Climatic Change (2007) 81:415–430
DOI 10.1007/s10584-006-9111-9

Implications of country-level decisions on the specification of crown cover in the definition of forests for land area eligible for afforestation and reforestation activities in the CDM

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Received: 28 March 2005 / Accepted: 8 March 2006 / Published online: 20 January 2007
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Abstract Within the Kyoto Protocol, countries have significant latitude to define a forest. The most important parameter affecting area designated as forest is the minimum crown density which can be set between 10 and 30 percent. The choice will have implications for the amount of land available in a country for afforestation and reforestation (A/R) activities within the Clean Development Mechanism (CDM). In this paper, we used GIS analysis to look at four case studies from countries involved in the EU-funded ENCOFOR project: Bolivia, Ecuador, Uganda and Kenya. We also looked at the effects of other factors that would exclude land from eligibility for A/R projects. A low threshold of 10 percent crown cover resulted in exclusion of 70 to 90 percent of the land area of all countries except Kenya, which differed from the other countries by its large dryland areas. Much less area was excluded when higher thresholds were used. The spatial analyses showed not only the effects of the choice of the crown cover criterion, but also where the land was available for CDM activities within each country at different thresholds. This is the first time that the effect of the crown cover element of the Kyoto forest definition on land availability and distribution for CDM A/R activities has been quantified. While there are a number of reasons to choose different thresholds, this analysis suggests that countries that are considering using CDM finance for rural development might want to select the higher minimum threshold for crown cover in order to maximize their participation and flexibility.

1 Introduction

Under Article 3.1 of the Kyoto Protocol, Annex I Parties have agreed to reduce their emissions of greenhouse gases to specific target levels and maintain them at these levels during the first

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commitment period between 2008 and 2012. The Kyoto Protocol makes provision for Annex I Parties to take into account afforestation and reforestation (A/R) activities (Article 3.3) in meeting their commitments under Article 3. A/R refers to tree planting on land that was not forested in January 1990, and the distinction between afforestation and reforestation is made by whether the land had trees on it during the previous 50 years (reforestation) or not (afforestation). In order to distinguish whether land was forested in 1990 or within the previous 50 years, parties must be able to identify what constitutes forested land. Parties to the UN Framework Convention on Climate Change (UNFCCC) have agreed on a forest definition for reporting purposes set out in Articles 3.3 of the Kyoto Protocol and have extended this definition to article 12, which establishes the CDM. However, that definition leaves significant latitude for individual countries to set a minimum crown density threshold in defining forest cover.

Only two types of activities under the rubric land-use change and forestry are allowed in the CDM: afforestation, which is the establishment of trees on land that has not had forest on it for more than 50 years; and reforestation, which is the establishment of trees on land that has had forest on it within the last 50 years, but is not currently forested. A second condition is that the land must not have been forested at the beginning of 1990, which is the baseline year for the Kyoto Protocol against which changes in emissions and removals of GHGs from the atmosphere are measured. In order to take advantage of this financial mechanism, countries need to establish their 1990 forest cover baseline in a spatially explicit way. That is any agency or group undertaking A/R activities under the CDM must be able to demonstrate that the land upon which they are planting trees was not forested at the beginning of 1990. In order to do this, countries must define, for the purposes of the Kyoto Protocol, what constitutes a forest.

Although at first sight the definition of forest may seem obvious, there are in fact hundreds of definitions of the term "forest" in use throughout the world (Lund 2002; Helms 2002). Because of the wide geographic distribution of forests within many diverse biomes and the diversity in composition and structure of vegetation, forests are not always easily distinguished from other land cover types or defined. In addition to the great diversity and varying abundance of the world's forests – from dry and sparse to moist and dense – definitions also vary because of differences in culture, forest use, societal dependence on forest products, and the stage of societal development (Helms 2002). This has led to much debate about what constitutes a forest. In a number of fora, the definition of forest has become both a political as well as a technical issue (FAO 2004). Definitions are conceptual, as well as legal constructs, and in the case of global exercises, like multilateral environmental agreements, they are compromises.

Throughout the history of forest policy as a science, a reasonable consensus has grown on the essential elements of a forest definition. They are: (1) a land cover (von Cotta 1831; FAO 1967) (2) dominated by trees or other woody vegetation (Hundeshagen 1821; FAO 1967), (3) with a certain minimum crown density (Leibundgut 1951; FAO 1967). Alternatively, lands designated as national forests or forest reserves for administrative reasons are also considered forestland regardless of landcover. Only a few authors mention a certain minimum height of the tree cover, while many consider the complexity of a biocenosis or an ecosystem an essential aspect of a forest (Morosov 1922; Leibundgut 1951; FAO 1967). Legal definitions typically add thresholds and clarifications to these elements of the definition. A minimum area threshold is sometimes defined bi-dimensionally (FAO 1967), because a narrow tree belt can not be considered a forest from an ecological point of view, or because it cannot be monitored with medium resolution satellite remote sensing. Clarifications are commonly made by adding a list of doubtful objects, such as other land cover types that erroneously

look like a forest because of the way land is used (e.g., parks, fruit orchards, tree nurseries, Christmas tree plantations), and/or forests that erroneously look like another land cover type (e.g., clearcut areas, forest roads, forest ranger houses) (Dieterich 1953; Tromp 1976; Van Miegroet 1976).

When attempting to compile world statistics on how much forest exists, or on the dynamics of deforestation, afforestation, and reforestation, the lack of a commonly accepted definition for "forest" has caused substantial discontinuities when combining various national level forest inventories (Helms 2002). A recent comparison of forest definitions used for National Forest Inventories in Europe by COST E43 "Harmonisation of National Forest Inventories in Europe: Techniques for Common Reporting" showed that, out of 19 countries in the survey, all used a minimum forest extension criterion, 17 used a minimum crown coverage, 14 used a minimum forest width and 13 used a minimum tree height (Vidal 2005). Table 1 gives an idea about the variation in area and crown density thresholds in national forest inventories in Europe. The consequence of the discontinuities illustrated in Table 1 are that in the European Union, which had 15 member states at the time the analysis was done, the area of forest and other wooded area varied between 113 and 127 million ha when comparing discontinuous data from national forest inventories (FAO 1990) with continuous data from the Temperate Zone Forest Resources Assessment (UN-ECE FAO 1992).

In response to this pronounced need for a standardized set of forest definitions, the FAO convened three "Expert Meetings on Harmonization of Forest Definitions for Various Stakeholders" (FAO 2004; 2005). Standardized definitions were deemed essential, both to accommodate global forest resource assessments (FRA), and to provide consistency to international conventions on biodiversity and climate change. As a result of that process, standard definitions of forest-related terms were adopted by the FAO (FAO 2004). Within this FAO set

Table 1 Minimum crown cover (%), minimum size (ha) and minimum width (m) applied in European national forest inventories (Köhl and Päivinen 1996)

Country	Minimum crown cover (%)	Minimum size (ha)	Minimum width (m)
Albania	30		
Austria	30	0.05	10
Denmark		0.5	
Finland		0.5	
France	10	0.05/0.5/4	15/25
/ermany		0.1	10
Greece	10	0.5	30
Hungary	30		
Ireland	20	0.5	
Italy	20	0.2	20
Netherlands	20	0.5	30
Portugal	10	0.2	30
Spain	10		
Switzerland	20		
UK	20	0.25	20
FRA 1990[1]	20		
Eurostat	20		

(FRA/UN – ECE/FAO Forest Resources Assessment)

of terms, a forest is defined as being "more than 0.5 hectares, with trees higher than 5 m, and a tree canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. This does not include land that is primarily under agricultural or urban land use" (FAO 2000; 2004). A key element in this definition is the idea of primary function, which introduces a land use element into the definition. A given parcel of land can have a number of functions, but when a designated function is significantly more important than other functions it is considered primary (FAO 2004). According to this definition, forest is determined by the presence of trees or the nature of the predominant land use.

Many of the recent international conventions, such as the CBD and the Kyoto Protocol, use different definitions of forest, which has led to inconsistencies in national reporting for the different conventions (IPCC 2000). The likely effect of varying forest definition thresholds on detected forested areas and forest resource assessments is given in Table 2. The importance of defining a forest, however, goes beyond inventorying and reporting. In the case of the UNFCCC, the choice of a definition will have a significant and substantial impact on activities undertaken during implementation. Although the forest definition in the UNFCCC is in close agreement with the FAO definition described above, it makes no stipulations regarding the primary function of the land. Importantly, it provides significant

Table 2 The effect of forest definitions on forest area detected. Signs indicate the expected change in the forest area estimated due to an increase in the given parameter. (– small decrease, – – large decrease, 0 no significant impact. Brackets indicate uncertain effect.) (After FAO 2002, from: Second Expert meeting on Harmonizing Forest-Related Definitions for Use by Various Stakeholders)

Geographic area	Forest type	Min. area	Min. height	Min. crown cover
Tropical				
	Tropical rain forest	0	0	0
	Tropical moist deciduous forest	0	0	0
	Tropical dry forest	0	0	–
	Tropical shrubland	–	– –	– –
	Tropical desert	0	0	0
	Tropical mountain systems	(–)	–	(–)
Subtropical				
	Subtropical humid forest	0	0	0
	Subtropical dry forest	0	0	–
	Subtropical steppe	– –	– –	– –
	Subtropical desert	0	0	0
	Subtropical mountain systems	(–)	–	–
Temperate				
	Temperate oceanic forest	0	(–)	(–)
	Temperate continental forest	0	0	0
	Temperate steppe	– –	–	– –
	Temperate desert	0	–	0
	Temperate mountain systems	(–)	–	–
Boreal				
	Boreal coniferous forest	–	–	–
	Boreal tundra woodland	– –	– –	– –
	Boreal mountain systems	– –	– –	– –

latitude to individual countries to define what constitutes the minimum crown cover threshold used to determine a forested area. Annex A of the Marrakech Accords (UNFCCC 2002a, b) states that for land use, land-use change and forestry activities under Articles 3.3 and 3.4 of the Kyoto Protocol, the following definition of forest shall apply:

> "Forest' is a minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 m at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest."

As part of the decisions made at the 9th Conference of the Parties in Milan, this definition of forests was retained in the modalities and procedures for afforestation and reforestation project activities under the Clean Development Mechanism (CDM) in the first commitment period of the Kyoto Protocol. Thus, the rules have been written to acknowledge that forest types are variable and to permit greater participation by allowing each country to set its own definition of forest. Setting these definitions will have a substantial impact on the land area available for afforestation and reforestation activities. The decision on the minimum crown cover requirement taken by each country, will determine the country's ability to offer CDM A/R activity. The height element of the definition is perhaps the least problematic element of the definition as it is possible to find tree species that can attain 5 m height for all but the most arid of environments. The minimum area element of the definition is also not particularly problematic. It is difficult to see how an A/R activity on a very small parcel of land would be economically viable given the high transaction costs associated with monitoring and verification. The crown cover element of the definition is a different story and, as this study will show, the decisions made by a country will determine the availability of land for these activities.

Many agricultural landscapes have a tree cover that exceeds 10%, and these could be eliminated from consideration with the choice of a low minimum threshold. If the tree cover threshold is high, however, there is a risk of the CDM providing perverse incentives to convert natural ecosystems with relatively low tree cover to other forest-type land-use, e.g., plantations (Dutchke 2002). For example, 50 percent of woodlands have canopy cover less than 20 percent and as the threshold for crown cover rises, less of the woodland area would be classified as forest (IPCC 2000). Some countries have already made their decisions with the objective of enhancing the viability of CDM A/R activity. Uganda is one such country, and has defined a forest as having a minimum of 1 ha, a minimum canopy cover of 30% and trees with a minimum potential height of 5 m. The 30% criterion was adopted to facilitate agroforestry projects in rural areas where tree cover is already significant (Tennigkeit, personal communication).

In this paper we present an analysis of the effects of decisions about the minimum crown cover on the area available for CDM A/R activity. Our objective is to determine how the choice of a high or low threshold value for crown cover will affect the area available for CDM activities and how the limitations imposed by this element of the definition compares to other factors that are likely to limit CDM activities. Unfortunately global datasets that allow analysis of the other elements of the forest definition do not exist. We will present four case studies from the countries involved in the EU-financed "ENvironment and COmmunity based framework

for designing afFORestation, reforestation and revegetation projects in the CDM: methodology development and case studies" (ENCOFOR) Project (www.joaneum.at/encofor). The ENCOFOR Project is working to develop a framework for the planning and evaluation of CDM A/R projects and is building a toolbox for project planners and other stakeholders, incorporating a series of modules that will take the process from the pre-feasibility stage through to the development of a Project Design Document. The four ENCOFOR case study countries Bolivia, Ecuador, Uganda and Kenya span a diversity of geographic conditions, allowing for the comparative evaluation of the effect of forest definitions across a range of tropical conditions.

2 Methods

A geospatial analysis of the interaction of crown cover density and other potential exclusion categories was used to test the effect of the minimum crown cover threshold on the definition of forest and on the availability of land for CDM A/R projects in the four ENCOFOR case study countries. The analysis is based primarily on publicly available global datasets, and was performed within a geographic information system (GIS) environment. A range of crown density thresholds from 10% to 30% was delineated, and their effect on land availability for CDM/AR was tested.

In the first step of the spatial analysis, land use categories assumed not have significant potential for carbon sequestration through A/R projects within each country were excluded. The set of exclusion categories consisted of wetlands and water bodies, arid lands, urban areas, wetlands, protected areas, and high altitude zones. In the second step of the analysis, the pre-determined range of minimum crown cover definitions was used to exclude areas with existing "forest" from the remaining land available for CDM A/R. The minimum crown cover density was used to delineate forested area at 5% increments from 10% to 30%, to correspond to the available options for forest definitions under the UNFCCC. This resulted in the production of ten maps for each country illustrating the implications of the definition of forest, first based solely on the crown density criterion, and then combined with the other exclusion categories. The areal extent and percentage of each country available for CDM A/R projects, and that area excluded by the combined crown cover criteria and land use categories, were determined.

2.1 Data sources

Both global and national level datasets were used to produce the individual exclusion map layers. Whenever possible, datasets were obtained from publicly available and free data sources to promote the replication of this methodology in other countries. The sources for the datasets used in this analysis are listed below:

- MODIS VCF-Tree Cover Dataset: Tree cover and canopy density estimates were obtained from the MODIS (500 m) Vegetation Continuous Fields – Tree Cover Dataset. The tree cover estimates in this dataset were calculated using an automated algorithm for images acquired over a period of several months in the year 2000. This dataset is available online from the University of Maryland's Global Land Cover Facility (GLCF) at http://glcf.umiacs.umd.edu/data/modis/vcf/
- SRTM 90 m Digital Elevation Dataset: Void-filled NASA Shuttle Radar Topographic Mission (SRTM) 90 m digital elevation data was used to delineate areas above 3500 m. The

void-filled SRTM data can be downloaded from http://srtm.csi.cgiar.org. The unprocessed SRTM tiles are available from http://srtm.usgs.gov.

- Land-use and Land Cover Datasets: Water-bodies, urban areas and wetlands exclusion criteria were identified and extracted from various national level land-use maps. For the two African countries, land-use information was obtained from the FAO Africover Program (http://www.africover.org/). The Africover land-use data are currently available for 10 African countries. The land-use map for Bolivia was obtained from Superintendencia Agraria (2001), and the land-use map used for Ecuador was obtained from SIGAGRO (2000a).
- Precipitation Datasets: The precipitation maps utilized for each country varied, with the "best" available dataset chosen for each country. For Kenya, a rainfall distribution map created by the National Water Master Plan of Kenya (JICA 1992) was used. This dataset reported precipitation ranges based on 200 mm classes, hence the minimum precipitation criteria for Kenya was delineated to exclude areas with less than 400 mm yr^{-1}. This also accommodated somewhat for the large extent of semi-arid to arid zones in Kenya where dryland agroforestry schemes might be appropriate. The Ugandan precipitation data were prepared by Hanna (1967). The Ecuadorian precipitation map was obtained from SIGAGRO (2000b). The Bolivian precipitation data originated from "WorldClim", a global precipitation dataset of rainfall interpolated at a 1 km resolution. The full WorldClim global dataset is available for download at http://biogeo.berkeley.edu/worldclim/worldclim.htm.
- Protected Areas: National Parks and other protected areas in each of the four countries were identified from the IUCN World Database on Protected Areas. This database is available online through the Global Land Cover Facility (GLCF) at http://glcf.umiacs.umd.edu/data/wdpa.shtml.

2.2 Data processing

Data processing steps are illustrated in Fig. 1. All exclusion land category areas (left side of Fig. 1) within the respective data sets, were selected and merged into one raster layer to produce a map delineating the areas that are likely to be unsuitable for A/R, based upon the biophysical condition and/or political designation. Exclusion using the crown cover criteria

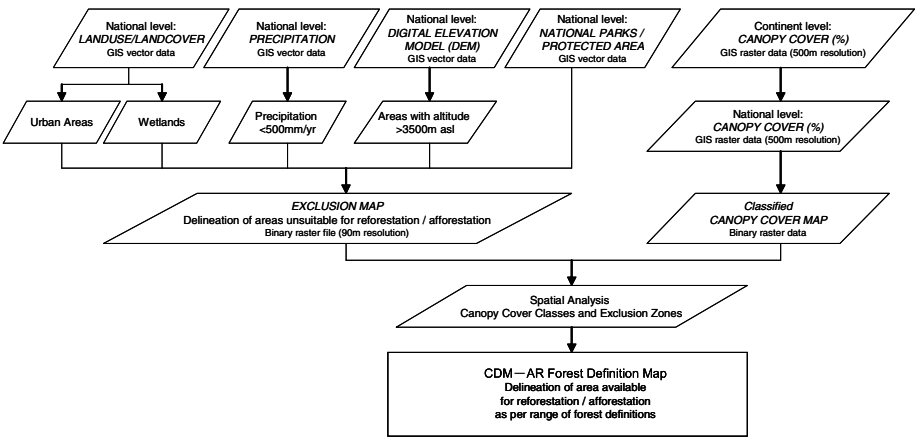

Fig. 1 Data processing steps for the spatial analysis of forest definitions.

(right side of Fig. 1) was done using the MODIS VCF-Tree Cover data. The dataset was queried to delineate the areas with crown cover percentages greater than 10, 15, 20, 25 and 30 percent, respectively. Separate maps were produced for each of the crown cover classes and the resulting excluded area was spatially delineated and the areal extent calculated. For the final analysis, the area excluded based on the crown cover criteria results was combined with the other exclusion categories and the areal extent of the resulting available area for CDM A/R projects calculated.

3 Results

Because of the lack of MODIS data from 1990, we used data from 2000 to estimate the effects of different decisions on crown cover in the forest definition on land availability for DCM A/R projects. This does not provide a completely true picture of the forest cover criteria because the data upon which it is based are not from the baseline year. However this analysis paints the picture with a fairly broad brush in analyzing land availability at the national level. These data allow us to show the spatial patterns properly and allow us to analyze the spatial trends and land availability trends associated with different decisions regarding the crown cover criterion in the definition of forest.

The importance of the different exclusion categories varied among countries (Table 3). Kenya has a large area of land that is semi-arid to arid, whereas Uganda has no dryland areas. A large part of the national territory of Uganda is covered by Lakes Victoria, Kyoga, Albert and other Rift Valley lakes, so water bodies make up a large portion of the excluded area of that country. All countries have large protected areas, and these areas contributed significantly to area excluded. Substantial portions of Ecuador, and particularly Bolivia, were excluded due to the prevalence of high elevation zones in the Andes Mountains.

We considered protected areas to be unsuitable for CDM projects, which excluded between 10 and 20% of the area in each country. Protected areas are usually protected for their unique ecosystems and it is unlikely that a land use change in these areas would be desirable. However, the Kyoto Protocol does not proscribe A/R activities in these areas and we recognize that there may be ecosystem restoration in protected areas that would qualify for CDM finance. The FACE project on the slopes of Mt. Elgon in Uganda is one such example (http://www.stichtingface.nl/).

The area excluded by crown cover criteria decreased as the threshold increased, as expected (Table 4). When the threshold was set to the level of 30%, only a small proportion of Kenya, and a relatively small proportion of Uganda, was excluded. In the Latin American countries more than half of the area was excluded based on crown cover density. At the low end of the spectrum specified in the Marrakech Accords (UNFCCC 2002a, b), i.e. ten percent crown cover, more than two-thirds of the land area was excluded in all countries except Kenya. Kenya is a particular case, as we noted above, since much of the country is semi-arid or arid, and consequently tends to have much low-cover forest, open woodland, and shrub vegetation. Ecuador in particular would exclude much of its available land area (more than 90% of total area) by adopting a 10% minimum crown density threshold.

Combining the exclusion categories with the crown cover criterion shows that at low threshold levels for canopy cover, most of the land area of each country is excluded from CDM projects because this area would meet the definition of forest. Even with high threshold levels more than 75% of the area of the two Latin American countries is not eligible for projects. For the two African countries, the total area excluded was between 50 and 60% at the high threshold level. This analysis shows that crown cover is an important factor in

Table 3 Area excluded (x 1000 ha) using different exclusion categories and the corresponding percentages of national territory

	Kenya		Uganda		Ecuador		Bolivia	
Exclusion categories	Area excluded (ha)	% of country	Area excluded (ha)	% of country	Area excluded (ha)	% of country	Area excluded (ha)	% of country
Water bodies	1,428	2.4	3,660	15.2	304	1.2	1,437	1.3
Urban areas	46	0.1	49	0.2	66	0.3	49	0.1
Swamps and mangroves	2,060	3.5	2,064	8.6	378	1.5	15,286	14.1
Low rainfall	29,807	49.9	0	0.0	828	3.3	16,016	14.7
Protected Areas (National Parks, Game Reserves)	5,591	9.4	3,035	12.6	4,012	16.1	19,799	18.2
Areas located higher than 3500m a.s.l.	57	0.1	41	0.2	1,455	5.9	17,368	16.0
Other areas					165[1]	0.7	117[2]	0.1
Total area excluded using all criteria	34,422	57.66	8,621	35.8	6,269	25.2	48,553	44.7

[1] Salt flats and shrimp producing areas
[2] Snow or ice covered

Table 4 Area excluded (x 1000 ha) due to crown cover limitations and crown cover combined with other exclusion categories

	Kenya		Uganda		Ecuador		Bolivia	
	Area	% of country	Area	% of country	Area	% of country	Area	% of country
Crown cover threshold								
10%	16,772	28.1	17,218	71.5	22,410	90.1	78,726	72.4
15%	10,332	17.3	14,534	60.3	20,762	83.5	75,279	69.2
20%	6,035	10.1	10,937	45.4	19,059	76.6	71,627	65.9
25%	3,930	6.6	7,587	31.5	17,627	70.9	66,702	61.4
30%	2,593	4.3	5,228	21.7	16,416	66.0	61,202	56.3
Crown cover combined with other exclusion categories								
10%	46,953	78.7	21,657	89.9	23,388	94.0	103	94.6
15%	42,045	70.4	19,492	80.9	22,238	89.4	100,688	92.6
20%	38,742	64.9	16,501	68.5	20,979	84.3	98,409	90.5
25%	37,050	62.1	13,812	57.3	19,827	79.7	95,743	88.1
30%	35,949	60.2	11,947	49.6	18,820	75.6	92,602	85.2
Total Area of Country	59,693		24,094		24,875		108,721	

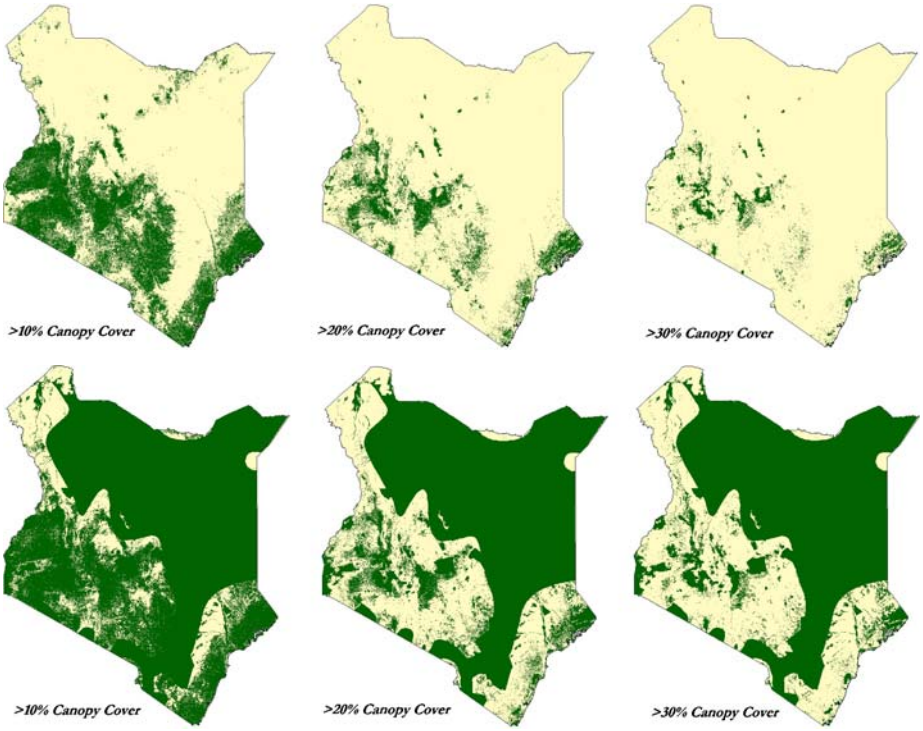

Fig. 2 Exclusion areas in Kenya based on crown cover only (top) and on crown cover combined with other exclusion criteria (bottom). Areas suitable for CDM A/R projects are designated by white shading.

determining the area eligible for CDM projects. As crown cover increases, more area of the area in a country with low crown cover becomes eligible.

The spatial analysis also allows us to see how the crown cover exclusion criterion limits the areas available for CDM AR projects in each country. In Kenya (Fig. 2) much of the high potential highlands in Central and Western Kenya, the coastal zone, and the cropping areas of the Rift Valley were excluded with low a canopy cover threshold. At higher thresholds, more of this area was available for CDM A/R projects. The addition of the other exclusion categories limited areas available in the semi-arid northern part of the country and in the semi-arid band in the southeastern part of the country.

In Uganda (Fig. 3) with a low canopy cover threshold, large areas for A/R activities can be found only in the northeastern part of the country. As the threshold increases, much of the country becomes suitable for these activities, including the humid southwestern highlands and the drier northeast. The addition of the other land categories limits the areas available, particularly along an east-west band through the center of the country, but there is still a fairly even distribution of land available for A/R activities. The protected areas around Mt. Elgon are prominently excluded, although this is the site of an on-going reforestation and carbon sequestration project coordinated by the FACE Foundation, illustrating the fact that the broad brush analysis and the exclusion categories that we are providing here needs to be reconsidered for site-specific assessments. There may be times when CDM activities would be appropriate in a number of our exclusion categories.

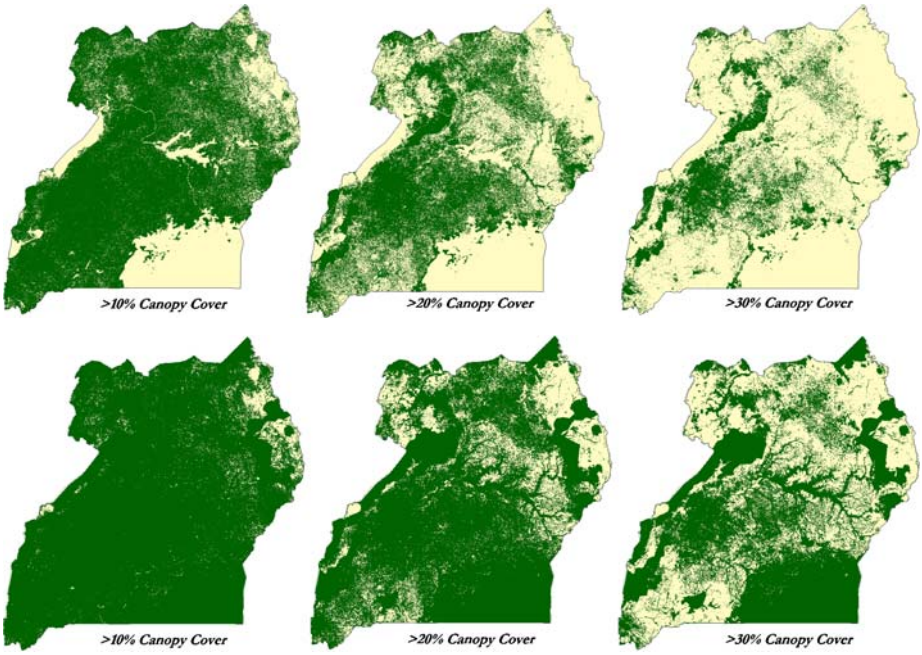

Fig. 3 Exclusion areas in Uganda based on crown cover only (top) and on crown cover combined with other exclusion criteria (bottom).

In Ecuador (Fig. 4), areas suitable for A/R activities with a low crown cover threshold are restricted to small areas in the central and eastern part of the country. These areas expand as the threshold increases. The portion of the country on the Amazonian side of the Andean cordillera remains excluded even at high crown cover levels. Addition of the other criteria results in decreased availability of land primarily in the northwestern part of the country, along the central coast zone, and along the high Andean cordillera.

In Bolivia (Fig. 5), application of the crown cover criteria alone resulted in large areas of the Altiplano in the western part of the country and extending into the center of the country (Cochabamba) being identified as suitable for CDM A/R activities. Much of the Altiplano was later excluded with the addition of an elevation category. On the Amazonian side of the country, areas in the northeastern and eastern part of the country were suitable for A/R activities when using the upper limit of the crown cover criteria. Much of the area in the northeast was ruled out using the additional exclusion categories. In the final analysis, using the combined exclusion categories, areas primarily in the south-central portion of the country were deemed suitable for CDM A/R activities.

4 Discussion

Earlier forest policy analysts argued that a forest definition should not include any reference to human function, land use or destination in a zoning plan, because they are not essential characteristics of a forest (Tromp 1976; Van Miegroet 1976). In accordance to these, the UNFCCC, and consequently the CDM, defines forest land strictly by crown cover, tree height or the potential of trees to reach a minimum height, and area. In contrast to the

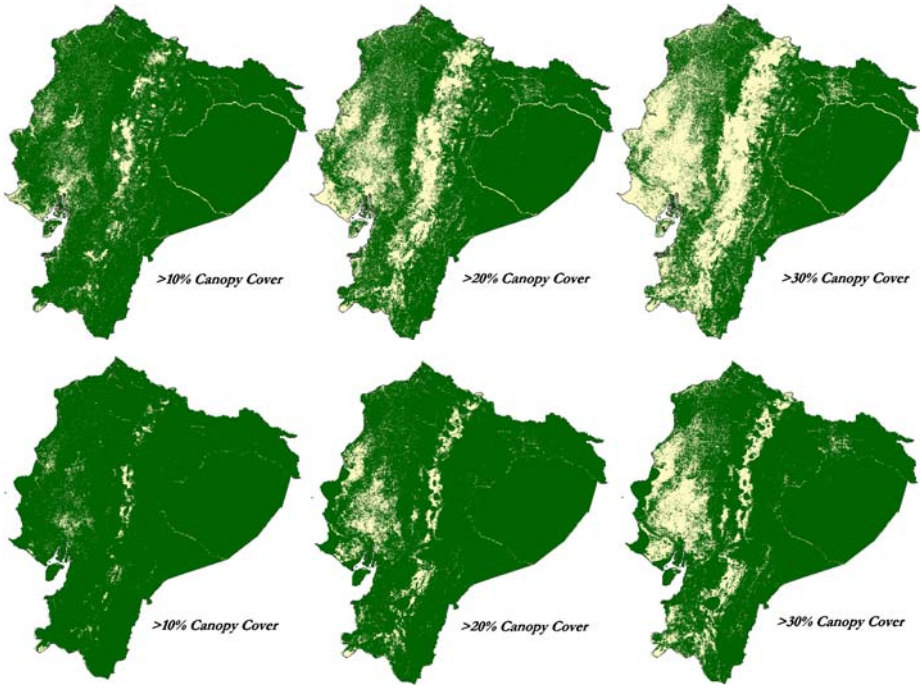

Fig. 4 Exclusion areas in Ecuador based on crown cover only (top) and on crown cover combined with other exclusion criteria (bottom). Areas suitable for CDM A/R projects are designated by white shading.

FAO definition (FAO 2004), the UNFCCC definition ignores the primary function of the land. The consequence of this is that it potentially leads to the exclusion from CDM A/R of many rural landscapes where tree cover is relatively low, yet the primary function of the land is agriculture. For example, this can easily be the case where smallholder mixed farming systems incorporate boundary plantings and other multipurpose trees into a primarily agricultural landscape. The lack of a definitional element regarding the primary function of the land in the Kyoto definition creates a situation where, if countries set a low canopy cover threshold, many small-holder agroforestry projects will be excluded from eligibility for carbon finance through the CDM. In both Kenya and Uganda, it is not unusual to find large numbers of trees on farms, consequently, many of these rural areas which could benefit from the CDM will be excluded a priori (Kindt et al. 2004, 2005). These issues are further complicated in agricultural systems that incorporate recurring forest fallows, such as found in the Bolivian and Ecuadorian Amazon, or in landscapes with swidden type farming systems.

This exclusion of large areas of land due to crown cover is of course an artifact of the decision to allow only afforestation and reforestation for CDM land-use change and forestry projects in the first commitment period of the Kyoto Protocol. There is no reason why revegetation should not be eligible for CDM projects (IPCC 2000)

The results of our analysis suggest that the decision of minimum crown cover for a Kyoto forest definition will significantly impact the area available for CDM projects and the geographic distribution of projects. However, choosing a high crown cover threshold in order to maintain flexibility for countries that wish to use carbon finance to fund rural development is only one of the considerations that should be taken into account when deciding on a

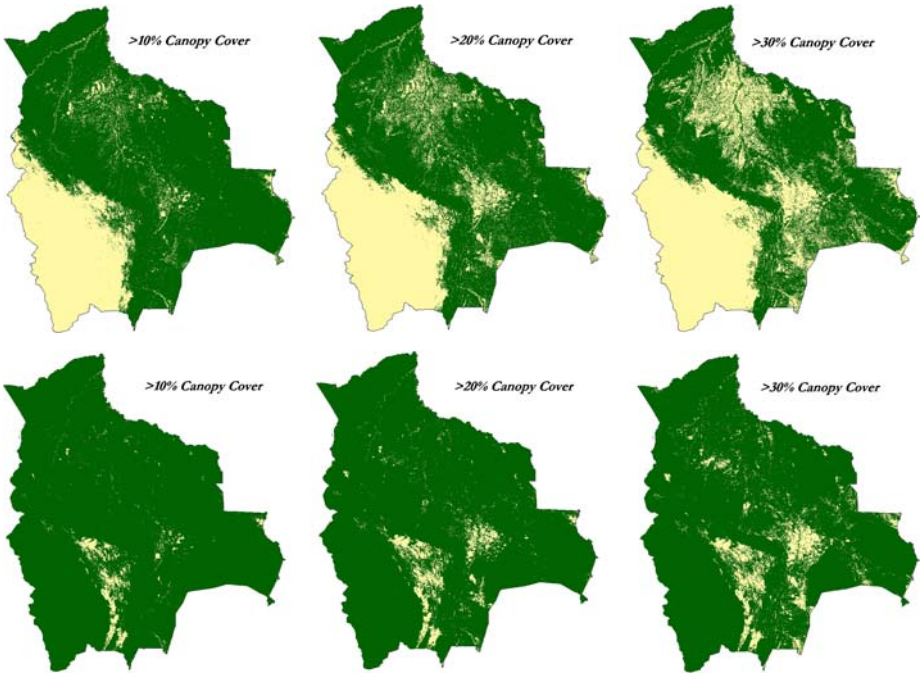

Fig. 5 Exclusion areas in Bolivia based on crown cover only (top) and on crown cover combined with other exclusion criteria (bottom). Areas suitable for CDM A/R projects are designated by white shading.

definition. Choosing a high crown cover raises the bar for A/R activities and requires the establishment of more trees in the project area to meet the crown cover requirements than if a low cover threshold were chosen. The costs of assessing forest area with different criteria also need to be weighed against the benefits of increased flexibility for project implementation. If definitions are set at the FAO level of 10% (FAO 2000) to make reporting simpler, for example, large areas of the land will be ineligible. In the case of the countries we analyzed, using a low threshold in combination with other criteria that would reasonably exclude land from being eligible for carbon sequestration projects resulted in 10% or less of the land area being suitable for CDM A/R activities in three of these countries. In the case of Kenya, just over 20% of the national territory would be deemed suitable. Another consideration is that the choice of a forest definition for Kyoto will also affect other aspects of Kyoto implementation, for example, how deforestation is determined.

For countries with large areas of territory in biomes with primarily low crown density vegetation types, such as dry forests and open woodlands, the opposite may be true. In these areas, choosing a high minimum crown cover threshold could classify large areas of low-cover indigenous forest as non-forest areas, allowing for their conversion to higher density plantations that would meet the definition of a forest, with potentially significant loss of biodiversity, habitat, and perhaps significant impact on local livelihoods. We admit that this is not necessarily the case, but countries may want to consider the possibility of unintended consequences when defining the crown cover threshold. Additionally, trees outside forest play a significant role in low forest cover countries, and not including them in forest assessments can give an incomplete picture of the importance of woody vegetation. Choosing a higher threshold, however, may allow for inclusion in the CDM A/R scheme of degraded forested

areas which have not been completely cleared, or degraded open woodland, which may benefit from restoration incentives provided through the CDM.

5 Conclusion

The forest definition that countries choose for forest land for activities and reporting under the Kyoto Protocol will have a significant impact on land availability and the spatial distribution of activities that can be undertaken under the CDM in the Kyoto Protocol. It may be tempting for consistency in reporting between multilateral environmental agreements and for reporting to the Forest Resources Assessment to choose a definition close to that used for reporting to the FAO. However, the Kyoto Protocol does not require that forest land have a primary function. Thus, if the crown cover threshold is set low, much of the agricultural land of a country might be excluded from A/R activities in the CDM. There are a number of reasons to select different crown cover thresholds for the Kyoto definition of a forest, including the eligibility of other types of activities in the CDM in subsequent commitment periods. The definition of forest also determines the criteria by which deforestation will be assessed. The analysis that we present here suggests that the crown cover choice will have a significant impact on the area available for CDM activities and quantifies for the first time the spatial impact of this choice in the four case study countries. This suggests that countries that are considering using CDM finance for rural development might want to select the higher minimum threshold of 30% crown cover in order to maximize their participation and flexibility. Clearly the decision a country makes should not be made solely on the basis of impact on land availability for CDM, other factors are equally important. However this study should help inform countries on the consequences of different decisions. This study also highlights the negative consequence of the decision by the Parties to limit CDM land-use change and forestry activities to A/R and to eliminate other types of revegetation where development goals would be well served.

Acknowledgements Support for this research was provided by a grant from the European Union/EuropeAid (B7-6200 2002 069-203 TPS), by the International Centre for Research in Agroforestry (ICRAF), and the International Water Management Institute (IWMI). We would like to thank institutions responsible for leading the work of the ENCOFOR project in the participating countries for facilitating the data collection: in Bolivia, Fundación Centro Técnico Forestal (CETEFOR), in Ecuador, Programa Face de Forestación (PROFAFOR) and in Uganda, Forest Industry Services/Unique Forestry Consultants. We would also like to thank Igino Emmer of the FACE Foundation, Bernhard Schlamadinger of Joanneum Research Institute, and two anonymous reviewers for valuable comments on earlier drafts of this manuscript.

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