Creating Masoala National Park in Madagascar: Who Pays? Who Benefits?
A cost-benefit analysis at multiple scales[1]
Distributed: January 14, 2020 | Due: January 30, 2020 (beginning of class)

Please submit a report with your written answers and a copy of the final cost-benefit summary table (the first excel tab), as well as your actual Excel workbook (.xlsx file) via myCourses. Your written answers should be concise but please include enough detail about your thought process and calculation steps so that we can assign partial credit in the case that your final numerical results are incorrect.

With millions of hectares of tropical forest lost through land clearing each year, deforestation is the greatest cause of biodiversity loss globally and a major source of CO_2 emissions to the atmosphere (with recent estimates of approximately 5.6 – 8.6 GT of carbon released per year). As such, conserving tropical forest can make an important contribution to decreasing biodiversity loss and mitigating climate change. Across the tropics, however, conservation efforts have not always been successful; in many 'protected' areas, existing park regulations have not been enforced, and unprotected forests have often been subject to high logging, hunting, and agricultural pressures.

Although there are economic benefits to conserving tropical forest (e.g., ecotourism, the extraction of non-timber forest products, and the provisioning of ecosystem services such as carbon sequestration), there are competing economic benefits from clearing forest such as timber sales, agricultural production, or other development options. Both conserving and clearing forest also incur different kinds of costs. Moreover, these costs and benefits are not shared equally. For example, while the costs of forgoing timber sales are borne at the local or national scales, the climate benefits of avoiding carbon emissions are shared globally. The parties that have rights to the land do not always take into account all the *social* costs and benefits of any particular type of land use. As such, the economic incentives that a private landholder faces when making a decision to conserve a patch of tropical forest or develop it may not always reflect the value of that choice to society.

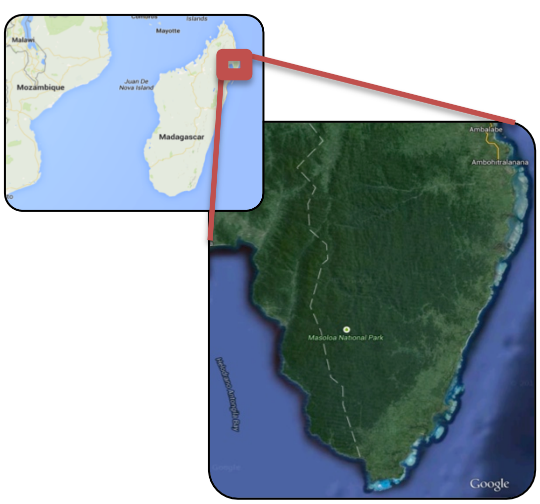

Figure 1: Masaola National Park, north-eastern Madagascar, in dark green.

In this lab, you will conduct a **cost-benefit analysis** at multiple scales to determine who bears the costs and who receives the benefits when a new park is established in the tropics. Using data provided by Dr. Claire Kremen (a conservation biologist affiliated with the University of British Columbia and the University of California-Berkeley), you will examine the case of the Masaola National Park Integrated Conservation and Development (ICDP) Program in Madagascar. Established in 1997, the park is 2,300 km^2 of primary rainforest with a 1,000km^2 buffer of unprotected forest (Figure 1). Farmers in the region often clear forest using slash-and-burn techniques for subsistence rice production. Given the rates of forest clearing at the time the park was set up, farmers were expected to reach the park boundaries within a few years.

[1] Based on Kremen, C, JO Niles, MG Dalton, GC Daily, PR Ehrlich, JP Fay, D Grewal, RP Guillery (2000) Economic incentives for rain forest conservation across scales. *Science* 288:1828—1832. Dr. Kremen's generosity in sharing the raw data and analysis from the paper is gratefully acknowledged. Drs. J. Rhemtulla and N. Ramankutty adapted these data for this lab.

One of the main goals of the Masaola ICDP, therefore, was to allow for and support alternate employment opportunities such as small scale sustainable forestry, non-timber forest products collection, and eco-tourism in the park and buffer zones, thereby providing local incentives for park creation. Establishing and managing a park, especially in the early years, is also a costly endeavour, and therefore is usually dependent on financial inputs from national governments and foreign donors. It also, of course, prevents other productive industries from utilizing the resources or developing the land in the park. Taking all these things into account, the overarching question is: **does creating a new park represent a net-benefit to society or does it represent an overall cost in economic terms?** At the outset, however, it is clear that we must be able to quantify many non-market environmental benefits at various scales if conservation is stand a chance.

<u>Conducting a Cost-Benefit Analysis</u>

The spreadsheet **'CostBenefit_Madagascar.xlsx'** contains all the data you will need to do your work. In essence, you will conduct three cost-benefit analyses: one at the <u>local</u> (here defined as one of the individual communities within or surrounding the park), one at the <u>national</u>, and another at the <u>international</u> scales. You will then compare the results. The first worksheet in the Excel file contains the master cost-benefit analysis table that will sum the various costs and benefits at each scale, over two time periods (10 years, 30 years) and two discount rates (3% and 10%). Subsequent worksheets contain the raw data needed to calculate the values that you will later compile into the master sheet. Each represents a different cost or benefit relevant at one or more of the different scales. In the sections below, we will discuss how to estimate each of the individual components of the final budgets.

In general, you will see that the data for each component is provided as a series of estimates of the annual costs and/or benefits of that particular component through time. Because these streams of flows vary through time, we must convert all annual values into their **Present Value (PV)** – their value to us today – using a discount rate, and then sum them to calculate the overall **Net Present Value (NPV)** for the whole time period:

NPV = SUM (Present values for each year over the entire time period)

$$NPV = \sum_{t=0}^{T} (Value_t) \left(\frac{1}{1+r}\right)^t$$

Where: *Value* = Net value (Benefit – cost) in a given year
t = time (e.g. the year -- Year 1, Year 2 ... Year T)
r = discount rate

For each individual worksheet, you will convert the annual flows into their PV (using the two discount rates) and then sum them to calculate the NPV (Question 1 below shows how to use this formula in a more detailed example). You will then input the resulting NPVs into the summary cost-benefit analysis table. When all calculations are complete, you will sum the costs and benefits at each of the three scales to show who 'wins' and who 'loses' (at least in monetary terms), and how this depends on your perspective (that is, the perspective for which you conduct the cost-benefit analysis).

1. Park Development & Management Costs (1 point)

The worksheet 'ParkCosts' contains an itemized list of costs that will be incurred for establishing, developing, and managing Masaolo Park and its associated development projects. (At which scale are these costs relevant?) Annual costs are listed for the first year, Years 2-5, Years 6-10, and Year 11-onwards; note that costs are typically the highest in the first year and decrease thereafter. For Years 11-onwards, we will assume that all costs remain stable at 60% of the Year 6-10 costs.

Question 1: Begin by manually calculating the NPV for a 30 year period at a 3% discount rate. In the column starting at C76, input the park costs for each year from 1996 to 2025 (using the appropriate totals from row 71). In the next column, calculate the PV (present value) of each of those annual costs using the formula above (i.e. for each row, calculate: $(Cost_t)(1/(1+\mathrm{r}))^t$). Finally, sum all of those PVs to obtain the NPV in cell D107. To check your answer, use the Excel function NPV (search the help to see how it works).

Question 2: Now calculate the NPV over 10-year (1996-2005) and 30-year (1996-2025) periods using 3% and 10% discount rates. You can use the Excel function NPV to do this. Also calculate the total costs without converting to PV. Input your results into the table in cells H76-I78 and compare all these values graphically and explain the trends. What do your results suggest about the effects of *discount rates* on cost-benefit analysis? What do your results suggest about the effect of the *period of time under consideration* for cost-benefit analysis?

When you are done, transfer the NPV values to the appropriate rows in the summary-costs benefit analysis worksheet. **WHEN ENTERING NUMBERS INTO THE SUMMARY TABLE, PLEASE BE SURE TO PUT A NEGATIVE SIGN IN FRONT OF VALUES THAT REPRESENT COSTS.**

2. International donors (1 point)

The creation of the Masaola ICDP was funded by international donors, who provided 5 years of aid for park management and 20 years for the associated development projects. The 'Donors Investment' worksheet provides data on the yearly amount of this international aid. (At what scale or scales is this cost/benefit relevant?)

Question 3: For each year, what is the proportion of aid being provided relative to the park costs that you calculated above (without converting to PV)? Does it seem reasonable, conservative, or generous?

Question 4: Calculate the NPV for 10 and 30-year periods using 3% and 10% discount rates. Transfer your values into the cost-benefit worksheet. Note that you need to put them in two places. **Why**?

3. National Employment Benefits from Park Creation & Management (1 point)

While hiring people to establish and run the park is a cost (that you accounted for above), it also represents an employment benefit that you need to consider.

Question 5: Using the 'National Employment' worksheet, calculate the total employment value using figures from the 'Parks Development and Management Costs' sheet. First summarize the costs of National Personnel and National Consultants in Y1, Y2-5, Y6-10, Y11-20, and Y21-30 in the table at the top of the 'National Employment' worksheet. Following Y10, assume:

- no national consultants are hired after Y10
- from Y11-Y20, national personnel continue at previous rate
- from Y21-30, no national development personnel are hired, and other personnel continue at 50% of previous rate.

As you did in previous calculations, calculate the yearly employment benefit, and then the NPV for 10 and 30-year periods using 3% and 10% discount rates. Transfer your values into the cost-benefit worksheet.

4. Sustainable Forestry (2 points)

The Masaola ICDP includes the development of small-scale sustainable forestry projects for local communities to export timber. Each local community will have access to 1,200 ha of forest where they can extract up to 111 m^3 of wood per year (maximum 11 m^3/ha). The 'Sustainable Forestry' worksheet includes the various costs and expected revenues of timber sales at the scale of the individual community. As before, you will use these numbers to calculate the NPV of this project at the local scale; you will then extrapolate the benefits at the national level assuming that multiple communities eventually develop such projects.

Question 6: Begin by examining the table in the top left corner of the sheet, which outlines the various costs of implementing a sustainable forestry project. Next, examine the table in the middle of the sheet, which summarizes the net benefit through time for a single community. How do these costs change through time and what are the most important factors contributing to these costs?

Question 7: As you have done before, use the row containing the 'Net benefits (costs)' values to calculate the NPV of sustainable forestry for a single community for 10- and 30-year periods with 3% and 10% discount rates in **cells G58-H59**. Enter these values into the cost-benefit summary sheet.

Question 8: In addition to benefitting from the revenue from selling the timber, the local community also benefits from the additional employment. The value of this employment is equivalent to the yearly 'wood production' costs (shown in the second table), as these correspond to the costs for felling and sawing timber, activities which are done manually in small-scale forestry operations. Using these values, calculate the NPV of the employment benefit for 10- and 30-year periods with 3% and 10% discount rates in **cells N58-O59**, and transfer these values into the cost-benefit summary sheet.

Question 9: To scale up to the national level, we will extrapolate the sustainable forestry NPV for a single community to all of the communities across the region that might be expected to develop such projects through time. In the table 'Extrapolate to All Communities' at the bottom of the worksheet, multiply the NPV value (for a given time period and discount rate) by the number of new communities that begin sustainable forestry projects in a given year (shown in **row 63** of the table). This will give you a new row of values of NPVs per year through time. Then calculate the NPV of this series of NPVs to estimate the present value of all such projects at the national level (**cells G76-H77**). Do the same thing for the employment benefits (in **cells N76-O77**). Transfer all values to the cost-benefit summary sheet.

5. Opportunity Costs – Industrial Logging and Hill Rice (0.5 points)

Opportunity costs are the costs of foregoing the next best alternative when making a decision. In the case of Masaola, the creation of the park means foregoing various activities that would likely have occurred in the absence of the park, namely industrial logging and clearing the forest for subsistence rice production. We will therefore account for the costs of these lost 'benefits'.

Question 10 (Industrial Logging): Calculating the net benefit that could come from industrial logging is complex and beyond the scope of this exercise. In essence, one must determine the total volume of marketable timber species per hectare over what harvestable forest area (the benefit), then plus all the potential costs: logging costs (including cost of road building, machinery, and personnel), transportation costs, stumpage fees, export taxes, and income tax. Further, a number of different logging scenarios are possible, depending on how much and how quickly forests are assumed to be logged. For the purposes of this analysis, Kremen and colleagues assumed a medium intensity scenario whereby 5 logging companies each log 2,211 hectares of forest per year, completely cutting the forest over a period of 30 years. The 'Industrial Logging' worksheet contains the NPV values for 10- and 30-year periods at 3% and 10% discount rates. Transfer them to the appropriate cells in the summary cost-benefit sheet.

Question 11 (Hill Rice): On a smaller community scale, farmers often traditionally plant hill rice. After clearing the forest and burning the remaining vegetation, farmers plant hill rice for subsistence purposes (using swidden-fallow techniques, they plant one year of rice and then allow the land to go fallow). The creation of the park also deprives farmers of this benefit. In the 'Hill Rice' worksheet, calculate the NPV of the lost rice opportunity at two scales: national and local.

For the national scale, assume that all land cleared yearly under the industrial logging scenario (see previous question for details) would have been put into rice for one year at a value of $69.24 per hectare.

At the local scale, assume that farmers would have cleared land and grown rice within the 1200ha area that they are now using for sustainable forestry. Assume that they would clear 1.5% of the 1200 ha forest at each year (the national deforestation rate), grow rice for a single year before leaving the land fallow (indefinitely), and that the value of the rice is $69.24/ha. Calculate the NPV for 10- and 30- year periods at 3% and 10% discount rates and transfer the results into the summary cost-benefit table.

6. Value of Carbon Conservation (0.5 points)

In the absence of Masaola ICDP, it is reasonable to assume that forests would have been cleared, likely through industrial logging such as in the scenario described above. Tropical forests also store massive amounts of carbon, and forest clearing contributes about 30-40% of annual global CO_2 emissions. Logging activities can contribute strongly to climate change, especially when clearing primary forest and replacing it with industrial timber species. By avoiding this forest clearing and the resulting emissions, the Masaola National Park thus provides a carbon conservation benefit.

Question 12: As in the industrial logging scenario, assume that 5 companies each log 2,211 ha of forest per year. Although some of this timber will be exported, much of the remnant non-merchantable timber will be burned or left to rot, resulting in 190.57 t of total CO_2 equivalent emissions per hectare (based on Fearnside 1997); these emissions will be slowly released over 10 years (assume 19.057 t/year for 10 years). For the purposes of this lab, we will assume that carbon is valued at \$20/t CO_2/year (however, note that we could use *considerably* higher values based on more recent studies and are using this smaller one only for simplicity). In the 'Carbon' worksheet, calculate the total value of these avoided carbon emissions per year, then calculate the NPV at 10- and 30-year time periods at 3% and 10% discount rates. Transfer the values to the cost-benefit summary table. At what scale is carbon conservation a benefit? Why?

7. Compare the Cost-Benefit Results

Question 13 (1 point): Sum the individual costs and benefits at the local, national, and global scales. Comment on the results: who 'wins', and who 'loses'? Are you surprised? Would you support the project if you were a local farmer, the president of Madagascar, or an international donor?

Question 14 (1 point): How different are the results calculated over the two time periods and discount rates?

Question 15 (2 points): If you had to design a system of payments to increase the incentives for conservation, who should pay who and how much? What are the pros and cons to such a system?

Question 16 (2 points): If you were to develop this analysis further, what other costs or benefits (or associated methodology) would you consider? Are there other factors that would be important to take into consideration that would could be quantified or that would be difficult to assess?

Reminder of Other Dates

January 16 – More detailed introduction of Lab #1
January 21 and 23 – Dedicated lab sessions (work on lab in class)
January 28 – Paper discussion
January 30 – Lab #1 report due / Brief lab discussion in class