however help with these important tasks.

1. Identify broad goals and audience

It is expected that the use of Marxan for REDD+ would happen in the context of a broader spatial planning exercise, where stakeholders impacted by REDD+ have been identified. Tools such as the UN-REDD/FCPF Guidelines On Stakeholder Engagement⁴ may support this process. As a first step in the spatial planning process, and the Marxan exercise, a consultation should take place with stakeholders on what the multiple benefit goals might be when locating REDD+ activities.

⁴ http://www.un-redd.org/Stakeholder_Engagement/Guidelines_On_Stakeholder_Engagement/tabid/55619/Default.aspx

Broadly, these should be to enhance benefits and mitigate risks, but they should be specific to the countries priorities and quantitative.

The first outcome of the meeting should be to review which REDD+ actions have yet identified locations, and to review if Marxan is a useful tool for identifying priority areas for these actions (see section 5 on when it is appropriate to use Marxan). Once the action being considered have been established it will then be possible to define what the priorities are for these actions.

Points for discussion could be:

- Which zones should not be included as priority areas for the REDD+ actions? These may include:
 - zones containing communities who do not wish to participate in REDD+;
 - zones where development activities such as mining or agriculture are planned in the future.
- Which zones should be included as priority areas for the REDD+ intervention?
 - For example, it may already be known that protected areas should form part of the REDD+ intervention.
- What are the risks and benefits of the intervention?
 - Some interventions should be located outside of areas where they would otherwise pose a risk. No plantations, for example, should be located in highly bio-diverse grasslands as this would conflict with the Cancun safeguards.
 - Some benefits may be enhanced by interventions being located in certain zones, for example protecting forests which are known to contain endemic species.
- What are the biodiversity priorities in the country?
 - Which species or habitats are considered national priorities? A starting point for national priorities may be contained in the National Biodiversity Strategies and Action Plans, an instrument of the international Convention on Biological Diversity.
 - National legislation is also a good source of information to identify these priorities. Forestry, protected areas and biodiversity laws, as well as programmes and policies in these areas are likely to contain relevant information.
- What ecosystem services priorities are there in country?
 - Some ecosystem services may have particular value, for example a country dependent on hydroelectric power for its energy needs may place particular emphasis on the services forest serve for soil erosion control

As discussed in section 5, discrete numbers need to be agreed for each target once it has been established. Below are three examples of targets that could **not** be entered into Marxan and a fourth example which could:

Target 1: Reforest land close to urban areas

Target 2: Reforest 50% of land close to urban areas

Target 3: Reforest 40-50% of land within 20 km of urban areas of populations of 1 million or more

Target 4: Reforest 50% of land within 20km of urban areas. Urban areas are defined as areas containing 10 people per hectare.

Targets 1, 2 and 3 could not be entered into Marxan as targets because 1 does not have figures associated with it, 2 doesn't have a quantitative definition of what "urban" should be and 3 contains a range of values

for the target. Target 4 could be entered into Marxan as it has numeric figures for both the target and the definition of the target region.

1. Acquire datasets

Once priorities have been identified, datasets then need to be acquired for each target. Some target layers may need to be prepared (see section 7 for detailed instructions on how this can be carried out). For some targets, it may not be possible to acquire data meaning they should be left out or alternative proxies found. A list of international datasets which may be useful is below:

Table 2 - Possible sources of data for Marxan

Dataset	Link
Harmonized World Soil Database v 1.2	http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/
Continental Tropical Carbon Maps (Saatchi et al., 2011)	http://carbon.jpl.nasa.gov/data/dataMain.cfm
Pan-tropical Forest Carbon Mapped with Satellite and Field Observations (Baccini et al., 2012)	http://www.whrc.org/mapping/pantropical/alos.html
IUCN Red List species distributions	http://www.iucnredlist.org
Landscan population	http://web.ornl.gov/sci/landscan/landscan_data_avail.shtml
Administrative and Political Boundaries, Infrastructures (FAO 2013)	http://www.fao.org/geonetwork/srv/en/main.home
Pan-tropical Forest Cover Mapped with Cloud-Free Radar Imaging	http://www.whrc.org/mapping/pantropical/alos.html

Carbon datasets

REDD+ targets are likely to include those which relate to reducing carbon emissions. Some REDD+ countries are in the process of creating spatially explicit maps of where future emissions from forests are expected, in which case setting carbon emission reduction targets will be straightforward. In absence of a carbon emissions map, there is a technical challenge to setting carbon emission reduction targets and an alternative may need to be created.

It is technically possible to convert a carbon stock map into a carbon emissions map where drivers of deforestation are understood, however it may be more robust and rapid to use forest cover loss if there is some doubt over drivers of deforestation and their impact on carbon loss.

In section 7, a basic method for creating a threatened forest map layer is described. Rather than setting a carbon emissions target, an avoided forest–cover-loss target is used in the worked example that follows. Such a proxy could be appropriate where a spatially explicit carbon emissions map is not available. Sources of carbon stock maps are found in Table 2.

2. Create planning units, target layers and cost layer

Detailed descriptions of how to prepare datasets for Marxan can be found within the online tutorial [here](#), and specifically for REDD+ in Section 6. A summary of the key inputs that need to be prepared and a description is in the table below:

Input	Description
Planning units	The area first needs to be divided up into units that are either to be selected as priority areas for REDD+ or not selected. Units can be regular or irregular, regular units could be squares or hexagons, irregular units could be districts or communities.
Target layers	These are the layers to which a target is applied. For example a target layer for Bonobos might be the Bonobo range. The target layers need to be prepared separately in GIS software, and exported into text files before they can be imported into Marxan.
Cost layer	Each planning unit is assigned a unit of cost, this is known as the “cost layer”. Based on this layer, Marxan selects planning units so as to achieve the defined target(s) at minimum costs. Depending on data availability, the cost layer can represent the opportunity costs (the potential financial benefits from non-REDD+ land use/management options in a certain location) and/or the implementation cost of REDD+ (the costs of implementing a REDD+ intervention in a certain location). The cost layer can also be based on non-monetary information, such as agricultural suitability or other pressures. If no spatially-explicit information on costs is available, cost can be assumed to be the same for each planning unit, so that costs are minimized the fewer planning units are selected. Only one cost layer can be considered by Marxan.
Lock out areas	These are the planning units which will never be included in the areas identified by Marxan.
Lock in areas	These are the planning units which will always be included in the areas identified by Marxan. Any areas locked in will contribute to whether or not the targets have been met.

The technical preparation for running Marxan may be time consuming and requires a resource person with GIS skills. The length of time spent preparing the dataset will vary according to the number of layers that need to be prepared, and the complexity and size of the dataset itself. Producing one target layer can take anywhere between a few minutes and a week. Producing a cost layer may require an independent cost benefit exercise, requiring the input of an economist. While it will vary widely, it is possible to estimate for a medium size country, the technical steps of a Marxan for REDD+ exercise might take a GIS technician at least one and a half months.

GIS software extensions are available to support the preparatory steps for both open-source and non-open-source software. These will speed up the processing required to prepare the layers. In the table below, are links to factsheets describing the software extensions:

Software extensions	Link
PANDA	http://www.mappamondogis.it/panda.htm
CLUZ	http://anotherbobsmith.wordpress.com/software/cluz/
Pacmara	http://pacmara.org/tikiwiki/tiki-index.php?page=Marxan+Resources+and+Training
QMARXAN	http://aproposinfosystems.com/products/qmarxan/

3. Run Marxan

Once input layers have been prepared, the GIS technician will then be able to run Marxan. They may then wish to calibrate the final solution. For example Marxan may identify solutions that are very dispersed, this might not be practical to present to a policy makers who may wish to have discrete areas identified. Marxan has parameters that can be calibrated to adjust the degree to which the solution can be dispersed.

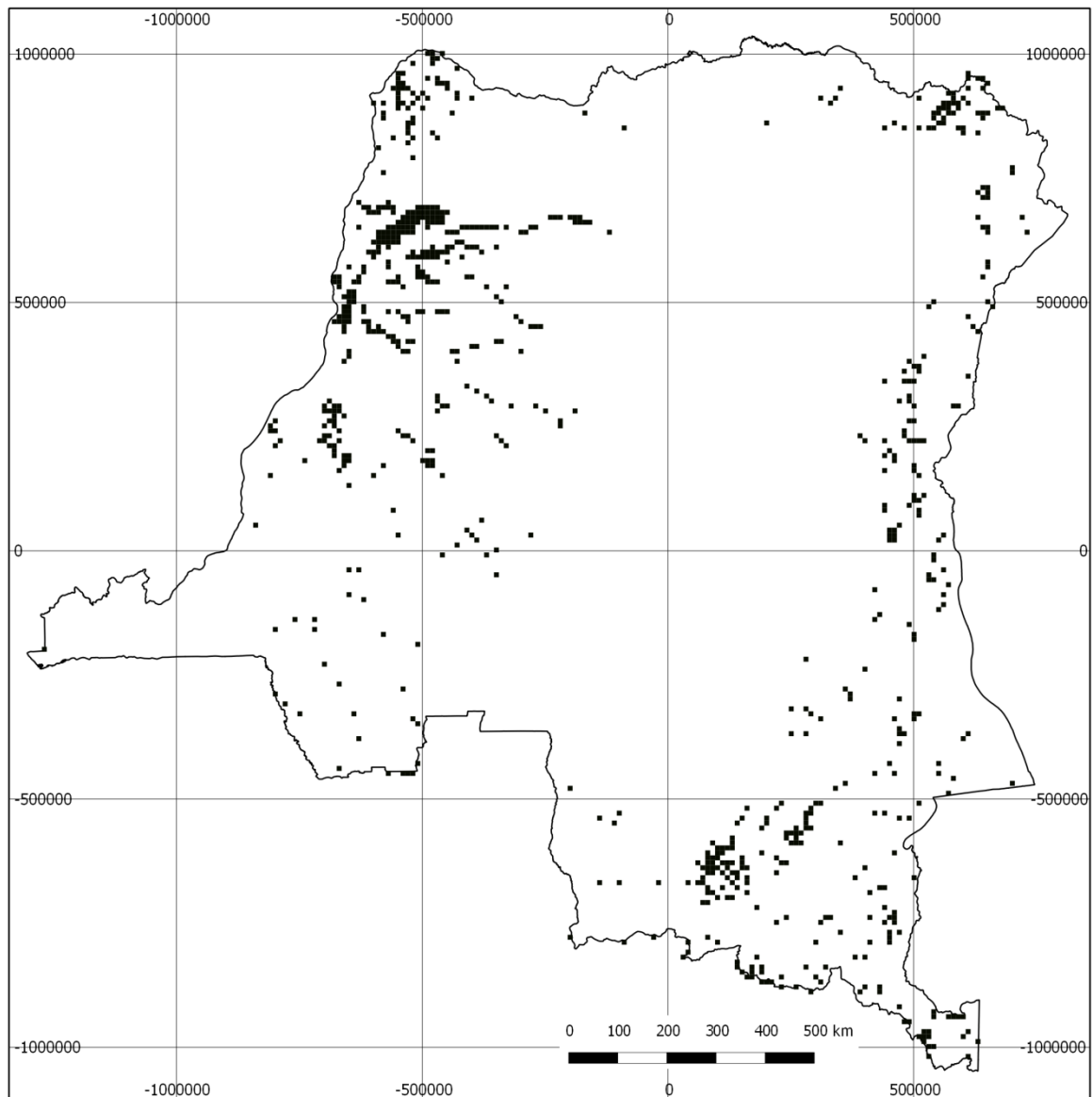


Figure 7 - Reserve system selected by Marxan very dispersed - may be inappropriate for some REDD+ actions

Further, one target layer may have an undue impact on the solution, and it may be necessary to therefore adjust the target or the weight it is given, or if one target layer is having undue impact on the solution. Calibration can take a week or more dependent on what the initial outcome is.

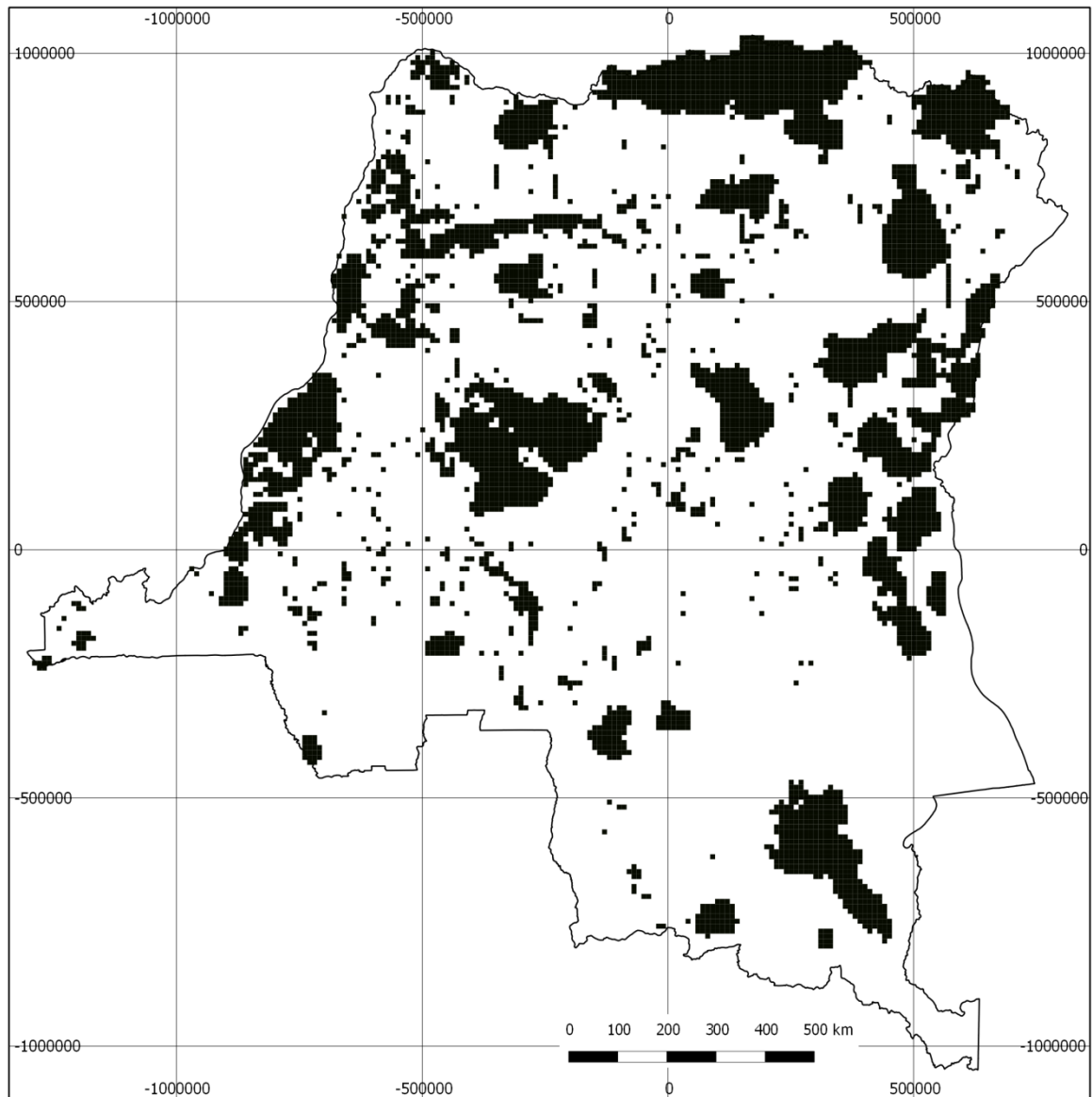


Figure 8 - Protected areas overly influencing the areas being selected by Marxan

4. Review results with stakeholders

The results should then be reviewed by stakeholders involved in step 1. The areas prioritised for different REDD+ interventions should reflect the targets set in step 1. If areas selected are inappropriate, it may be necessary to adjust the numeric values associated with each target, or the target layers being used, and to revisit steps 2 -4 for those layers. It is expected that this will be an iterative process, and plenty of time should be allowed.

7. An illustration of using Marxan for REDD+ planning questions in the DRC.

Section summary

To demonstrate how Marxan can be used for REDD+ planning, this section contains an illustration of the steps that the DRC would need to go through with Marxan to identify priority areas for the expansion of forêts classées (see CODE FORESTIER). The DRC is an appropriate country for this exercise as it has ongoing land use planning processes in country, and has a draft REDD+ strategy but has yet to identify locations for its REDD+ activities. The objective of this section is to support the training of technical persons interested in using Marxan for REDD+, not to prioritise areas for REDD+ in the DRC.

1. Spatial planning in the DRC

Table 3 - REDD+ interventions planned in the DRC draft REDD+ strategy

REDD+ interventions	Description
1. Community micro-zoning	To relieve pressure on the forest without threatening food security, community land will be zoned into production areas for agriculture, non production areas for sustainable harvesting and core protected areas. This is to avoid agricultural pressure being displaced from one forest to another.
2. Woodlots close to urban areas	Sustainably managed woodlots close to urban areas will relieve pressure from fuelwood collection and charcoal production.
3. Fuel efficient stoves	Fuel efficient stoves will reduce the amount of biomass removed from the forest for fuelwood.
4. Zoning and identifying permanent forest estate	Permanent forest estate is the area of forest designated by a country to be retained as forest in perpetuity. This may overlap with, but is different to, a core protected area, as anthropogenic activities in the estate are allowable as long as they do not remove forest cover. Zoning and identifying the permanent forest estate is a planned REDD+ action in the DRC strategy and is within the draft framework strategy.
5. Expansion of forêts classées	The DRC has a legal category “forêts classées”. This covers forests that are inside protected areas, hunting concessions, forest reserves and other areas where agricultural expansion is illegal, such as botanic gardens. There is an undertaking in the forest code that this area should be expanded to 15% ⁵ , that will contribute to meeting the REDD+ strategy targets of reducing deforestation and degradation.

This illustration uses the DRC as a test country for applying Marxan for REDD+. There are several ongoing land-use planning exercises, which this test case can be informed by and that ultimately that Marxan could contribute to. These are the refinement of the REDD+ strategy, an intersectoral zoning initiative and forestry zoning initiative.

The draft REDD+ strategy was launched in Doha in 2012 and outlines several targets and activities (see Table 3) which can inform the Marxan exercise. An inter-sectoral zoning initiative,

⁵ CODE FORESTIER (Article 10, 12,13,14)

coordinated by the Comité National de Pilotage du Zonage, seeks to delineate priority zones for different sectors, for example agriculture, forestry and mining. A follow-on process is to zone, within the forest priority zones, different forest categories such as forest concessions. This process is being co-ordinated by GTZ and the World Bank. A Marxan exercise in early 2014 could support the macro-zoning processes by providing cost-effective priority areas for REDD+ that can provide multiple benefits, and inform the refinement of the REDD+ strategy.

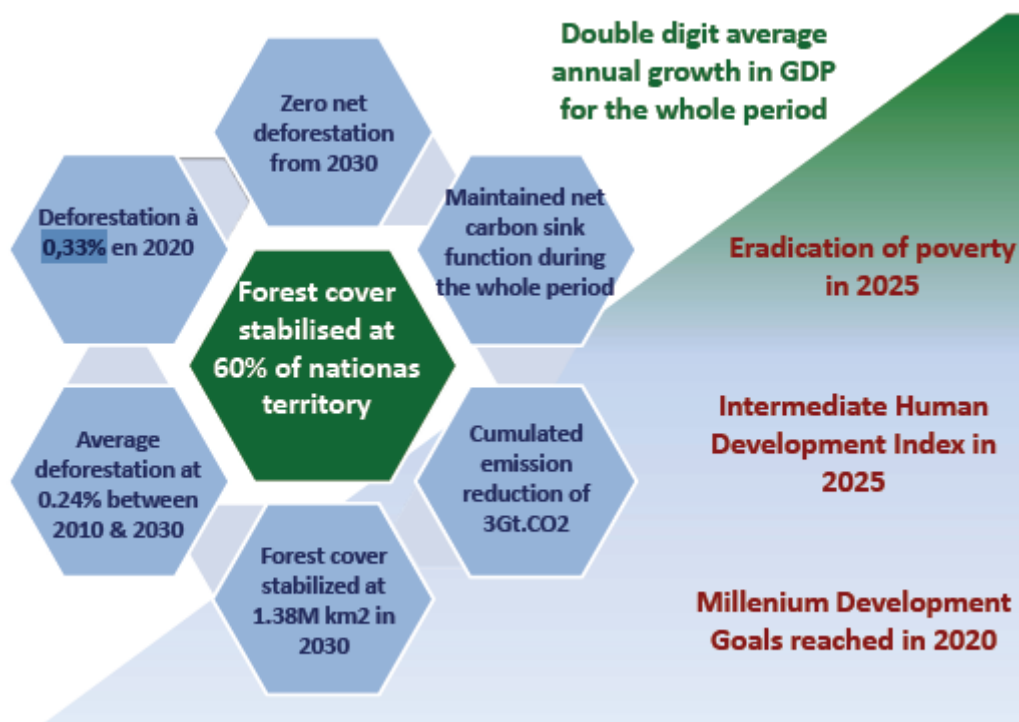


Figure 9 - REDD+ targets from the DRC REDD+ strategy

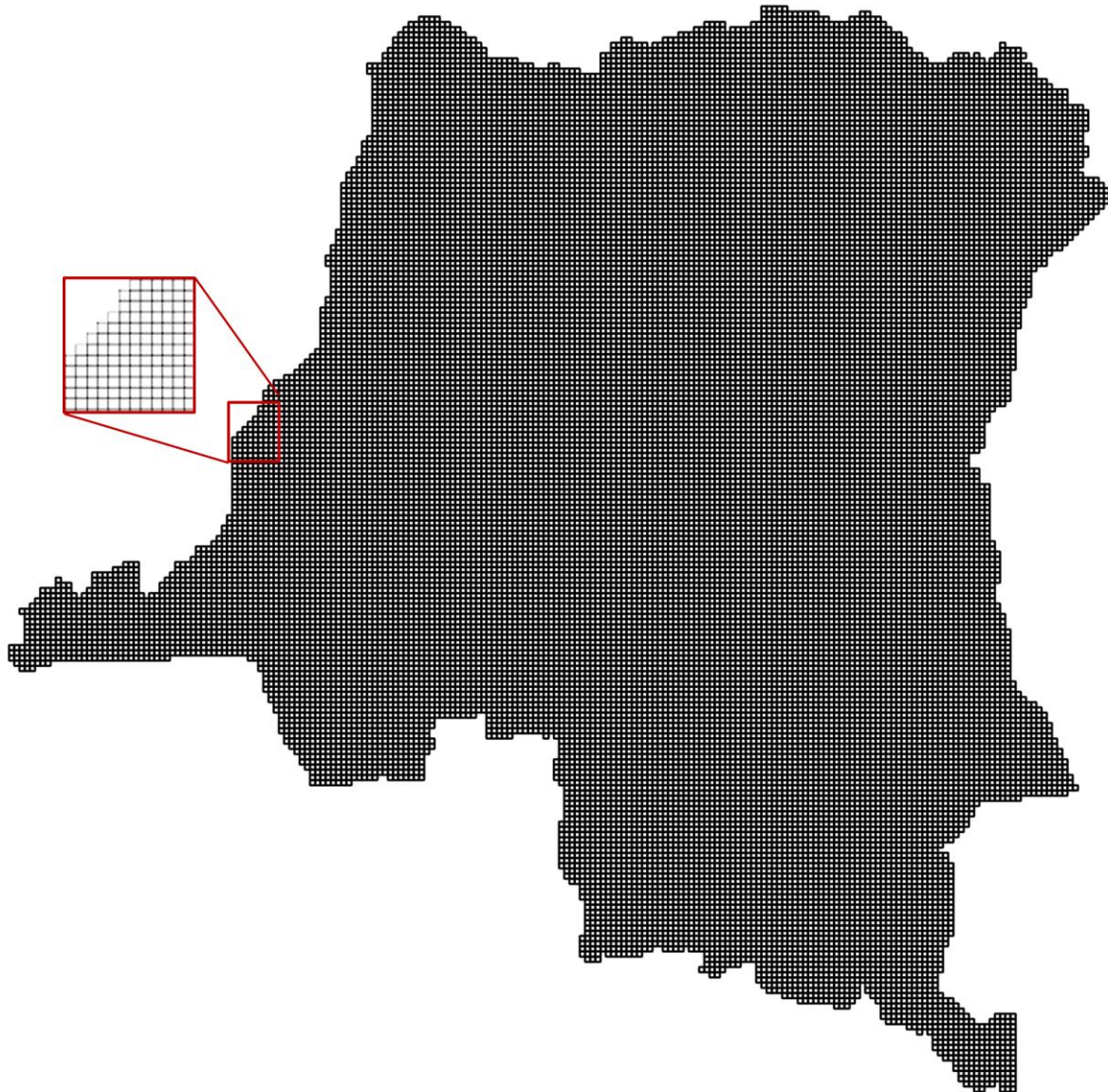
2. Targets and interventions used for the worked example

Marxan is used in the following worked example to prioritise areas for one distinct REDD+ action, the expansion of forêts classées. This is a specific action that will contribute to the REDD+ targets in the REDD+ framework strategy (see figure above).

The indicative targets in the worked example are drawn from international biodiversity agreements such as the Kinshasa Accord on Great Apes, the Convention on Biological Diversity and the UNFCCC Cancun safeguards, the REDD+ strategy and a policy session held in Kinshasa in June 2013. **These targets serve just as examples of how Marxan could be used for REDD+ and are not representative of all stakeholder concerns in the DRC.** It is nonetheless hoped the layers produced as part of this example may contribute to spatial planning for REDD+ in the DRC, following a full stakeholder consultation.

Where are priority areas for expansion of forêts classées that deliver multiple benefits?

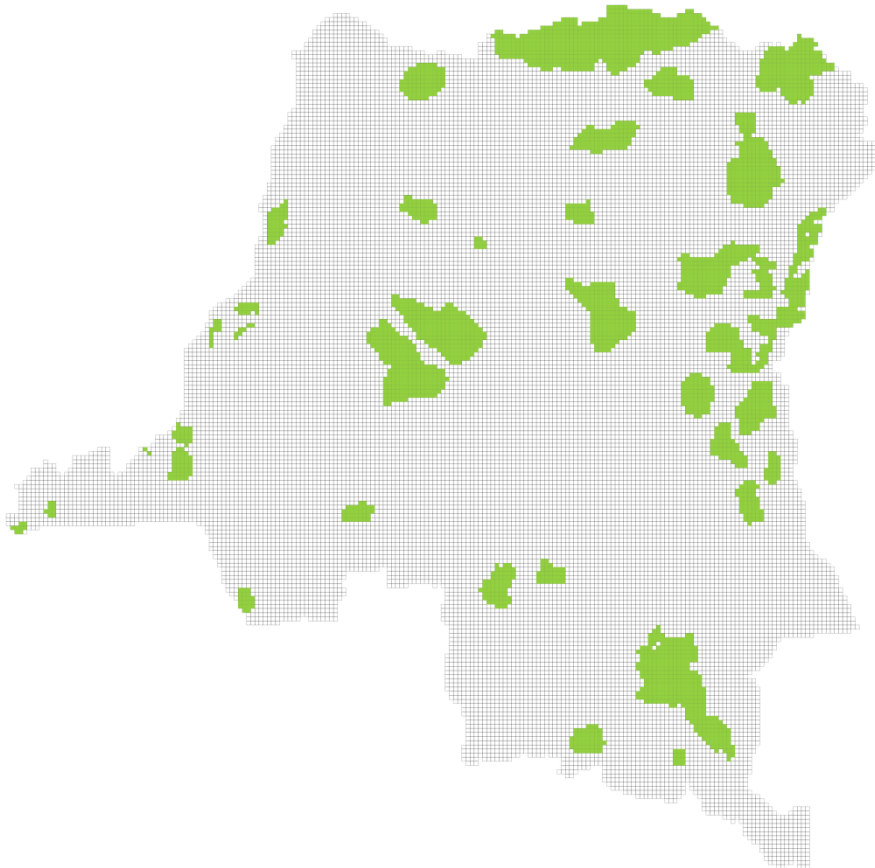
First a planning unit grid should be created for the area of interest, for the demonstration, a 100km² grid was chosen, to balance the processing time against a scale that is useful for planning. It was found that a finer resolution led to long processing time that was impractical for the exercise.



The next necessary steps are to set the “cost” of including each cell if it is selected to be included in the solution or reserve. In this demonstration, area was used as cost:

	pu_id	pu_cost	pu_status	bnd_cost	area
0	145	100000000	2	1	100000000
1	146	100000000	2	1	100000000
2	147	100000000	2	1	100000000
3	148	100000000	2	1	100000000
4	149	100000000	2	1	100000000
5	357	100000000	2	1	100000000
6	358	100000000	2	1	100000000
7	359	100000000	2	1	100000000
8	360	100000000	2	1	100000000
9	361	100000000	2	1	100000000

The user then has an option to ensure before the software is run that some planning units are either excluded or included in the solution. In this demonstration planning units that did not include forests were excluded from the solution, given that they could not include forêts classées. Planning units that included both protected areas and forests were included in the solution; this is because forests inside protected areas are already forêts classées, and when meeting the target of 15% it is important to know how much already exists.



Following this, each square of the grid is assigned a value with respect to each layer that is going to be used as a target:

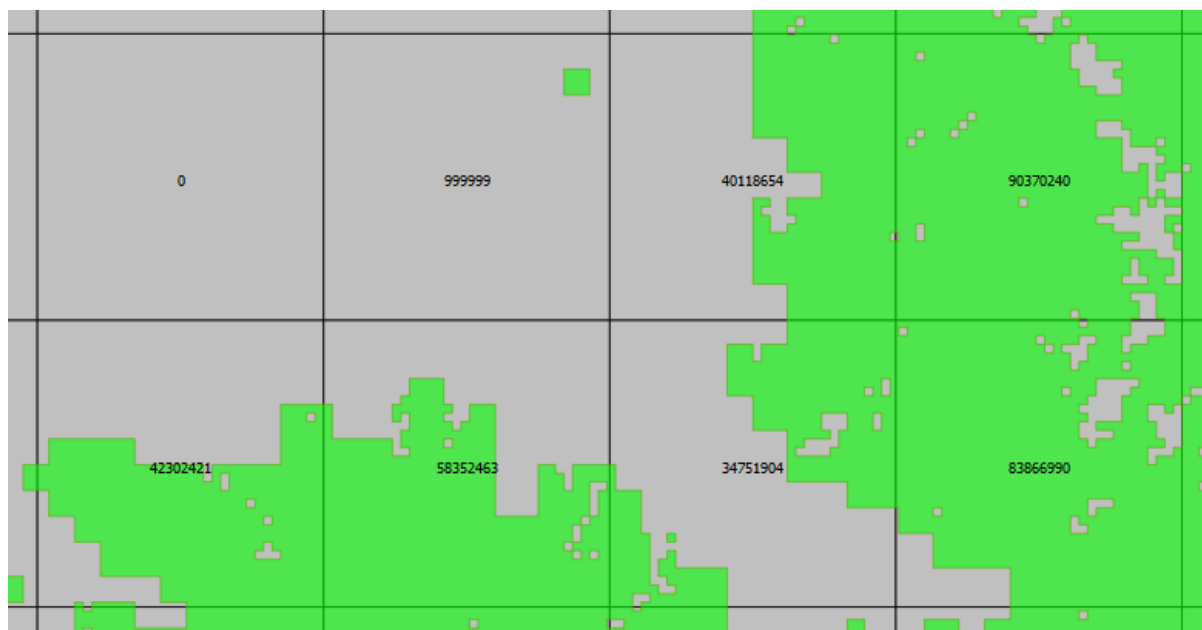


Figure 10 - Example of values assigned to planning unit grids of dense moist forest (in m^2), where green is coverage of dense moist forest, and each square is a planning unit.

Then targets are set in a text file that will be used by Marxan, in this demonstration the following targets were used to determine where priority areas should be for forêts classées.

- 20% of all forests (source – UCL)



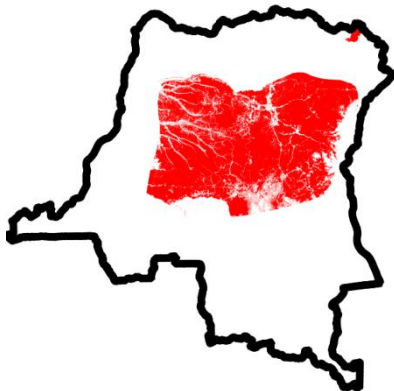
- 30% of all great ape ranges (source – IUCN species ranges, refined to the habitat where the species occurs)



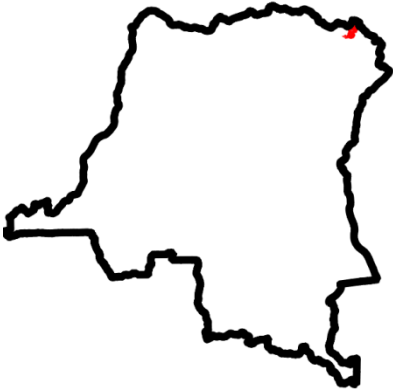
- 30% of elephant ranges (source – IUCN species ranges, refined to the habitat where the species occurs)



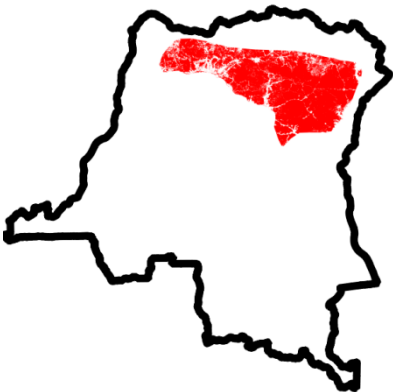
- 30% of the Congolese peacock range (source – IUCN species ranges, refined to the habitat where the species occurs)



- 30% of the rhinoceros range (source – IUCN species ranges, refined to the habitat where the species occurs)



- 30% of the Okapi range (source – IUCN species ranges, refined to the habitat where the species occurs)



The result is priority areas that can meet the proposed targets for forêts classées around existing forêts classées, while minimising the area and dispersion of the solution.

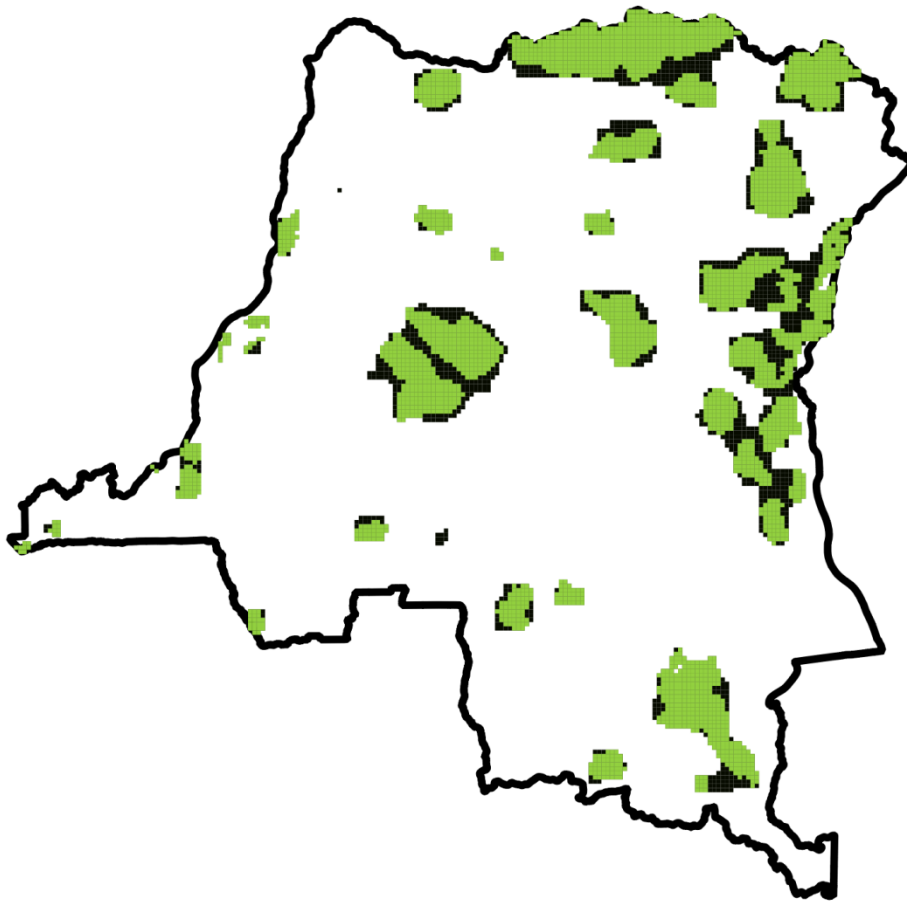


Figure 11 - Light green is areas which are locked into the solution for forêts classées, while dark green areas have been selected by the software.

Some aspects cannot be readily integrated into the inputs to the software, for example roads and mining concessions. If all potential mining concessions were excluded from being selected as priority areas for forêts classées, then majority of the country would be excluded. Roads have a relationship with deforestation, but the relationship is not necessarily constant throughout the country, being dependant on traffic and the motorability of the road. However both roads and mines are important information for identifying priority areas for forêts classées to meet REDD+ targets, therefore they can be overlaid with the “summed solution” for this demonstration, which gives a gradient of priority:

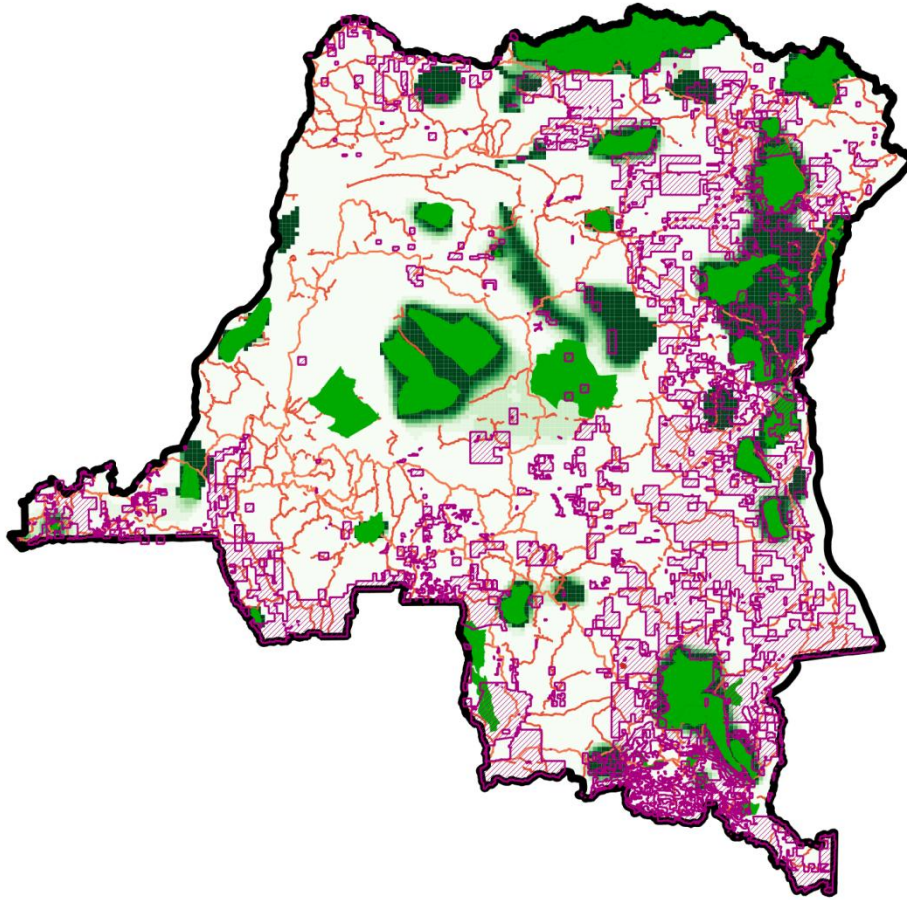


Figure 12 - Here the darker the shade of green, the higher its priority for forêt classees, the roads are in orange and the forest concessions in purple.

8. Displaying the results and communicating with decision makers

Section summary

Key to the success of using Marxan for REDD+ is communicating the results transparently and in a way that can inform decisions. It is therefore important to display the information so that the inputs can be directly related to the output priority areas for REDD+. It is also important that the format used to communicate results is appropriate, this could be digital or in report form, as long as it can be used to inform for real spatial decisions. It may also be important to demonstrate the impacts of using different datasets for the same target (e.g. the impact of using the IUCN ranges of vulnerable bird species or the Key Biodiversity Areas), and explain why choices were made to include certain datasets. It is anticipated that presentations of results to decision makers will be iterative, in response to reactions to the impact of varying the targets.

Step 5 of “What should a Marxan exercise entail” described in [Section 6](#) is presenting the results to decision makers. This section is devoted to more detailed guidance on this step, as key to the success of running Marxan is communicating the results transparently and in a fashion that can inform decisions. A great deal of further guidance on this is provided in the Marxan Good Practice Guide; here we discuss how the results should be presented to inform REDD+ decisions.

The results should clearly show what the input data sets and targets were, be in a format that is appropriate for planners and demonstrate the impact of varying both the targets and the input datasets.

1. Demonstrating the input data sets and targets

Where possible the input datasets and targets should be presented alongside the output priority areas for the REDD+ action. This enhances transparency of how the output was produced to all stakeholders, who may be interested in assessing how the solution Marxan has addressed their individual concerns.

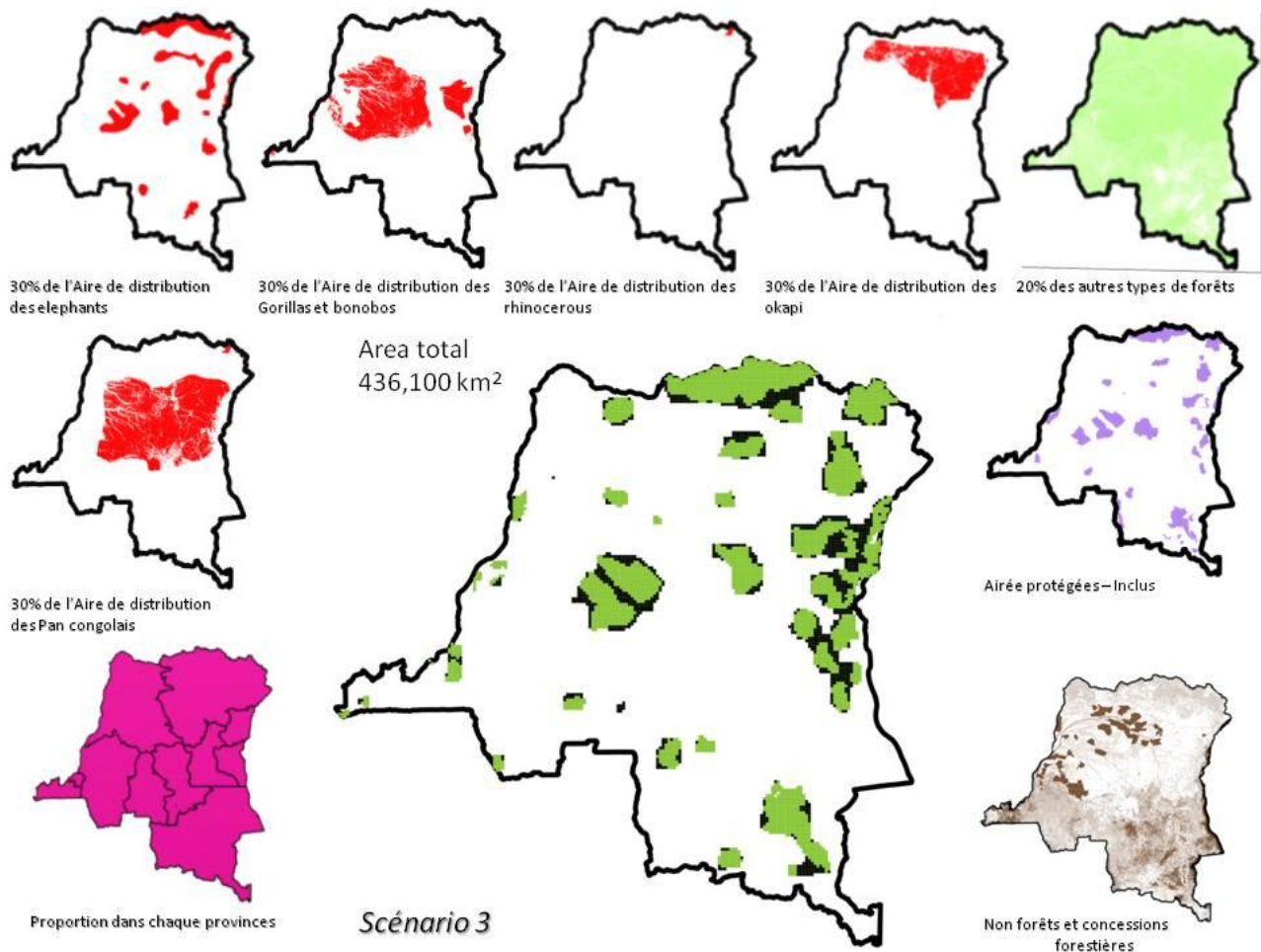


Figure 13 - Presentation of the demonstration Marxan output for the DRC, the central map shows the priority areas for forêts classées in dark green, around the light green planning units which fall inside protected areas. Surrounding the priority areas, are the target inputs with their spatial distribution.

2. Format for decision makers

Marxan has two possible outputs, the so called “best solution” (Figure 11) and the summed solution (**Error! Reference source not found.**). Marxan can produce several thousand good solutions for any one set of inputs, and out of these solutions selects “the best”, defined as the output which meets all the targets it was set (e.g. retain 10% of forest cover, 50% of gorilla ranges) at the lowest cost found. What this means in reality will depend on how the user has chosen to represent costs, it could be the opportunity cost of REDD+, implementation cost of REDD+ or a proxy for those things such as area.

In order to understand the summed solution, it is easiest to revisit how Marxan works. The software cycles through different combinations of planning units, and will start to hold onto planning units in the solution that support the combination to meet the targets set at minimum cost. The user can set the software to repeat this process hundreds or thousands of times, in order to increase the chance of finding a near optimal solution. During this process, the software can log the number of times a planning unit is selected to be part of the solution, this count gives the level of importance or irreparability of this planning unit for the REDD+ action.

Decision makers can use both the best solution and summed solution to inform the decision making process for REDD+. It may be more useful to use the summed solution, which gives a gradient of importance rather than a single yes/no map.

When using either the best or summed solution or both for REDD+ planning, it is important to consider whether a digital or paper output is more informative. Marxan outputs are likely to be just one spatial layer considered in the process, so providing digital as well as printed outputs to planners may be useful. Digital outputs could be files which can be opened using GIS software, or interactive pdfs which do not require GIS software but allow you to turn layers on or off.

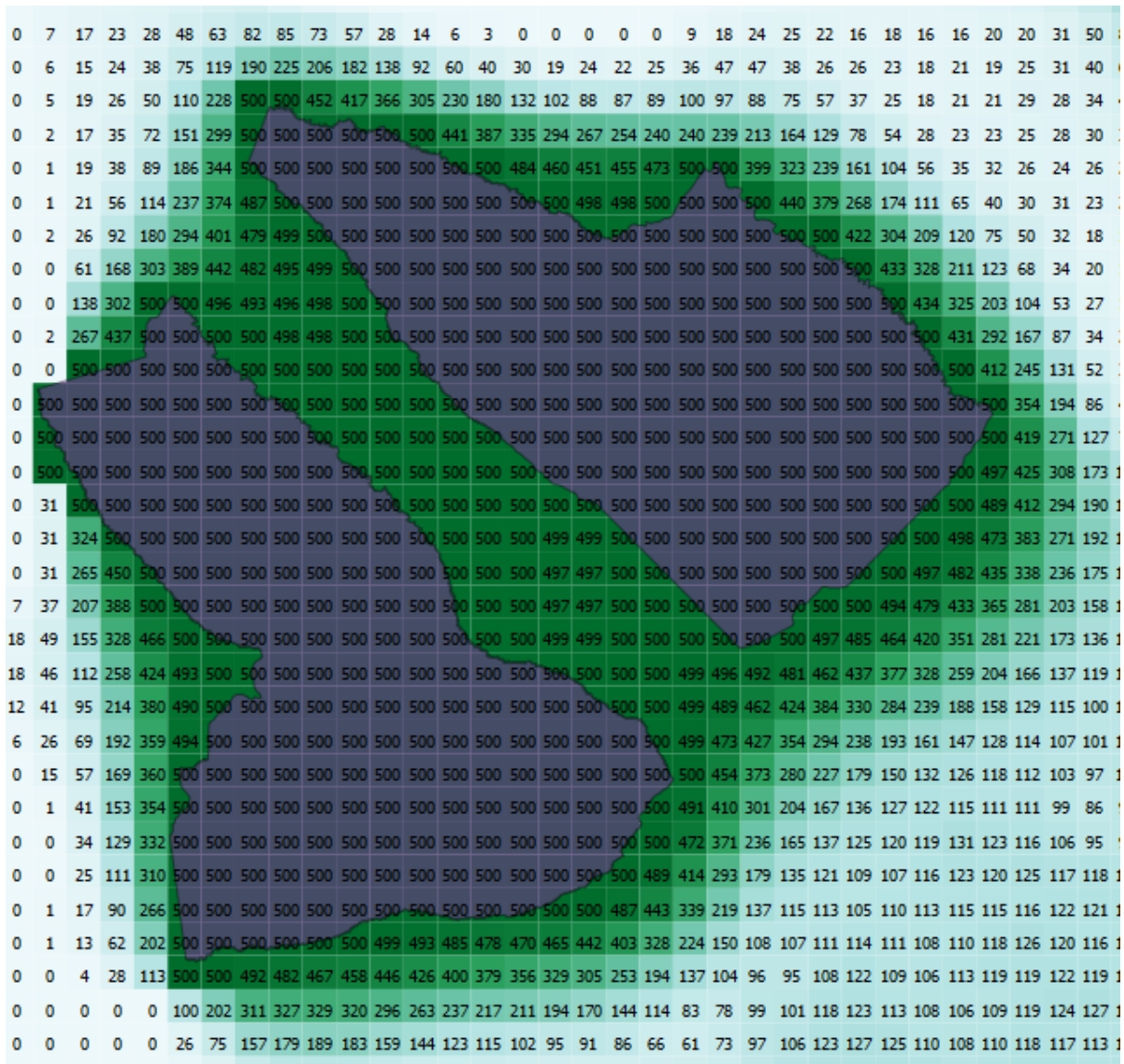


Figure 14 - Summed solution. Purple represents the protected areas that are “locked in” darker green represents a planning units that have been selected frequently when Marxan is identifying priority areas for forêts classées, numbers represent the number of times a square has been selected. In the demonstration it was decided that there was a strong need for the solution to be clumped, and not dispersed, hence the strong pattern for the planning units around the protected areas (which are locked in) to be selected.

3. Varying the targets

When presented with decision support tools, REDD+ decision makers are likely to have some immediate questions which can be anticipated in the way that the results are presented. It is useful to use the stakeholder consultation as an opportunity to understand the key questions which are likely to be asked, however for REDD+ the following are going to be common:

- What would the emission reductions be if we adopted the priority areas for conservation of forests?
- How much carbon would be sequestered if we adopted the priority areas for reforestation/afforestation?
- How does the best solution compare in terms of carbon protected to the existing protected area network/logging concessions?
- What is the impact of varying target X on the overall cost of the REDD+ action?

What would the emission reductions be if we adopted the priority areas for conservation of forests?

If there is a carbon emissions layer available, it will be possible to use a GIS package to estimate the total emission reductions from the best solution for the conservation of forests, assuming there was no leakage. This can be presented alongside the best solution. If there is not a carbon emissions layer available, it is possible to present the total carbon stock retained within the best solution as a proportion of total national carbon stock using one of the internationally available. However there is a limitation on how useful this information is, as carbon stock does not equate directly to the climate benefit of protecting an area from deforestation. It does highlight what proportion of carbon stock could be protected by conservation of forest carbon stocks, and which areas are not protected and at risk of leakage⁶.

How much carbon would be sequestered if we adopted the priority areas for reforestation/afforestation?

If a spatially explicit sequestration-potential layer exists as part of a country's MRV work, this may be readily overlaid with the best solution. It may be possible to create a sequestration-potential map using data layers such as soil type and rainfall; however this is likely to be time consuming and may produce inaccurate results. Therefore it may be more practical to present a proxy for sequestration potential, such as the increase in forest cover that would result from afforestation/reforestation in the priority area, noting that forest cover increase will be gradual.

⁶ Where a REDD+ intervention results in drivers of deforestation being displaced from one area to another this may result in no, or reduced, benefits to the climate. This is known as "leakage".

How does the best solution compare in terms of carbon protected to the existing protected area network/logging concessions?

If the locations in country of logging concessions are known it may be most informative for decision makers to understand how these relate to the priority areas for REDD+. A pertinent question is to compare the multiple benefits potential of different REDD+ activities, including sustainable management of forest to Reducing Emissions from Deforestation and Degradation. For example, logging concession activities may have lower carbon benefits than the expansion of forêts classées.

What is the impact of varying target X on the overall cost of the solution?

Targets make up the final solution presented by Marxan; they can be for a particular species range, a proportion of carbon stock and/or the proportion of a certain province. They can be set in percentages or absolute values such as tonnes of carbon. Presenting the best solution resulting from varying individual targets, while keeping the others the same is a transparent way of demonstrating the impact of the targets on the solution, and the implications of reducing or increasing a target. For example if the target for a particular species such as bonobos is increased, this may have a positive impact on the sustainability of the population, but will potentially double the cost of the solution (see figure 15). It is not possible to present every option to the decision makers, priorities for these analyses should be based on the initial stakeholder consultation.

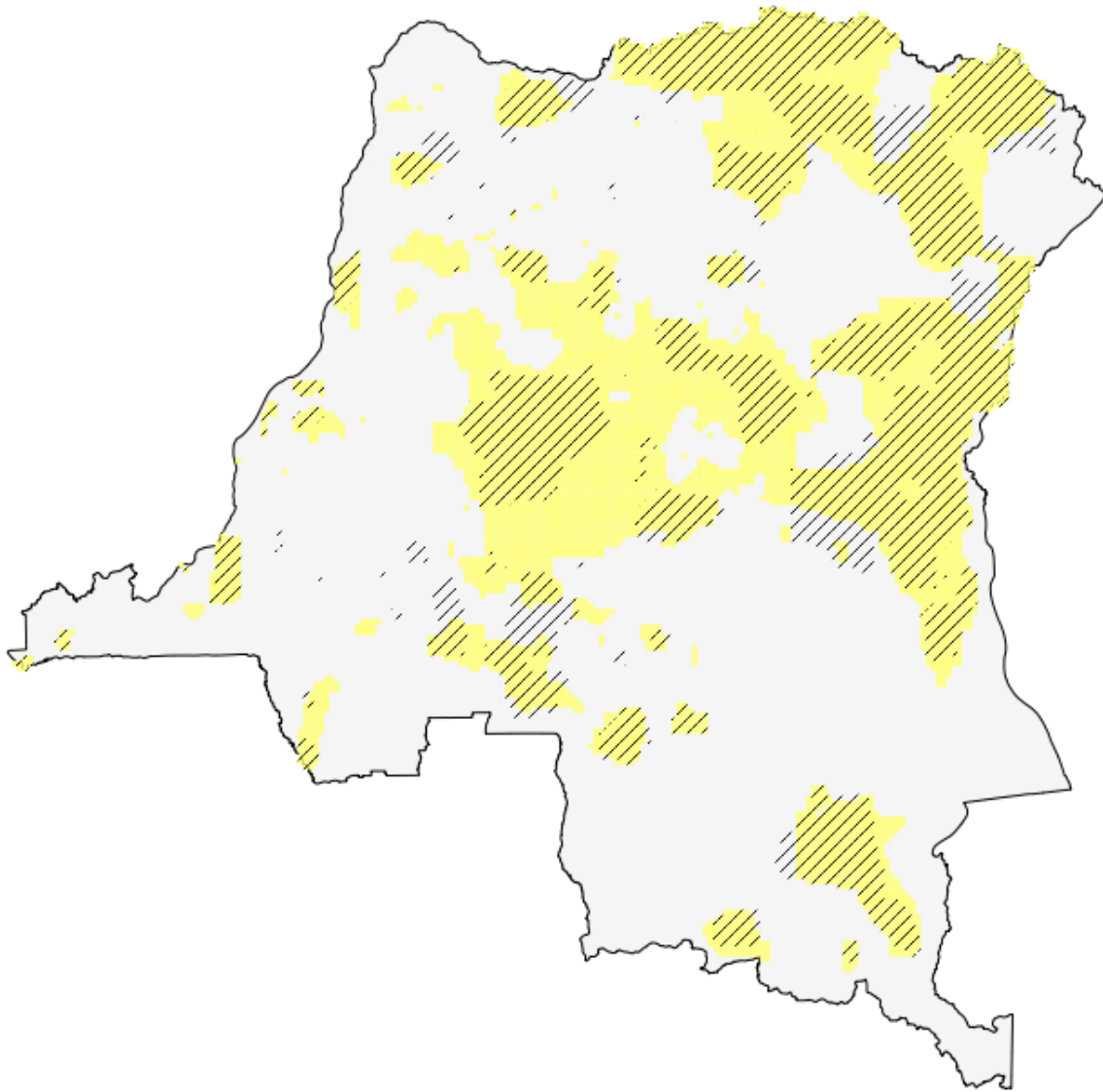


Figure 15 - The impact of doubling the target for bonobos on the best solution. Here yellow is the best solution with a target of 50% for the Bonobo range, and hashed where it was 25% of the Bonobo range. The rest of the targets (20% of forest and 40% of threatened forest) were kept the same.

4. Varying the input datasets

There is likely to be some debate over which datasets have been used to represent different targets. These could be methodological concerns, for example which species were considered when biodiversity targets were set, or data quality concerns, for example using one dataset for carbon emissions when another was available. It may be possible to produce or analyse more than one dataset where the quality of one is under question, for example, and significantly for REDD+ there is more than one pan-tropical dataset available for carbon stocks. The most transparent and robust way to present the results is to demonstrate the impact of using both. Depending on the result, it may be necessary to highlight areas of uncertainty.

5. Final stages

Once the results have been presented, it is likely the final step will be to run Marxan again with revised targets (see section 6). Once a priority area has been presented, it may be immediately obvious that a certain area needs to be excluded due to known plans for the area (for example hydroelectric dams) or that a critical target has been missed during the consultation process. This is an important part of refining the regions for REDD+ interventions to those that will ultimately deliver the most multiple benefits.