BIODIVERSITY IMPACTS OF CHINESE ECONOMIC ACTIVITIES IN AFRICA

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ABSTRACT

Over the past few years, the pace of growth and the magnitude of the Chinese presence abroad have fuelled international debates on the social, political and economic impacts of this trend on developing countries. Much attention is directed towards Chinese economic activities in Africa. However, thus far little research has been done on the actual social and environmental impacts of Chinese economic activities in Africa. Current paper is meant as a scoping study to identify and compare for twenty selected African countries the Chinese economic activities with the highest potential impact on biodiversity. An analytical framework has been developed for this purpose and will be presented in this paper. The top-ten country – sector combinations of the resulting final ranking are highly recommended for future more in-depth (field) research on the impact of Chinese economic activities on biodiversity in Africa on.

1. INTRODUCTION

Booming demand caused by domestic consumption as well as large scale manufacturing of goods for export, are driving the demand for natural resources in China. As part of this trend, Chinese companies, investors and traders have been searching for natural resources across the world and established a solid presence abroad. Over the past few years, the pace of growth and the magnitude of the Chinese presence abroad have fuelled international debates on the social, political and economic impacts of this trend on developing countries. Much attention is directed towards Chinese economic activities in Africa. The ‘economic cooperation’ approach taken by the Chinese government, which encompasses all different financial flows between China and Africa from both private and public organisations, creates suspicion about the Chinese government being actively supporting Chinese companies in Africa to secure projects and get access to natural resources. Western companies traditionally trading with and investing in Africa fear to lose access to Africa’s fast growing markets and its abundant availability of natural resources, while Western countries fear to lose political allies and influence. These fears are further fuelling the debate on the social, political and economic impacts of Chinese economic activities in Africa. However, thus far little research has been done on the actual social and environmental impacts of Chinese economic activities in Africa. The lack of such research can be partly explained by the fact that longitudinal research is needed in order to study impacts, and this kind of research is costly and time-consuming.

Current paper is based on a large study on the impact of Chinese trade and investment on biodiversity in Africa for which a slightly different approach was taken. The study was meant as a scoping study to identify and compare for twenty selected African countries the Chinese economic activities with the highest potential impact on biodiversity. The aim of the study was twofold. Firstly, it aimed to develop an analytic framework to contribute to measuring the impact of economic activities on biodiversity and, secondly, it aimed to identify the economic sectors within selected African countries in which Chinese actors are important investors and/or trade partners with a high possibility that these Chinese economic activities have a negative impact on biodiversity.

This paper presents and discusses the analytical framework. The first section discusses the challenges for measuring the impact of economic activities on biodiversity in Africa. The second section describes how a ranking was made based on the trade and investment relationships with China; a second ranking based on the potential impact on biodiversity and ecosystem services; and, finally, it describes how both rankings were combined. The top-ten country – sector combinations of the resulting final ranking are highly recommended for future more in-depth (field) research on the impact of Chinese economic activities on biodiversity in Africa on.

2. Challenges for measuring the impact

There are many challenges to measuring the impact of economic activities on biodiversity in Africa. Most importantly, there is a lack of data on biodiversity in Africa due to, on the one hand, a lack of capacity for monitoring and, on the other hand, many difficult-to-access terrains and violent conflict situations in Africa. South Africa is one of the few African countries for which detailed assessments of biodiversity have been undertaken (see for example Wynberg, 2002 and the work of the South African National Biodiversity Institute (SANBI)). Secondly, in order to study the impacts of economic activities on biodiversity, one needs to conduct longitudinal research or at least one needs a baseline study. There are no baseline studies available and there is hardly funding for such a long-term research project. As a consequence, most claims of the impacts of Chinese economic activities in Africa are currently based on assumptions rather than evidence. See for example Taylor (2007) who is assuming a high ecological impact of Chinese logging activities in Africa based on estimations about a high share of illegal logging only.

In order to study the real impact of economic activities on biodiversity, one should look at the level of the firm. The amount of Chinese firms in Africa is often estimated to be around 2,000 (Ncube & Fairbanks, 2012); however, nobody knows the exact number. Wang Duanyong showed that this is a conservative estimation showing with his study that there were three times as much Chinese companies active in Libya as was estimated before the evacuation in 2011 (Wang, expected to be published soon). Many Chinese small and medium enterprises (SMEs) operate off the radar because they no longer need to register with the Chinese Ministry of Commerce and Chinese local embassies do not keep track of all Chinese companies active in their respective host country (based on interviews with representatives of local Chinese embassies and foreign offices of the Chinese Ministry of Commerce (MOFCOM) in Africa). An increasing number of studies on the number and location of Chinese firms in Africa appear; however, these studies are still largely incomplete. A study that received much attention lately is the study on Chinese development finance activities in Africa by AidData (2013) resulting in an interactive online database. This database provides

information on a number of Chinese projects in Africa. Although the focus of the AidData study is on development finance, some projects mentioned in the database do include joint ventures and foreign direct investment (FDI). This can be explained by the fact that the Chinese government is not always making a clear distinction between aid, trade and investment like the Development Assistance Committee (DAC) countries do, but instead often refers to "economic cooperation" which includes these three, and other (hybrid), financial flows. The number of projects identified by AidData is not complete and not reliable yet. They presented their findings in the form of a web-based platform (at china.aiddata.org) with the aim to crowd-source information about Chinese aid and investment projects and programs and to continue improving the data. AidData used a systemised media-based methodology for collecting the initial data, which they refer to as a new methodology. This methodology is however not as new as they suggest. Professor Brautigam has described and criticised a number of research findings on Chinese FDI to Africa based on news reports already (Brautigam 2010-2012). A huge challenge for this methodology is that pledges reported in the media do not always materialise and therefore the total amount of China's development finance is expected to be much lower than the estimated amount mentioned by AidData. The AidData database does not provide information on the location of Chinese firms in Africa yet. However, they are currently working on a geocoded dataset of all Chinese official finance projects to Africa from 2000 to 2011.

In order to overcome the challenges mentioned, more field research and longitudinal is required. The main aim of this paper is to identify the country-sector combinations that are most suitable for further in-depth research in order to direct funding and other research resources. The next section describes the analytical framework used to identify the economic sectors which combine strong trade and/or investment relations with China with a large potential impact on biodiversity in selected countries.

3. Ranking

3.1 Introduction

Both quantitative and qualitative research methods have been used to identify and measure Chinese economic activities and the level of biodiversity and ecosystem services in the African countries under study. This section describes the process of getting to a final selection of ten country-sector combinations that are highly recommended for further research. The ranking focuses on five sectors, namely: agriculture, fisheries, forestry, infrastructure and mining.

This ranking process involves four steps, namely:

1. Initial selection of twenty African countries
2. Ranking of country-sector combinations based on their economic relations with China
3. Ranking of the country-sector combinations based on their impacts on biodiversity and ecosystem services
4. Combining the China country-sector ranking with the biodiversity country-sector ranking into a combined ranking.

The different steps are described in more detail below. The final combined ranking is used to identify the top-ten sector-country combinations with a large potential impact on biodiversity as well as close trade and/or investment relationships with China.

3.2 Initial selection of twenty African countries

At the start of the study, twenty African countries were selected by making a quick comparison between all 33 sub-Saharan African countries. The selection was based on weighted criteria combining the biodiversity and ecosystem services values of these countries with data on trade with, and FDI from China. The value of the biodiversity and ecosystem services per country was measured using data from Ruesch & Gibbs (2008) on carbon storage (measured as total biomass), data from Nelson et al. (2009) on water service (measured as water available for rain fed agriculture), and from UNEP (Groombridge & Jenkens 2002) on endemic vertebrate species (mammals, birds, reptiles, and herpetofauna). Furthermore, the inclusion of a country in a WWF Priority Place was used as an indicator (WWF, 2013).

Production data and relevant Chinese import data (volume and/or value) per commodity and country were compiled using USGS Minerals yearbooks for African countries (USGS 2011a) and specific minerals (USGS 2011b; USGS 2013), UN Comtrade (2013), International Trade Centre (2013) and the FAO Stat database (2013) for Chinese import data. Data on Chinese FDI to Africa were obtained from the Chinese Ministry of Commerce (MOFCOM 2009, 2010 and 2011). Table 1 shows the results of this initial selection process, indicating the twenty countries selected for this study.

Table 1. Selection of 20 sub-Saharan Africa countries

Country	**WWF Priority Place**	**Conservation values (rank)**	**Trade in soft commo-dities (rank)**	**Trade in hard commo-dities (rank)**	**Chinese FDI flow (rank)**	**Combined rank**	**Selected**
DR Congo	Yes	1	7	3	4	1	Yes
South Africa	Yes	8	6	1	1	2	Yes
Nigeria		4	1	9	2	3	Yes
Tanzania	Yes	3	4	4	17	4	Yes
Ghana		18	5	2	11	5	Yes
Angola	Yes	6	17	12	7	6	Yes
Ethiopia		5	13	20	6	7	Yes
Guinea	Yes	13	8	7	20	8	Yes
Cameroon	Yes	6	3	12	30	9	Yes
Zambia	Yes	13	28	8	3	10	Yes
Republic of the Congo	Yes	21	9	10	14	11	Yes
Gabon	Yes	19	16	10	16	12	Yes
Madagascar	Yes	2	24	29	9	13	Yes
Mozambi-que	Yes	11	13	20	22	14	Yes

Country	WWF Priority Place	Conservation values (rank)	Trade in soft commo-dities (rank)	Trade in hard commo-dities (rank)	Chinese FDI flow (rank)	Combined rank	Selected
Kenya	Yes	17	25	23	8	15	Yes
Zimbabwe	Yes	20	30	5	19	16	Yes
Botswana	Yes	25	32	6	15	17	Yes
Liberia		12	27	18	23	18	Yes
Uganda	Yes	13	20	20	28	19	Yes
Namibia	Yes	24	31	14	26	20	Yes
Ivory Coast		10	2	16	31	21	No
South Sudan		8	9	31	12	22	No
Senegal	Yes	29	13	25	21	23	No
Chad		33	22	23	5	24	No
Central African Republic	Yes	23	28	28	10	25	No
Sierra Leone		22	19	15	29	26	No
Mali		29	20	26	13	27	No
Benin		32	17	17	25	28	No
Equatorial Guinea	Yes	27	26	27	18	29	No
Togo		31	12	31	24	29	No
Malawi	Yes	25	23	30	27	31	No
Burkina Faso		27	9	19			No
Sudan		13					No

3.2 Chinese economic relations

In the first step of the ranking, the economic sectors in the selected twenty African countries are ranked focusing on their economic relations with China. The ranking is based on an analysis of FDI and trade data for which four indicators were selected, namely:

- The number of Chinese projects in each country-sector combination;
- The total exports of the sector as a share of the GDP of the country;
- The share of the exports to China of the sector;

- The share of China's import from the country out of China's total import for the sector.

The Chinese share of total FDI flows and or stock are not taken into account because FDI data for the twenty selected African countries were mostly absent in recipient country sources as well as in international sources, therefore it was not possible to check nor compare the data from MOFCOM. Furthermore, the data collected from the most important FDI source countries appeared to represent an underestimation of the actual investments due to the following reasons:

- Some countries report for one or more years no FDI flow to the 20 African countries; sometimes FDI flows are confidential. This is especially the case when the FDI flow is composed of only one or two investors originating from one country, as publishing the FDI data would reveal commercially sensitive information.
  Some countries, such as Australia, Portugal, Spain, Switzerland and the United Kingdom hardly publish any FDI flows for the twenty African countries, although it is unlikely that they are not investing in any of them. Other countries, such as Austria and Canada, do not publish OFDI flows at all.
- Different definitions can create differences between flow data reported by investor and recipient countries.
- The most important complication, however, seems to be that companies from many countries guide their outward FDI through other intermediate countries, often for tax purposes. Intermediate countries often are the Netherlands, Luxembourg, Hong Kong, Mauritius, the Cayman Islands, the British Virgin Islands and Bermuda.

For the four selected indicators standardised scores were calculated and combined to a weighted average. A weight of 40 per cent was assigned to the number of Chinese projects and an equal weight of 20 per cent was assigned to the three trade indicators. As the trade indicators are not relevant for the infrastructure sector, a weight of 100 per cent or the country-infrastructure combinations the only indicator used was the number of Chinese projects.

Table 2 shows for the sectors agriculture, fisheries, forestry and mining the country-sector combinations in the twenty African countries which have the strongest economic relations with China.

Table 2. Country-sector ranking based on economic relations with China

Rank	Country	Sector	Chinese projects	Total Exports by sector / GDP 2007-2011 (%)	Exports to China / Total sector exports 2007-2011 (%)	Imports from country / Chinese sector imports 2007-2011 (%)
1	Zambia	Mining	70	34.6%	39.5%	0.6%
2	South Africa	Mining	23	12.2%	16.3%	4.0%
3	DRC	Mining	35	25.2%	54.0%	0.7%
4	Mozambique	Forestry	20	0.6%	89.0%	0.4%
5	Gabon	Forestry	18	4.3%	43.4%	1.3%

6	Zambia	Agriculture	26	3.3%	10.2%	0.1%
7	Zimbabwe	Mining	14	15.7%	7.3%	0.0%
8	Namibia	Mining	5	26.1%	9.8%	0.1%
9	Mozambique	Mining	16	12.6%	2.1%	0.0%
10	Tanzania	Mining	6	8.2%	38.6%	0.1%
11	Congo	Forestry	0	1.5%	53.4%	0.7%
12	Botswana	Mining	0	29.3%	3.2%	0.0%
13	Zimbabwe	Agriculture	3	12.2%	20.6%	0.2%
14	Cameroon	Forestry	7	2.4%	17.9%	0.5%
15	Guinea	Mining	3	22.1%	0.0%	0.0%
16	Guinea	Forestry	0	0.6%	59.1%	0.1%
17	Mozambique	Agriculture	11	5.0%	5.2%	0.0%
18	Gabon	Mining	1	1.5%	43.7%	0.2%
19	Madagascar	Forestry	0	0.5%	54.5%	0.0%
20	Madagascar	Mining	3	1.1%	41.9%	0.0%

Seven mining sectors figure in the top-ten, as the mining sector has attracted relatively much Chinese investment, as mining contributes strongly to the GDP of many of the twenty African countries and as China is a main export destination for the mining sector in many of the African countries. The importance of the mining sectors of the twenty African countries for China's mining imports plays a smaller role, except for South Africa and - to a lesser extent - Zambia and the DRC. There are also two forestry sectors in the top-ten, which is caused by a high orientation on exports to China and a fairly high number of Chinese projects. The only agriculture sector in the top-ten is mainly based on the large number of Chinese projects in Zambian agriculture and the relatively high share of exports to China.

As the trade indicators are not relevant for the infrastructure sector, the infrastructure-combinations were ranked by using the number of Chinese projects only. The Chinese projects identified for this sector are not investments by Chinese companies however infrastructure projects for which Chinese construction companies are contracted. The top-5 infrastructure country-combinations are summarized in Table 3.

Table 3. Country-infrastructure ranking based on relations with China

Rank	**Country**	**Chinese infrastructure projects**
1	Zambia	29
2	DRC	24
3	Kenya	24
4	Ethiopia	19
5	Ghana	16

3.3 Biodiversity and ecosystem services

The second step in the ranking process aims to define which country-sector combinations are expected to have a strong impact on biodiversity and ecosystem services in the twenty African countries. First a ranking was made of the twenty African countries, based on three indicators of biodiversity and ecosystem services, namely:

- Forest area in hectares according to the World Bank (2013), divided by the total land area;
- Total internal renewable water resources in billion m^3 per year according to the FAO (2013b), divided by the total land area;
- Biodiversity value per area unit, according to a methodology developed by the UNEP World Conservation Monitoring Centre (Groombridge & Jenkins, 2002).

As indicators are measured in incomparable units, a standard statistical procedure was applied to calculate standardised Z-scores for each indicator. Based on the normal average of the three Z-scores, a biodiversity value and ecosystem services ranking of the twenty countries was determined (1 - 20). This ranking is presented in section 4.3. The indicators are relative to the size of the country, so large countries do not necessarily rank higher than small countries. By taking the average of the standardised scores of the three indicators, the twenty African countries are ranked as presented in Table 4.

Table 4. Biodiversity and ecosystem services ranking of twenty African countries

Rank	Countries	Surface area (million ha)	Forest area (% of total surface)	Total internal renewable water resources (billion m^3 / year / ha)	Biodiversity value per area unit
1	Gabon	26.77	82%	6.13	0.56
2	Liberia	11.14	39%	17.96	0.13
3	Congo	34.20	66%	6.49	0.59
4	Madagascar	58.70	21%	5.74	1.28
5	DRC	234.49	66%	3.84	0.58
6	Cameroon	47.54	42%	5.74	0.76
7	Guinea	24.59	27%	9.19	0.37
8	Angola	124.67	47%	1.19	0.54
9	Tanzania	94.73	35%	0.89	0.69
10	Zambia	75.26	66%	1.07	0.07
11	South Africa	121.91	5%	0.37	0.92
12	Ghana	23.85	21%	1.27	0.57
13	Uganda	24.16	12%	1.61	0.62
14	Zimbabwe	39.08	40%	0.31	0.30
15	Mozambique	79.94	49%	1.25	0.01
16	Kenya	58.04	6%	0.36	0.56

Rank	Countries	Surface area (million ha)	Forest area (% of total surface)	Total internal renewable water resources (billion m^3 / year / ha)	Biodiversity value per area unit
17	Ethiopia	110.43	11%	1.10	0.38
18	Nigeria	92.38	10%	2.39	0.13
19	Namibia	82.43	9%	0.07	0.12
20	Botswana	58.17	20%	0.04	-0.29

As shown in Table 4, Gabon has the highest relative ranking (per hectare) on biodiversity and ecosystem services among the twenty African countries, followed by Liberia, Congo and Madagascar. This country ranking will be used for the next steps of the ranking process.

Secondly, since the value of biodiversity and ecosystem services differs per location within a country and since economic activities are also not spread evenly over the territory of a country, it was decided to further zoom in on the level of ecoregions in the twenty selected African countries. Biodiversity follows complex patterns determined by climate, geology and the evolutionary history of the planet. These patterns are called "ecoregions", defined by Olson et al. (2001: 933) as

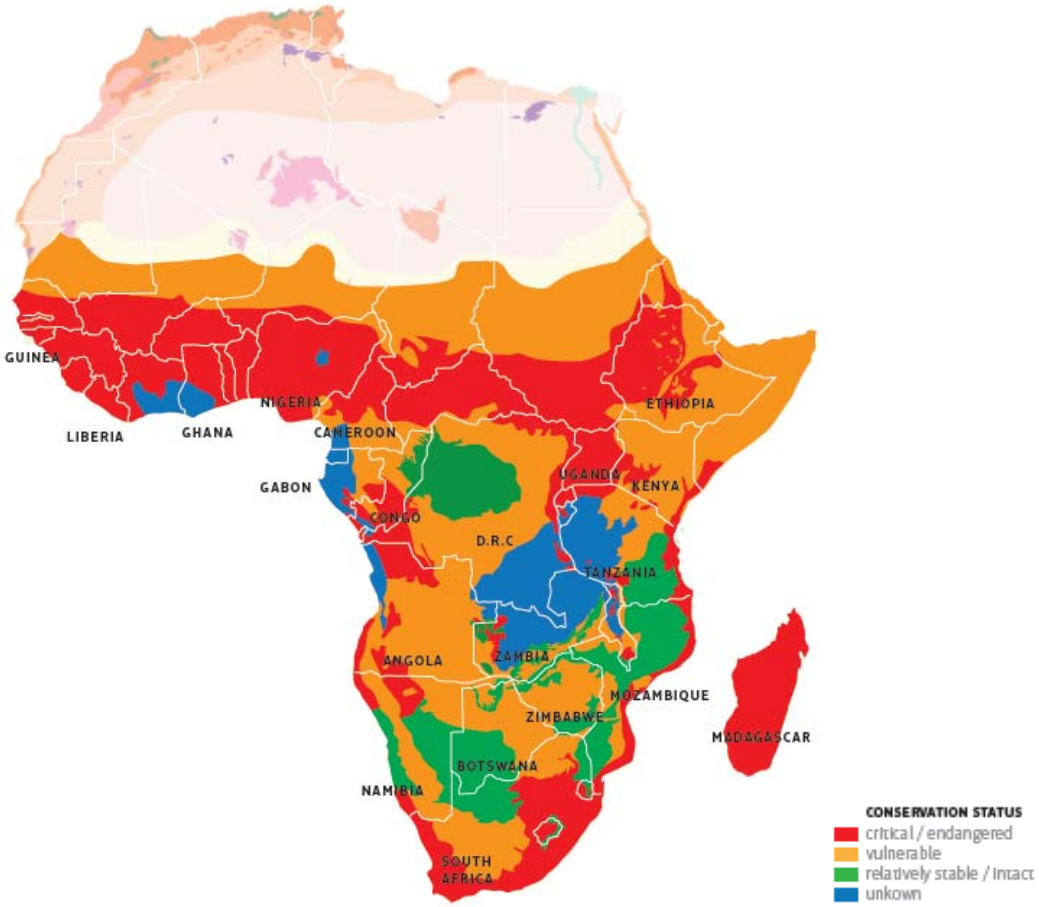
> relatively large units of land containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use change.

A ranking was made of the ecoregions located in the twenty African countries, based on their relevance for biodiversity and ecosystem services based on three criteria, namely:

1. the biodiversity value and ecosystem services score of the country in which the ecoregion is located (see Table 4), as this indicates the importance of the biodiversity and ecosystem services of this country;
2. the conservation status of the ecoregion: critical/endangered ecoregions should have more prominence in the ranking than relatively stable/ intact ecoregions;
3. the size of the area of the ecoregion located in the country in hectares: a large area deserves more attention than a small area with equal conservation status.

A country usually covers more than one ecoregion. For ecoregions located in more than one country, each country-part of the ecoregion was ranked separately. The conservation status of the ecoregion was retrieved from the Wildfinder database developed by WWF's Conservation Science Program (see http://worldwildlife.org/science/wildfinder/). The Wildfinder website defines the conservation status of ecoregions as either relatively stable/intact, vulnerable, or critical/endangered. Figure 1 shows the ecoregions located in the selected twenty African countries for this study and their conservation statuses.

Figure 1. Conservation status of the ecoregions in twenty African countries



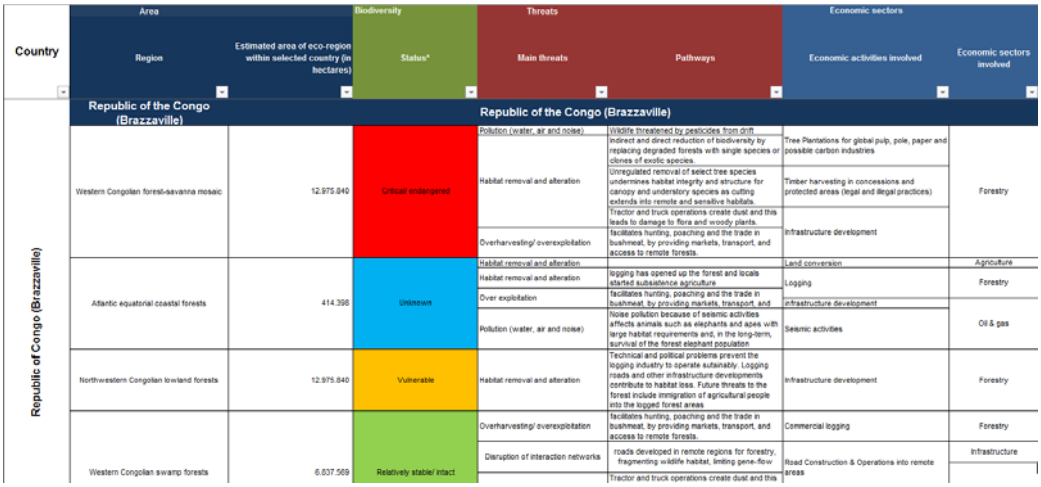
Combining the data on the three indicators, a ranking of ecoregions on their relevance for biodiversity and ecosystem services was calculated. The top-twenty of the ranking of ecoregions is summarized in Table 5.

Table 5. Top-20 of the ecoregion ranking for the twenty African countries

Rank	Ecoregion	Country
1	Central Zambezian Miombo woodlands	DRC
2	Angolan Miombo Woodlands	Angola
3	Southern Congolian forest-savannah mosaic	DRC
4	Northeastern Congolian lowland forests	DRC
5	Madagascar subhumid forests	Madagascar
6	West Sudanian savannah	Nigeria
7	Madagascar dry deciduous forests	Madagascar
8	Western Congolian forest-savannah mosaic	Congo
9	Western Guinean lowland forests	Liberia
10	Northern Congolian forest-savannah mosaic	Cameroon
11	Madagascar lowland forests	Madagascar
12	Northern Congolian forest-savannah mosaic	DRC
13	Central Congolian lowland forests	DRC
14	Western Congolian forest-savannah mosaic	Gabon
15	Madagascar succulent woodlands	Madagascar
16	Central African mangroves	Gabon
17	Guinean forest-savannah mosaic	Guinea
18	Madagascar spiny thickets	Madagascar
19	Albertine Rift montane forests	DRC
20	Western Congolian forest-savannah mosaic	DRC

Based on data retrieved from WWF's Wildfinder database, complemented with an analysis of a scientific literature research on the impact of economic activities on biodiversity in the twenty African countries, a structured overview was developed detailing per ecoregion which threats to biodiversity are known, including pathways and economic activities causing these threats (see Figure 2). The structured overview links data on the threats and impacts caused by different economic sectors to the ecoregions in the twenty African countries.

Figure 2. Example of part of the structured overview



Country	Area		Biodiversity	Threats		Economic sectors	
	Region	Estimated area of eco-region within selected country (in hectares)	Status*	Main threats	Pathways	Economic activities involved	Economic sectors involved
Republic of Congo (Brazzaville)	Republic of the Congo (Brazzaville)			Republic of the Congo (Brazzaville)			
Republic of Congo (Brazzaville)	Western Congolian forest-savanna mosaic	12.975.840	Critical/ endangered	Pollution (water, air and noise)	Wildlife threatened by pesticides from drift		
				Habitat removal and alteration	indirect and direct reduction of biodiversity by replacing degraded forests with single species or clones of exotic species.	Tree Plantations for global pulp, pole, paper and possible carbon industries	Forestry
					Unregulated removal of select tree species undermines habitat integrity and structure for canopy and understory species as cutting extends into remote and sensitive habitats.	Timber harvesting in concessions and protected areas (legal and illegal practices)	
					Tractor and truck operations create dust and this leads to damage to flora and woody plants.		
				Overharvesting/ overexploitation	facilitates hunting, poaching and the trade in bushmeat, by providing markets, transport, and access to remote forests.	Infrastructure development	
	Atlantic equatorial coastal forests	414.398	Unknown	Habitat removal and alteration		Land conversion	Agriculture
				Habitat removal and alteration	logging has opened up the forest and locals started subsistence agriculture	Logging	Forestry
				Over exploitation	facilitates hunting, poaching and the trade in bushmeat, by providing markets, transport, and	infrastructure development	
				Pollution (water, air and noise)	Noise pollution because of seismic activities affects animals such as elephants and apes with large habitat requirements and, in the long-term, survival of the forest elephant population	Seismic activities	Oil & gas
	Northwestern Congolian lowland forests	12.975.840	Vulnerable	Habitat removal and alteration	Technical and political problems prevent the logging industry to operate sutainably. Logging roads and other infrastructure developments contribute to habitat loss. Future threats to the forest include immigration of agricultural people into the logged forest areas	Infrastructure development	Forestry
	Western Congolian swamp forests	6.837.569	Relatively stable/ intact	Overharvesting/ overexploitation	facilitates hunting, poaching and the trade in bushmeat, by providing markets, transport, and access to remote forests.	Commercial logging	Forestry
				Disruption of interaction networks	roads developed in remote regions for forestry, fragmenting wildlife habitat, limiting gene-flow	Road Construction & Operations into remote areas	Infrastructure
					Tractor and truck operations create dust and this		

The standardised scores calculated for the ecoregions in the third ranking step were assigned to the economic sectors that have an impact on the ecoregion. The intensity of the threats and impacts caused by each economic sector are not taken into account since the available information on the intensity of threats is very limited and cannot be quantified. When one sector has impacts on more than one ecoregion in a country, the scores of each ecoregion are assigned to this country-sector combination. Similarly, when more than one sector had a strong impact on a specific ecoregion, the score of this ecoregion was assigned to each of these sectors. The country-sector combinations were then ranked based on the sum of the scores of the ecoregions they have impact on. The top-twenty country-sector combinations resulting from this ranking are summarized in Table 6.

Table 6. Top-twenty country-sector combinations ranked on biodiversity impacts

Rank	Country	Sector	Ecoregions in which sector is a threat	Size of ecoregions (mln hectares)
1	Madagascar	Agriculture	6	58.6
2	Madagascar	Forestry	6	58.6
3	DR Congo	Forestry	8	119.9
4	DR Congo	Mining	3	104.2
5	DR Congo	Agriculture	6	56.9
6	DR Congo	Infrastructure	3	55.2
7	Cameroon	Agriculture	7	15.5
8	Cameroon	Forestry	7	26.6
9	Angola	Mining	3	80.6
10	Angola	Forestry	4	88.6
11	Madagascar	Fisheries	3	23.4

Rank	Country	Sector	Ecoregions in which sector is a threat	Size of ecoregions (mln hectares)
12	Cameroon	Infrastructure	4	17.3
13	Gabon	Mining	3	24.0
14	Guinea	Infrastructure	4	23.7
15	Liberia	Agriculture	2	10.9
16	Liberia	Infrastructure	2	10.9
17	Liberia	Mining	2	10.9
18	Nigeria	Mining	2	70.0
19	Guinea	Forestry	3	21.6
20	Cameroon	Mining	3	33.8

The ranking in Table 6 shows the economic sectors which have the strongest potential impacts on biodiversity and ecosystem services in the twenty African focus countries. Two sectors in Madagascar, agriculture and forestry, lead the ranking. This is caused by the facts that Madagascar ranks relatively high on the level of biodiversity and ecosystem services (see Table 4) and that both sectors are each threatening 6 ecoregions which are critically/endangered (see Figure 1). The four sectors in the DRC, two in Cameroon and two in Angola are included in the top-ten for similar reasons.

For the three countries - Gabon, Liberia and Congo - leading the relative ranking on biodiversity value and ecosystems services in Table 4, no sector is included in the top-ten of country-sector combinations in Table 6. This is caused by the relatively small size of Gabon and Liberia, and by the low number of ecoregions threatened by economic activities in these three countries.

The ranking of country-sector combinations in Table 6 is based on an existing database of WWF, an analysis of recent scientific literature on the biodiversity impacts of economic activities in Africa and on biodiversity and ecosystem services indicators provided by credible international institutions. However no extensive field work was undertaken to assess the impacts of economic activities on biodiversity and ecosystem services in each of the twenty African countries in detail. The ranking should therefore be interpreted primarily as a first indication of which country-sector combinations are most interesting for further research on the impact of economic activities on biodiversity and ecosystem services in Africa. For actors operating on the individual country level, such as governments and NGOs, the ranking can also help to assign priority to sectors within the country.

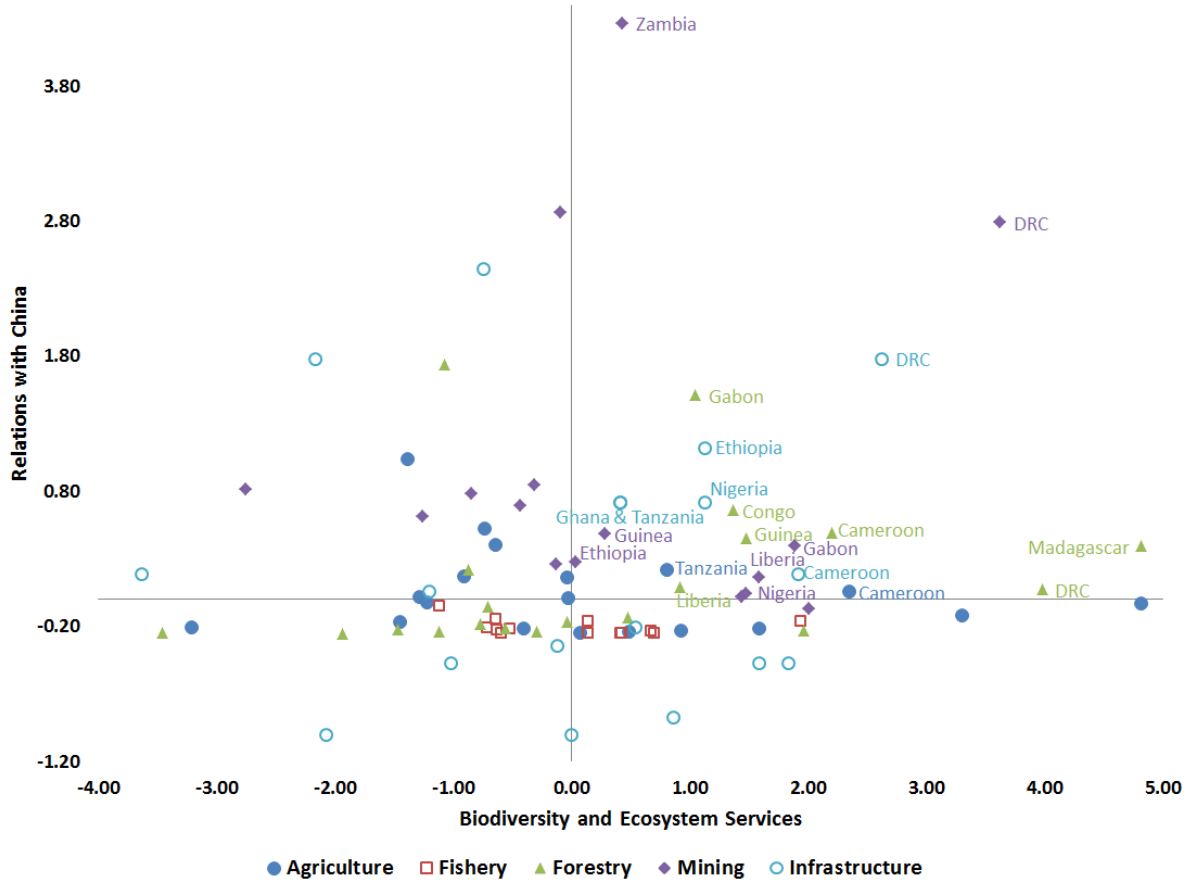
3.3 Step 3 combined ranking

The final step of the ranking process aims to identify the country-sector combinations with a strong potential impact on biodiversity and ecosystem services and in which Chinese actors are highly active. To do so, the rankings of country-sector combinations on economic relations with China (table 2) and on biodiversity and ecosystem services (table 6) are combined.

The scores for all country-sector combinations in both rankings were standardised and then

plotted in a diagram, with the economic relations with China ranking on the Y-axis and the biodiversity and ecosystems services ranking on the X-axis and, as shown in Figure 3. The 23 country-sector combinations in the upper-right quadrant of Figure 3 combine strong trade and/or investment relationships with China with a possibly strong impact on biodiversity and ecosystem services.

Figure 3. Combined ranking of country-sector combinations



The combined ranking of the 23 country-sector combinations in the upper-right quadrant of Figure 3 is summarized in Table 7. The Relations with China ranks refers to the ranks in Table 2 (for the sectors agriculture, fisheries, forestry and mining) and Table 3 (for the sector Infrastructure), while the Biodiversity and Ecosystem Services rank refers to the ranks in Table 6.

Table 7. Combined ranking of country-sector combinations

Rank	Country	Sector	Relations with China rank	Biodiversity and ecosystem services rank
1	DRC	Mining	3	4
2	Zambia	Mining	1	34
3	Madagascar	Forestry	19	2
4	DRC	Infrastructure	Inf2	6

Rank	Country	Sector	Relations with China rank	Biodiversity and ecosystem services rank
5	DRC	Forestry	31	3
6	Gabon	Forestry	5	24
7	Cameroon	Forestry	14	8
8	Ethiopia	Infrastructure	Inf4	22
9	Cameroon	Agriculture	33	7
10	Gabon	Mining	18	13
11	Congo	Forestry	11	21
12	Cameroon	Infrastructure	Inf9	12
13	Guinea	Forestry	16	19
14	Nigeria	Infrastructure	Inf6	23
15	Liberia	Mining	28	17
16	Nigeria	Mining	34	18
17	Cameroon	Mining	36	20
18	Tanzania	Infrastructure	Inf7	37
19	Ghana	Infrastructure	Inf5	38
20	Tanzania	Agriculture	25	28
21	Liberia	Forestry	30	26
22	Guinea	Mining	15	39
23	Ethiopia	Mining	22	43

While the 23 country-sector combinations in Table 7 combine a strong trade and/or investment relationships with China with a possibly strong impact on biodiversity and ecosystem services, it is clear that not many country-sector combinations rank very high in both rankings. Two country-sector combinations - Mining and Infrastructure in the DRC - rank in the top-ten of both rankings, while another five rank in the top-twenty of both rankings: Forestry in Cameroon, Guinea and Madagascar; Infrastructure in Cameroon; and Mining in Gabon. The other 16 country-sector combinations included in the combined ranking, have a high ranking for only one of the two aspects. Four of the country-sector combinations which rank in the top-ten on biodiversity value and ecosystem services in Table 6 are not included in Table 7 as they do not have strong economic relations with China, namely: Agriculture in Madagascar and the DRC, and Forestry and Mining in Angola.

Vice versa, seven of the country-sector combinations which rank in the top-ten of economic relations with China in Table 2 are not included in Table 17 as there is no evidence which suggests that these economic sectors have a large impact on biodiversity and ecosystem services in these countries. These are: Mining in South Africa, Zimbabwe, Namibia, Mozambique and Tanzania, Forestry in Mozambique and Agriculture in Zambia.

Most surprisingly is the low biodiversity and ecosystem services rank for Forestry in Mozambique, which is found to have an impact on 8 ecoregions in Mozambique of which various are categorized as critical/endangered. This low ranking of Forestry in Mozambique is caused mainly by the low ranking of Mozambique (15 out of 20) in Table 4, which is caused by a low level of internal water resources (according to the FAO 2013b) and one of the lowest biodiversity levels among the twenty African countries (according to the UNEP World Conservation Monitoring Centre 1994). This conclusion could be revaluated if more specific information is gathered on the relative biodiversity and ecosystem services values of the ecoregions in Mozambique which are most affected by the forestry sector.

4. Conclusion

The ranking model used for this study leads to the conclusion that many of the country-sector combinations which have strong trade and/or investments relations with China do not have strong impacts on biodiversity and ecosystems services: seven of the country-sector combinations which rank in the top-ten of economic relations with China are not included in the top-23 of the combined ranking. As the ranking of country-sector combinations on impacts on biodiversity and ecosystems services is based on a limited number of indicators, the WWF Wildfinder database and desk study of scientific sources, it seems sensible to also select one or two other country-sector combinations which have strong trade and/or investments relations with China, however which do not seem to have strong impacts on biodiversity and ecosystems services. This would allow verification of the ranking model and would prevent hampering further knowledge development by turning a blind eye to country-sector combinations which do not score high on some biodiversity and ecosystem services indicators. For this reason the following additional country-sector combinations are recommended:

- South Africa - Mining: Ranks second on the country-sector combination ranking based on relations with China. This sector is one of the few country-sector combinations in this study, which is of significant importance to China as it supplies China with large shares of its imports of manganese, diamonds and chrome. It has a high level of Chinese FDI and many Chinese projects. While strong biodiversity and ecosystem services impacts are less likely than for other country-sector combinations, it seems a significant case to research.
- Mozambique - Forestry: Ranks fourth on the country-sector combination ranking based on relations with China. This sector is oriented strongly towards China, many critical/endangered ecoregions are affected and many China-based and Chinese migrant-owned companies are involved. Researching the possible impacts of Chinese companies on biodiversity and ecosystems services therefore seems relevant.

To summarize, the following country-sector combinations are recommended for follow-up research:

- Cameroon - Agriculture
- DRC - Forestry
- DRC - Infrastructure
- DRC - Mining
- Gabon - Forestry
- Mozambique - Forestry

- South Africa - Mining
- Zambia - Mining

5. References

AidData, 2013, Tracking Chinese development finance to Africa, available at http://china.aiddata.org/, viewed in June 2013.

Brautigam, 2010-2012, China in Africa: the real story, bog available at http://www.chinaafricarealstory.com/, viewed in May 2013.

FAO, “Aquastat”,www.fao.org/nr/water/aquastat/data/query/index.html?lang=en, Viewed in March 2013.

FAOSTAT, “ForeSTAT”, faostat.fao.org/site/626/default.aspx#ancor, Viewed in March 2013.

FAOSTAT, “Production: Crops”, faostat.fao.org/site/567/default.aspx#ancor, Viewed in March 2013.

FishStatJ, “Total production”, www.fao.org/fishery/statistics/software/fishstatj/en, Viewed in March 2013.

Gelb, S. 2011, Foreign Direct Investment Links between South Africa & China, Paper prepared *for African Economic Research Consortium project on China-Africa Economic Relations*, The EDGDE Institute, Johannesburg, http://www.tips.org.za/files/foreign_direct_investment_links_between_south_africa.pdf, viewed on May 12, 2013.

Groombridge, B. and M. Jenkins, “World Atlas of Biodiversity”, UNEP World Conservation Monitoring Centre, 2002.

International Trade Centre, “Trade Map”, database available at http://www.trademap.org/, viewed in December 2012.

Nelson, E., et al. 2009, Modelling Multiple Ecosystem Services, Biodiversity Conservation, Commodity Production, and Tradeoffs at Landscape Scales, *Frontiers in Ecology and the Environment*, Vol. 7, No. 1, pp. 4-11.

MOFCOM, 2009 Statistical Bulletin of China's Outward Foreign Direct Investment, Chinese Ministry of Commerce (MOFCOM).

MOFCOM, 2010 Statistical Bulletin of China's Outward Foreign Direct Investment, Chinese Ministry of Commerce (MOFCOM).

MOFCOM, 2011 Statistical Bulletin of China's Outward Foreign Direct Investment, Chinese Ministry of Commerce (MOFCOM).

National Bureau of Statistics (Tanzania), 2009, "Tanzania Investment Report 2009", National Bureau of Statistics, online available at: www.bot-tz.org/Publications/TZInvestmentReports/Tanzania.Invest.Report.2009.pdf, viewed in February 2013.

Ncube & Fairbanks, 2012 China in Africa: Myths, realities and opportunities, *Harvard International Review,* Vol. 34, No. 2.

Nigerian Investment Promotion Commission, “Foreign Direct Investment Statistics (1999-2006)”, Website Nigerian Investment Promotion Commission (www.nipc.gov.ng), Viewed in December 2012.

OECD Statextracts, 2012. FDI flows by partner country, online available at: stats.oecd.org/Index.aspx?DatasetCode=FDI_FLOW_PARTNER, visited in December 2012.

Olson, D.M. et al., 2001, Terrestrial Ecoregions of the World: A New Map of Life on Earth, *BioScience*, Vol. 51, No. 11, pp. 933-938, available at http://wolfweb.unr.edu/~ldyer/classes/396/olsonetal.pdf, viewed in May 2013.

South African National Biodiversity Institute, http://www.sanbi.org/, viewed in December 2012.

South African Reserve Bank, 2002-2006. Statistical tables: International economic relations. In: Quarterly Bulletin, No.'s 226, 230, 234, 238, 242, 246, 250, 254 & 258, online available at: www.resbank.co.za/Publications/QuarterlyBulletins/Pages/Quarterly-Bulletin.aspx, visited in December 2012.

Ruesch, A. and H.K. Gibbs, 2008, New IPCC Tier-1 global biomass carbon map for the year 2000. Available online from the Carbon Dioxide Information Analysis Center, http://cdiac.ornl.gov, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Taylor, I., 2007, China's environmental footprint in Africa, *China Dialogue,* http://www.chinadialogue.net/article/show/single/en/741-China-s-environmental-footprint-in-Africa,viewed on May 12, 2013.

UN Comtrade, 2013, database available at http://comtrade.un.org/db/, viewed in December 2012.

USGS 2011a, Africa and the Middle East, minerals.usgs.gov, Viewed in March 2013.

USGS, 2013, Minerals yearbook, available at http://minerals.usgs.gov/minerals/pubs/myb.html, viewed in March 2013.

Wang, D., expected to be published soon, Chinese companies evacuated from Libya.

World Bank, “World Development Indicators: Forest Area”, Website World Bank (data.worldbank.org/indicator/AG.LND.FRST.K2), Viewed in March 2013.

WWF, 2013, Earth’s most special places, available at:

http://wwf.panda.org/what_we_do/where_we_work/, viewed in February 2013.

Wynburg, R., 2002, “A decade of biodiversity conservation and use in South Africa : tracking progress from the Rio Earth Summit to the Johannesburg World Summit on Sustainable Development”, *South African Journal of Science,* Vol. 98, No. 5/6, pp. 233