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Contribution to Forest Definition for Sudan

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Background

- Although *f*orest is a commonly used term, there is no universally accepted definition, demonstrated by the over 800 definitions of forest used around the world (Lund 2007).
- **The fact that "forest" has been defined in many ways is a reflection of the diversity of forests and forest ecosystems in the world and of the diversity of human approaches to forests**
- Three broad categories of forest definitions are in use: **administrative**, **land use**, and **land cover**.
  - *Administrative definitions* are based primarily upon the legal designations of land, even if no trees are growing on it. Such definitions have limitations for carbon accounting as they may bear little relationship to the amount of carbon in a site.
  - *Land Use definitions* are based upon the primary purpose that the land serves (e.g. for production of timber).
  - *Land Cover* definitions define forests based upon the type and density of vegetation growing on the land (e.g. trees growing above some threshold).

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International Forest Definitions

FAO (FRA2015)	Land spanning more than **0.5 hectares** with trees higher than **5 meters** and a canopy cover of more than **10 percent**, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use.
UNFCCC [Marrakesh Accord]	A forest has a minimum land area of **0.05-1.0 hectares** with tree crown cover of more than **10-30 per cent** composed of trees with the potential to reach a minimum height of **2-5 meters** at maturity *in situ*. [**Used for CDM**]
CBD	A forest is a land area of more than **0.5 ha**, with a tree canopy cover of more than **10%,** which is not primarily under agricultural or other specific non-forest land use.
IPCC	**Forest land** This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided into managed and unmanaged, and also by ecosystem type as specified in the IPCC Guidelines. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
WRI	Frontier forests are large, relatively intact forest ecosystems. A frontier forest must meet the following criteria: It is primarily forested, large enough to support viable populations of all species associated with that forest type, is forests where patches of trees of different ages occur naturally, is dominated by indigenous tree species, and is home to most, if not all, other plants and animals that typically live in this forest.

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Comments on Definitions

- FAO/FRA forest definition was derived after a review of over 650 forest definitions in an effort to harmonize them. *The 10% canopy cover threshold encompasses both "closed" and "open" forests. Definition includes forests used for multiple-purposes (production, protection, conservation..) as well as forest stands on agricultural lands (e.g. windbreaks or shelterbelts of width>20m), and rubber wood plantations and cork oak stands. It excludes trees established for agric. Production (e.g. fruit tree plantations) and those planted for agro-forestry systems.*

- The UNFCCC forest definition derives from that of FAO, however Parties are requested to use threshold values within the ranges specified in the definition. *This definition was used for the CDM of the Kyoto Protocol for the first commitment period. Low area (0.05 ha) and low height (2m) thresholds were included probably to encourage small scale stakeholders involvement in CDM.*

- The CBD definition is also based on the FAO definition, which thy considered the basic definition

- WRI definition doesn't stress on thresholds but on functional ecology and vitality of the forest; especially in the provision of ecosystem services.

- In general, forest definitions use three main thresholds: min. area, min. tree height and minimum canopy cover.

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Towards a biome-specific forest definition

Parties to the UNFCCC agreed on a forest definition for the Kyoto Protocol, to be applied for the 1st commitment period; and also requested the SBSTA to investigate the possible application of "*biome-specific forest definitions*" for the 2nd & subsequent commitment periods (Rakonczay, 2002). A critical analysis of the situation concluded that

- the development of new “biome” classification system could require considerable time and resources.
- An alternative could be to adopt one or more of the many global, regional and national ecological zoning systems that already exist.

- Of the existing classification systems, the Global Ecological Zones (GEZ) system, developed by FAO for the FRA 2000 report, seem to be the most promising, because:
  - it was developed for forestry purposes and it builds on the most widely accepted precedents,
  - it is well harmonized between countries and regions,
  - iIt is also likely to be the most acceptable politically.
- However, “biome-specific” forest definitions may also pose a problem, given that “biome” boundaries don’t follow country boundaries and each country is expected to use only one forest definition to avoid methodological problems and inconsistencies.

- A coarse system (based on a few biome parameters) will be unable to reflect local variation in vegetation, productivity, etc. and there could be inconsistencies within and between biomes.

Some Forest definitions for countries in Africa

Country	Forest Definition
Ghana:	Forest definition in the context of REDD+ is **15% canopy cover**, **5 meters tall, and 1 hectare** in area, based on thresholds set by the IPCC for these structural parameters and the Marrakesh Accord.
Côte d'Ivoire:	Forest is land with minimum surface area of **0.1 ha** with trees with canopy cover of at least **30%** and which is capable of attending a height of at **least 5 m** at *maturity[Adopted in Forestry Code CI]*
Liberia:	Forest is land that consist of a minimum canopy cover of 30%, with trees greater than 5 m, and a minimum mapping unit of 1 ha (from FCPF Document).
Sierra Leone:	Forest area is land under natural or **planted stands** of trees of at least **5 meters in situ**, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens (based on FAO Forest Definition: see http://www.indexmundi.com/facts/sierra-leone/forest-area)
DRC	Is considered as forest, land with minimum tree cove of 30%with minimum surface area of 0.5 ha and minimum height of 3m. [Def. was adopted for CDM projects to encourage small holder silviculture]
Congo	Land with minimum surface area of 0.5 ha, minimum tree cover of 30% and minimum tree height of 3 m.
Zambia	"forest" means any land with a tree canopy of more than 10% and area of more than 0.5 hectares and includes young stands that have not yet reached, but are expected to reach, a crown density of 10% and tree height of 5 m that are temporarily under-stocked areas.[*The Forest Act 4 of 2015*]
Tanzania	"Forests means an area of land with at 0.05 ha, with a minimum tree crown cover of 10% or with existing tree species planted or natural having the potential of attaining more than 10% crown cover, and with trees which have the potential or have reached a minimum height of 2.0 m at maturity *in situ*".
Uganda	**Due to technological limitation of mapping small woodlots Uganda Intends to develop a two Tiers Definition:** **1) For National use;** Area of land containing a vegetation association that is predominantly composed of trees **2) For reporting to the UNFCC (REDD+);** tree cover >=30%, >=1 ha attaining a height 4m

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Some forest definitions from Asia and Latin/South America

Country	Forest Definition
Cambodia	Forest is land area of at least 0.5 ha, with trees of at least 5 m height and tree cover of at least 10%. Excludes perennial crops, oil palm and rubber.
Mexico	"Forest lands with a canopy cover of more than 10 percent, with trees of more than 4 meters in height – or trees able to reach this height in situ – and a minimum mapping unit of at least 50 hectares. It does not include lands with predominant agricultural or urban use." [used in FREL Submission]
Guyana	Is considered forest, land that meets the following criteria: -Tree cover of min. 30%, Min. height of 5 m - Min. area of 1 ha
Brazil	Forest is defined as land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10 %, or trees able to reach these thresholds in situ. *Lands not classified as "Forest", spanning more than 0.5 ha; with trees higher than 5m and a canopy cover of 5-10%, or tree able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 % are classified as "Other Wooded Land". [Basically definition used for FRA Reporting]*
Ecuador	All land units bearing "a single minimum tree crown cover value of 30%; a single minimum land area value of 1.00 hectare; and, a single minimum tree height value of 5.00 meters"
Colombia	Land mainly covered by trees which might contain shrubs, palms, *guaduas*, grass and vines, in which tree cover predominates with a minimum canopy density of 30%, a minimum canopy height (in situ) of 5 meters at the time of identification, and a minimum area of 1.0 ha. Tree covers from commercial forest plantations, palm crops and planted trees for agricultural production are excluded.
Australia	". . an area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of over-storey strata about equal to or greater than 20 per cent. Definition is sufficiently broad to encompass woodlands.
Malaysia	Considers forest, lands with a minimum area of 0.5 ha. 30% canopy cover and 5m height at maturity.

Additional Forest definitions for countries in Africa

Country	Forest Definition
Uganda **(in FRELs Submission 2017)**	**A minimum area of 1 Ha, minimum crown cover of 30%, and comprising trees able to attain a height of 4 metres and above.** In addition to the minimum threshold values, the following qualifiers apply: -Tree is in reference to a perennial plant and excludes woody forms that may last for only a few seasons such as the *Solanum giganteum* or *Acanthus pubescens*; -Bamboo is considered a special tree under REDD+ and Uganda's national interests; -Orchards e.g. of oil palms are considered agricultural crops and are not included REDD+ forest definition.
Sri Lanka **(in FRELs 2017)**	"Land with tree crown cover of more than 10% and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. Forest Plantations are included in this definition and agricultural land, oil palm and rubber plantations are excluded."
PNG (in FRELs)	PNG's national forest definition is "*land spanning more than 1 hectare, with trees higher than 3 meters and the canopy cover of more than 10 percent (%)*". This excludes land that is predominantly under agricultural or urban land use.
Ghana (in FRELs)	Following Ghana's National REDD+ Strategy11, the definition used for Ghana's forest definition is a minimum of **15% canopy cover, minimum height of 5 meters, and minimum area of 1 hectare**.
Madagascar (in FRELs)	Minimum height of trees (≥5 m), minimum crown canopy (≥30%) and minimum surface area (≥1 ha)
Tanzania (in FRELs)	***'Forest' means an area of land with at least 0.5 ha, with a minimum tree crown cover of 10% or with existing tree species planted or natural having the potential of attaining more than 10% crown cover, and with trees which have the potential or have reached a minimum height of 3m at maturity in situ.***
(Sudan)	Government forest reserves managed by the forest department. It can be bare land intended to be planted with trees or shrubs in the future (K. H. Badi, Forest

Additional Forest definitions for countries in Africa

Country	Forest Definition
Nepal **(in FRELs)**	Land with tree crown cover of more than **10 %** and area covering more than **0.5 ha**, with minimum height of the trees to be **5 m** at maturity and in-situ conditions. The land may consist either of ***closed forest formations*** where trees of various storied and undergrowth cover a high proportion of the ground, or of ***open forest formations*** with a continuous vegetation cover in which tree crown cover exceeds **10 %**. Young **natural stands** and **all plantations** established for forestry purposes which have yet to reach a crown density of **10 %** or tree height of **5 m** are **included under forest**, as are areas normally forming part of the forest area which are temporarily un-stocked as a result of human intervention or natural causes but which are expected to revert to forest. This includes **forest nurseries** and **seed orchards** that constitute an integral part of the forest; forest roads, cleared tracts, firebreaks and other small open areas within the forest; forest in national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest; windbreaks and shelterbelts of trees with an area of more than **0.5 ha** and a width of more than **20 m**. Land predominantly used for **agricultural practices are excluded.**
Honduras (in FRELs)	**(Translation!!!):** "It is a **natural or planted trees** (at any stage of the natural cycle of life) which" may or not be accompanied by shrubs or other strata, that covers a surface minimum of **1 hectare** and that is capable of producing wood, others products forest, goods and services ecosystem to benefit of the population and that exert influence on the regime of water, soil, climate and provide habitat for the living wild. The crown cover of this association must in be greater than **10%** and the trees must reach a height minimum of **2 meters** for mangroves and **4 meters** for the rest of the ecosystem. Also considered forest “surfaces that temporarily lack forest as a result of human intervention human or other natural causes but with potential conditions, features and vocation to become forest."

Additional Forest definitions for countries in Africa

Country	Forest Definition
Cote d'Ivoire	According to the forest definition submitted by Côte d'Ivoire to the UNFCCC, forest means "all land area consisting of dynamic and heterogeneous environment, with a minimum area of **0.1 hectare** of trees whose crown cover is at least **30%** and which can reach a minimum height of **5 meters** at maturity. This concept includes: • Areas covered with young trees that have not yet reached, but should achieve, forest cover of at least **30%** and a height of **5** metres or more; • areas temporarily not wooded following clear felling through forest management practices or due to natural causes, and whose regeneration is foreseeable within the next 5 years; • Forest roads, fire-breaks and other small clearings; forests in national parks, nature reserves and other protected areas of ecological, scientific, historical, cultural or spiritual interest; • Windbreaks, shelter-belts and trees corridors occupying an area of more than **0.1 ha** and a width of more than **20 metres**; • The shifting cultivation land abandoned with regenerated trees that reach, or are able to attend, a canopy with a minimum area of **0.1 ha**, a forest cover of at least **30%** and a height of at **least 5 meters;** • The intertidal areas covered with mangroves, classified or non-classified; • Areas covered with bamboos provided that the land use, the height and canopy are consistent with the established criteria. • All woody plantations that meet the technical criteria of tree size, crown cover condition and minimum surface area; and which did not replace, as from 2015, natural forest lands according to the national forest definition submitted to the UNFCCC.

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Definitions related to Sudan

(UN-FAO 1958) All lands bearing vegetative associations dominated by trees of any size, exploited or not, capable of producing wood or other forest products, of exerting an influence on the climate or on the water regime, or providing shelter for livestock and wild life. *Includes:* Lands from which forests have been clear-cut or burned, but which will be reforested in the foreseeable future; Public and private forest of any size; Forest of slow growth and of dwarfed or stunted forms — e.g., subalpine; Bamboo lands; All land which is not part of a recognized fallow rotation of the shifting cultivator, and which will return to forest when he abandons the land; also lands under shifting cultivation on which forest production is maintained concurrently — e.g., *Acacia senegal* in Sudan; Savanna types with density averaging at least 0.05; Wattle (*Acacia, spp.)* plantations; Tree nurseries; Forest roads. *Excludes:* Areas occupied by orchards of fruit or nut trees, and plantations for non-forest crops such as rubber and cinchona; Areas occupied by individual trees or lines or groups of trees — for example, along roadways, canals and streams, or in city parks, private gardens and pastures — too small to be managed as forests; Areas of windbreak and shelterbelt trees that are in small groups or narrow strips, too small to be managed as forests; Lands primarily managed for permanent agriculture; All land which is part of a recognized fallow rotation of the shifting cultivator, or which will not return to forest even though it bear a light timber crop before being cut, burned over and re-cultivated. http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/007/ad906t/AD906T05.htm

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Technical Considerations on forest definition:
Minimum Height Threshold

- Minimum tree height threshold is important for natural tree lines in boreal forests and mountain (alpine) areas
- Also important for categorization of some dry forest/shrub land ecosystems and agroforestry systems.
- Most countries do not consider minimum height necessary in their forest definition as long as their definition specifies a dominant vegetation type (e.g. forest tree species)
- Countries that specify heights less than 5 m may (could) be low forest countries.

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Technical Considerations on forest definition:
Minimum Area Threshold

- In closed forest this parameter is needed only for administrative and ecological purposes. Ecological considerations are based on recognition that for forests to fulfill their ecological functions, and exhibit their representative structure and dynamics, they have to be of a certain size.

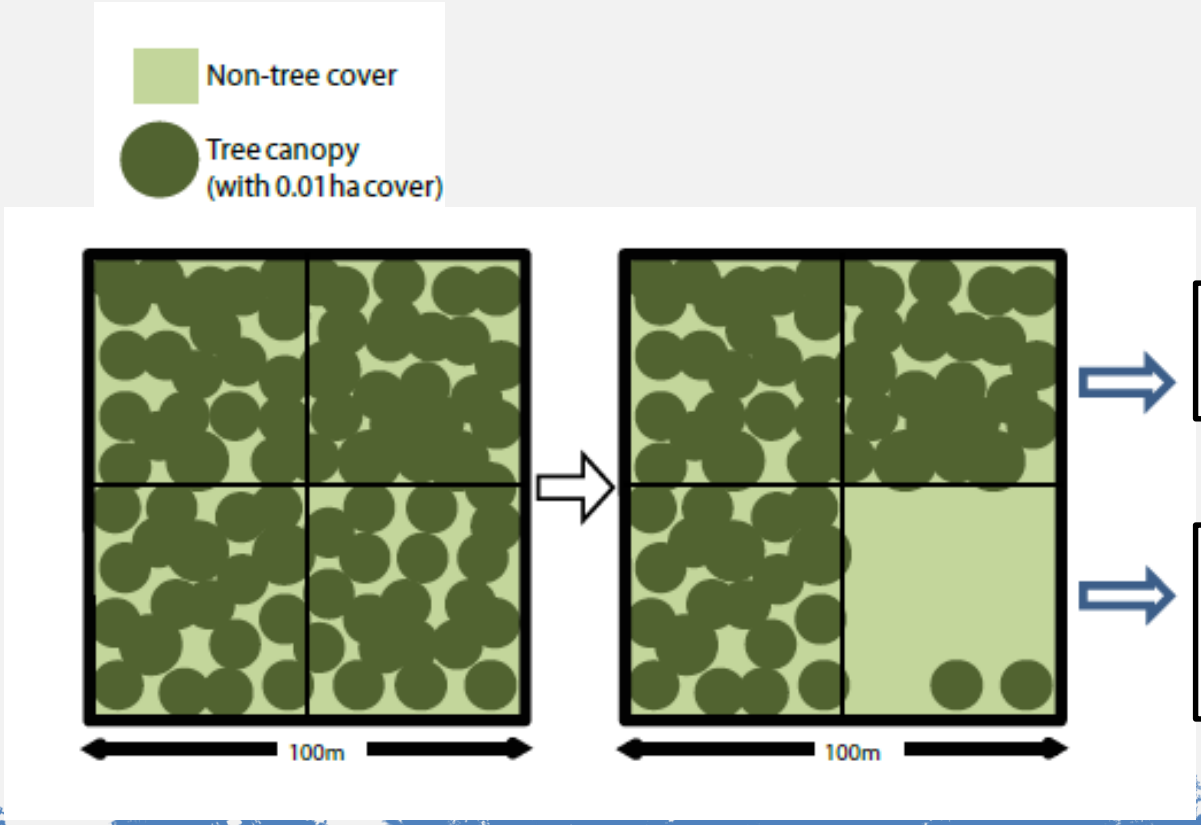
- In most temperate and boreal (taiga) forests the impact of area threshold on amount of land considered as forest is minimal

- Area threshold is influential in forests under human pressure (encroachment, logging etc..): open forest and fragmented closed forest.

- Simulation studies conducted on 19 EU countries indicated that varying the area threshold could overestimate forests by up to 10% or underestimate up to 6% for individual countries (but such studies have not be done for other major forests)

- For open forests, minimum area requirement is also linked to canopy threshold.

Impact on the choice of minimum surface area for land use change analysis

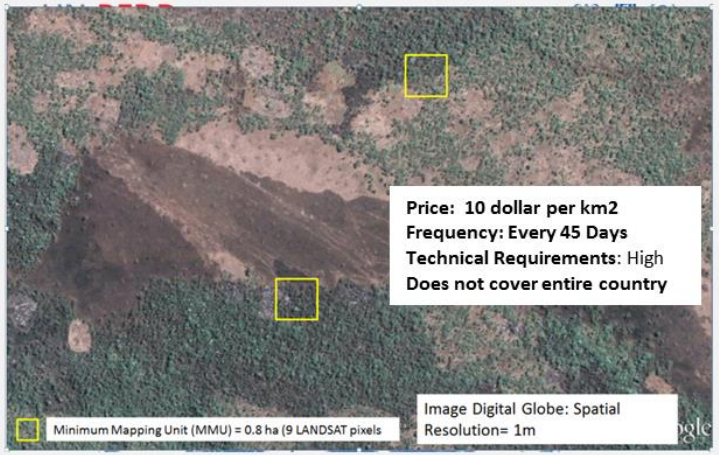


If minimum area is **1 ha,** then there is no deforestation

If minimum area is **0.25 ha**, then, there is deforestation of 0.25 ha

Minimum Area Threshold

- Adoption of a very low minimum area threshold could engender/stimulate a high level of participation in REDD+, but
  - – - can increase the cost of MRV considerably (e.g. cost of satellite imagery), and
  - - may also increase the amount and technical capacity for monitoring
- Choice of min. area threshold should also take into account the MMU for satellite imagery to use for monitoring (e.g 0.81 or 9 pixels for Landsat)



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Technical Considerations on forest definition:
Minimum Crown Cover Threshold

- Minimum Crown Cover can be a limiting factor in many areas where height can be limiting

- In addition, it is a very important parameter for classifying open woodlands (e.g. dry forest and steppe formations). However, crown cover has a major significance in all forest types, as virtually all disturbances, human induced or natural, have a temporary or lasting effect on crown cover, making it a sensitive indicator of “naturalness” and disturbance.

- Crown cover is the most commonly used proxy for assessing the naturalness of closed forest formations and it is the most important simple parameter for detecting degradation.

- Distinctions between “open forest” and “closed forest” are based on canopy cover percent cut-offs: >40% for closed forest and between 10 and 40% for open forest.

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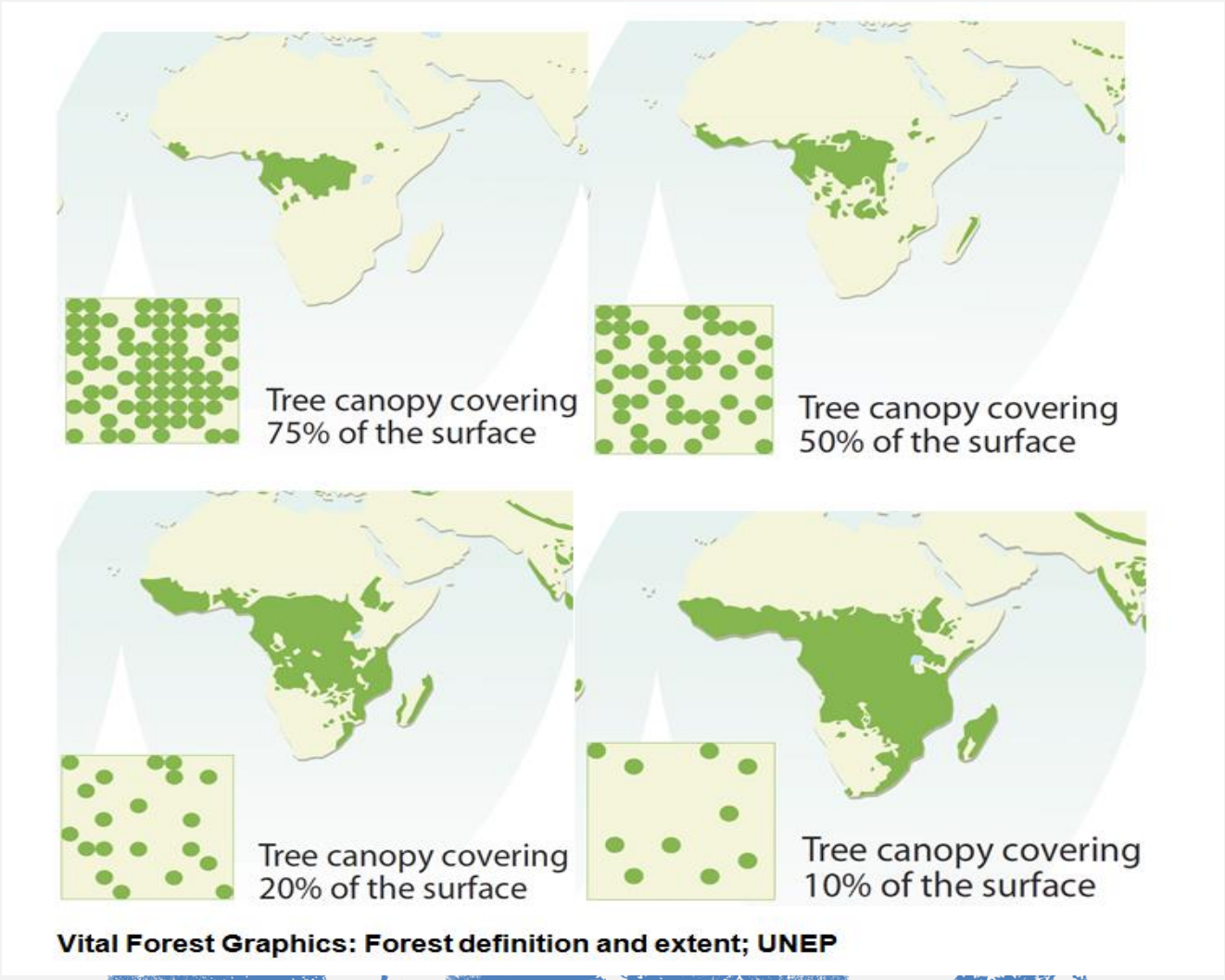
Impact of Canopy Cover threshold on forest surface area estimates

Estimates of remaining tropical forest can differ depending on the canopy cover threshold used: 10%, 20%, 50% and 75% give different estimates



Vital Forest Graphics: Forest definition and extent; UNEP

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Impact of canopy cover threshold on amount of (unnoticed) forest degradation

- If a high threshold for canopy cover (e.g. 70%) is used in definition of forest, then many areas of sparse forest & wood land could be cleared or could increase in cover without the losses or gains in carbon being accounted for.
- If a low threshold is set (e.g. 10%), then dense forest could be heavily degraded and significant amounts of carbon released, without the actions designated as deforestation
- However, in the case of REDD+, a national forest monitoring system must be put in place to monitor deforestations (and Forest degradation).

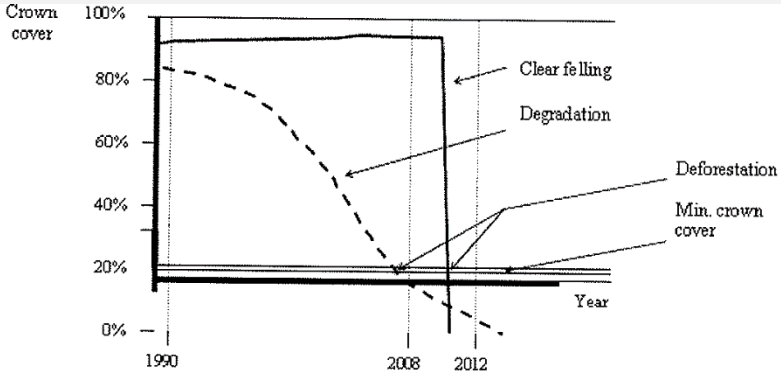

Figure 1. Sudden forest loss and degradation. Degradation is registered as deforestation only years after the process started.

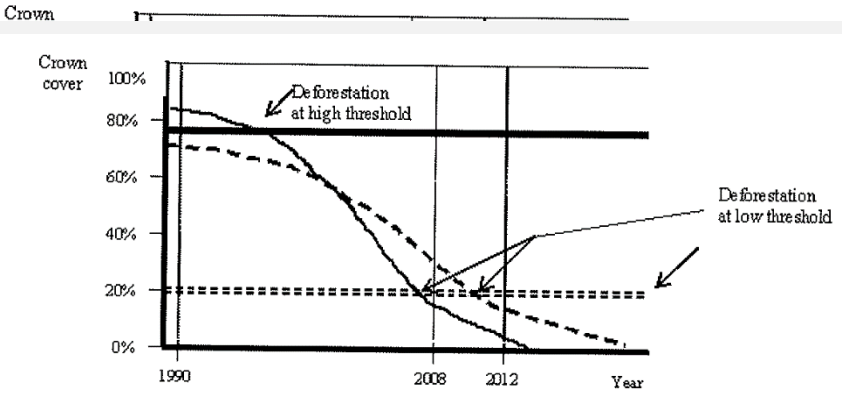

Figure 2. Forest degradation at different crown cover thresholds. While continued degradation always triggers deforestation at a low threshold, a high threshold is efficient only if degradation starts at a nearly full stocking level.

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Forest Transition Curve/Theory) and Deforestation Status of countries

The forest transition (Mather 1992):

Countries can be placed on a transition curve depending on their stage in the transition:

- Initially, a country has a high and relatively stable land under forest cover (HFLD).
- Deforestation begins, then accelerates and forest cover reduces (HFHD).
- At some point deforestation slows, forest cover stabilizes and begins to recover.

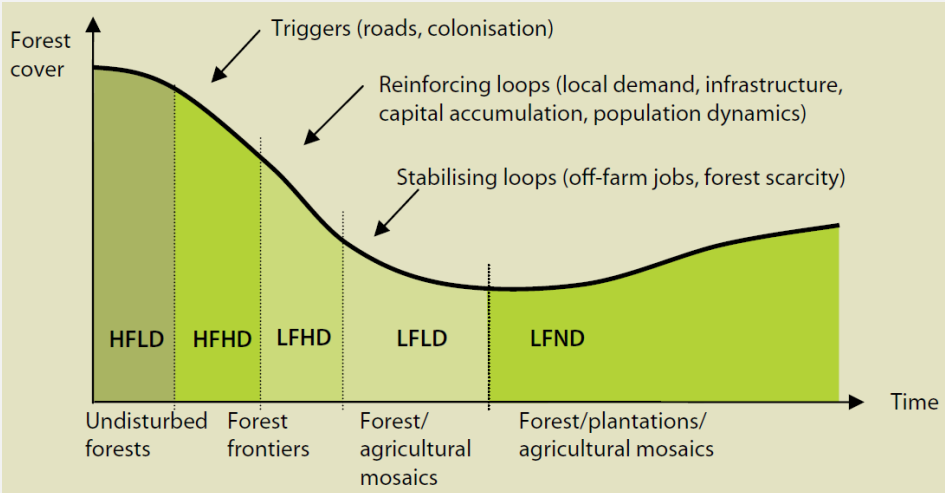

Figure 1.1. Different stages in the forest transition

Developing countries can be classified into four categories depending on amount of remaining forest cover and deforestation rate:

- **HFLD** = High Forest Low Deforestation Countries
- **HFHD** = High Forest High Deforestation Countries
- **LFHD** = Low Forest High Deforestation Countries
- **LFLD** = Low Forest Low Deforestation Countries

	Low Forest Cover (<50%)	High Forest Cover (>50%)
High Deforestation Rate (>0.22%/yr)	***Quadrant I*** e.g., Guatemala, Thailand, Madagascar High potential for RED credits High potential for reforestation payments under CDM Number of countries:44 Forest area: 28% Forest carbon (total): 22% Deforestation carbon (annual): 48%	***Quadrant III*** e.g., Papua New Guinea, Brazil, Dem. Rep. of Congo High potential for RED credits Low potential for reforestation payments under CDM Number of countries:10 Forest area: 39% Forest carbon (total): 48% Deforestation carbon (annual): 47%
Low Deforestation Rate (<0.22%/yr)	***Quadrant II*** e.g., Dominican Republic, Angola, Vietnam Low potential for RED credits High potential for reforestation payments under CDM Number of countries:15 Forest area: 20% Forest carbon (total): 12% Deforestation carbon (annual): 1%	***Quadrant IV - HFLD Countries*** **e.g., Suriname, Gabon, Belize** **Low potential for RED credits** **Low potential for reforestation payments under CDM** **Number of countries:11** **Forest area: 13%** **Forest carbon (total): 18%** **Deforestation carbon (annual): 3%**

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Table 1. Estimates of forest carbon stocks in the five largest national pools for each continent in the study region

	Canopy cover threshold								
	10%			25%			30%		
Country	Area (Mha)	Total C (Gt C)	C density (Mg C/ha)	Area (Mha)	Total C (Gt C)	C density (Mg C/ha)	Area (Mha)	Total C (Gt C)	C density (Mg C/ha)
Democratic Republic of Congo	205	24	118	177	23	128	164	22	134
Cameroon	36	5	129	30	4	142	27	4	151
Republic of Congo	28	4	144	24	4	160	23	4	162
Gabon	24	4	160	22	4	164	21	4	165
Angola*	73	3	44	42	3	66	34	2	70
Total sub-Saharan Africa	775	62	80	539	50	93	447	48	106
Brazil	596	61	102	481	56	116	442	54	123
Peru	80	12	153	75	12	158	73	12	160
Colombia	84	10	122	67	9	138	64	9	141
Venezuela	61	7	118	50	7	134	47	7	139
Bolivia	74	6	84	65	6	90	61	6	94
Total Latin America	1,209	120	99	977	110	112	893	107	119
Indonesia	165	23	142	127	20	155	121	19	158
Myanmar	49	7	146	42	6	155	40	6	157
Papua New Guinea	43	6	147	37	6	152	36	6	153
India†	63	6	89	43	4	104	36	4	112
Malaysia	30	5	172	25	5	179	25	4	180
Total Asia and Oceania	474	65	137	359	56	155	336	54	159
Total study region	2,458	246	100	1,875	215	115	1,677	208	124

All carbon values were calculated by using the pixel-based AGB value to compute BGB and total carbon (AGB + BGB). Carbon density (Mg C ha^{-1}) values were calculated from the ratio of total carbon to total forest area at national or regional levels.

*Central African Republic replaces Angola as no. 5 in Africa using 25% and 30% canopy cover thresholds.

†India switches from rank 4 to rank 5 using 25% and 30% canopy cover thresholds.

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Impact of variation of canopy cover threshold on Forest Area & Total forest carbon (Analysis for 31 African Countries)*

- Variation in forest canopy cover has greater impact on Forest Area and Total Carbon for Low Forest (LF) countries than High Forest (HF) countries*.
- Status of a Countries forest (LF, HF..) could have an impact on the choice of canopy cover threshold.

	Estimated Total Forest Carbon Change due to change in Forest Cover Threshold from:		Estimated Forest Carbon Area Change due to change in Forest Cover Threshold from:	
	10% to 25%	25% to 30%	10% to 25%	25% to 30%
West Africa [LFLD] 10 Countries	63.3%±16.1 %	48.2%±20.4%	68.4%±14.1%	50.2%±23.1%
Other African Countries[15]: LFLD	42.2%±8.6%	33.9%±11.3%	46.2%±8.3%	36.8%±15.7%
Other African Countries HFMD or HFLD. [6 Countries]	6.9%±1.0%	2.4%±1.1%	14.4±11.6%	6.2%±4.3

*Data from: http://news.mongabay.com/2011/05/new-global-carbon-map-for-2-5-billion-ha-of-forests/

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country	Status	Total forest carbon (Mt C)			Total forest carbon (Mt C) changes		Forest Area (M ha)			Forest Area (M ha) Changes	
		C10%	C_25%	C_30%	C10_25	C25_30	C_10%	C_25%	C_30%	AC10_25	AC25_30
Ethiopia	LFLD	1,037	698	547	32.7%	21.6%	22	13	10	40.9%	23.1%
Kenya	LFLD	209	111	90	46.9%	18.9%	4	2	2	50.0%	0.0%
Sudan	LFLD	926	567	289	38.8%	49.0%	25	13	6	48.0%	53.8%
Uganda	LFLD	428	244	184	43.0%	24.6%	7	4	3	42.9%	25.0%
Mali	LFLD	103	12	2	88.3%	83.3%	3	0.28	0.04	90.7%	85.7%
Senegal	LFLD	78	14	4	82.1%	71.4%	3	1	0.16	66.7%	84.0%
Tanzania	LFLD	1,406	764	545	45.7%	28.7%	34	17	11	50.0%	35.3%

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Impact of minimum Canopy cover Threshold on forest area and total forest carbon for some African countries

Country	Sub Region	Total Forest Carbon [Mt C]			Forest Carbon Change[%]		Forest Area [M_ha]			Forest Area Change [%]	
		c10	c25	c30	c10_25	c25_30	c10	c25	c30	c10_25	c25_30
Benin	WA	64	8	1	87.5%	87.5%	2	0	0	100.0%	100
G.Bissau	WA	97	50	22	48.5%	56.0%	3	1	1	66.7%	0.0%
Gambia	WA	2	0.4	0.2	80.0%	50.0%	0.14	0.04	0.02	71.4%	50.0%
Ghana	WA	530	288	251	45.7%	12.8%	8	3	2	62.5%	33.3%
Guinea	WA	968	473	284	51.1%	40.0%	18	8	5	55.6%	37.5%
Liberia	WA	1,355	1,257	1,226	7.2%	2.5%	9	9	8	0.0%	11.1%
Mali	WA	103	12	2	88.3%	83.3%	3	0.28	0.04	90.7%	85.7%
Nigeria	WA	1,072	579	495	46.0%	14.5%	18	7	5	61.1%	28.6%
Senegal	WA	78	14	4	82.1%	71.4%	3	1	0.16	66.7%	84.0%
Sierra_Leone	WA	510	385	343	24.5%	10.9%	7	5	4	28.6%	20.0%
Togo	WA	43	9	4	79.1%	55.6%	1	0.19	0.07	81.0%	63.2%
Cameroon	CA	4,646	4,268	4,089	8.1%	4.2%	36	30	27	16.7%	10.0%
CAR	CA	3,262	2,776	2,378	14.9%	14.3%	53	42	34	20.8%	19.0%
Congo	CA	4,091	3,817	3,775	6.7%	1.1%	28	24	23	14.3%	4.2%
DRC	CA	24,143	22,662	22,014	6.1%	2.9%	205	177	164	13.7%	7.3%
EQ_Guinea	CA	416	393	386	5.5%	1.8%	3	2	2	33.3%	0.0%
Gabon	CA	3,867	3,568	3,502	7.7%	1.8%	24	22	21	8.3%	4.5%
Tanzania	E	1,406	764	545	45.7%	28.7%	34	17	11	50.0%	35.3%
Uganda	E	428	244	184	43.0%	24.6%	7	4	3	42.9%	25.0%
Zambia	S	1,919	1,344	983	30.0%	26.9%	47	31	22	34.0%	29.0%

Thresholds for Forest Definition used by some countries and impact on carbon and Forest area

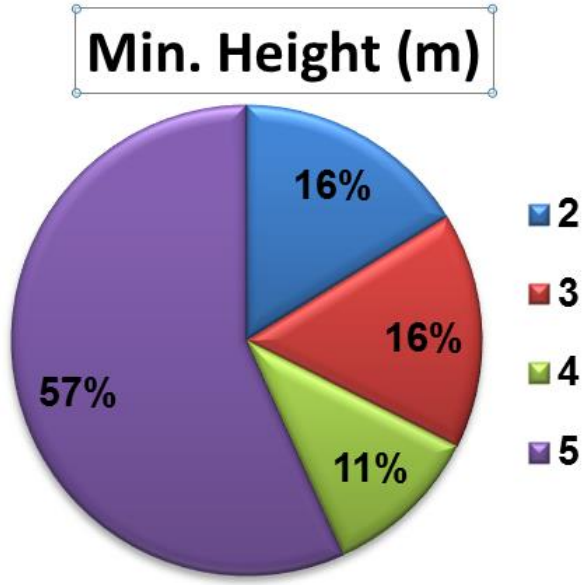
Country	Min. Area	Min. Ht	Min. Cover	Status	Purpose	Impact of canopy Cover on:	
						Forest Area	Total Carbon
Brazil	0.5	5	10	HFMD	FREL		
Colombia	1	5	30	HFMD			
Ecuador	1	5	30	HFHD			
Guyana	1	5	30	HFLD			
Mexico	1	4	10	HFMD			
Côte d'Ivoire	0.1	5	30	LFLD			
Ghana	1	5	15	LFLD			
DRC	0.5	3	30	HFMD			
Costa Rica	1	5	30	LFLD			
Congo Rep.	0.5	3	30	HFMD			
Vietnam	0.5	5	10	LFLD			
Peru	0.5	5	30	HFLD			
India	0.05	2	15	LFLD			
Malaysia	0.5	5	30	HFMD			
Paraguay	0.5	5	25	MFMD			
Thailand	0.16	3	30	LFLD			
Ethiopia	0.05	2	20	LFLD			
Madagascar	1	5	30	LFLD			
Cambodia	0.5	5	10	HFHD			
Nicaragua	1	4	20	MFMD			
Honduras	1	5	30	HFHD			
Panama	1	5	30	HFMD			
Uganda	1	5	30	LFLD			
Kenya	0.1	2	30	LFLD			
El Salvador	0.5	5	30	LFLD			
Tanzania	0.05	2	10	LFHD			

Analysis for 107 countries

MinArea	Count	%
0.01	1	0.9%
0.05	10	9.3%
0.0629	1	0.9%
0.1	14	13.1%
0.15	1	0.9%
0.16	1	0.9%
0.2	1	0.9%
0.25	4	3.7%
0.3	5	4.7%
0.4	2	1.9%
0.5	37	34.6%
0.67	2	1.9%
1	19	17.8%
3	3	2.8%
4	1	0.9%
5	1	0.9%
30	1	0.9%
100	1	0.9%
Grand Total	107	100.0%

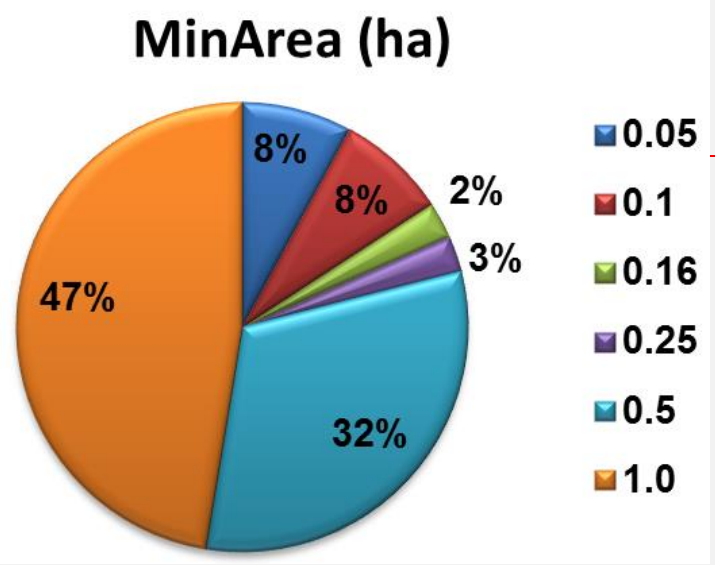
MinCover	Count	%
5	1	1.0%
10	35	33.3%
15	2	1.9%
20	20	19.0%
22.5	1	1.0%
25	4	3.8%
30	41	39.0%
75	1	1.0%
Grand Total	105	100.0%

MinHeight	Count	%
1	2	1.9%
1.3	2	1.9%
2	19	17.8%
3	13	12.1%
4	5	4.7%
5	60	56.1%
6	2	1.9%
7	3	2.8%
8	1	0.9%
Grand Total	107	100.0%



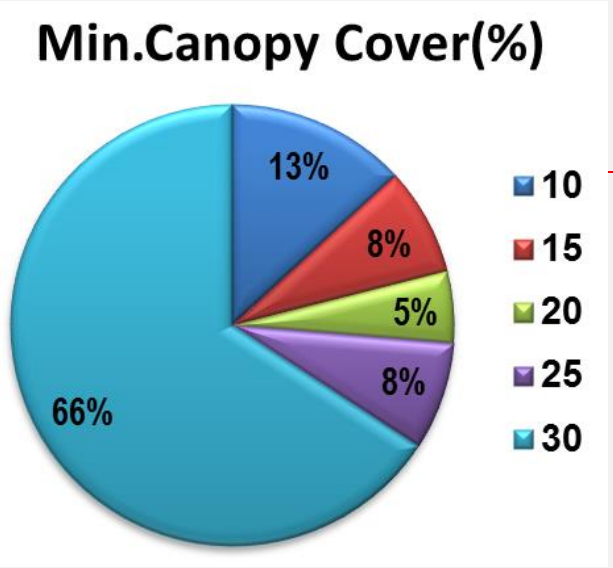
- 57% of countries use a minimum height of 5 m as threshold in their forest definition; 16% use 2 and 3 m respectively and 11% use 4 m.
- High and Medium forest countries use the 5 m height threshold, while some Low Forest countries use 2 and 3 m minimum height thresholds.

	Minimum Tree Height (m)				
	2 m	3 m	4 m	5 m	Total
HFHD	0	0	0	4[100%]	4
HFLD	0	0	0	2[100%]	2
HFMD	0	2[25%]	1[12.5%]	5[62.5%]	8
MFMD	0	0	1[50%]	1[50%]	2
LFLD	4[28.6%]	2[14.3%]	0	8[57.1%]	14
Total	4	4	2	20	30



- **77% of countries use min. area od 0.5 (32%) and 1 ha (47%).**
- **High and Medium Forest countries used 0.5 ha and 1 ha as minimum area, while low forest countries use 0.05, 0.1 and 0.16 ha as well [*probably in an attempt to declare more forest for CDM, but may be a problem for REDD+ to monitor such small areas*]**

	Min. Area (ha)					
	0.05	0.1	0.16	0.5	1	Total
HFHD	0	0	0	1[25%]	3[75%]	4
HFLD	0	0	0	1[50%]	1[50%]	2
HFMD	0	0	0	4[50%]	4[50%]	8
MFMD	0	0	0	1[50%]	1[50%]	2
LFLD	2[14.3%]	3[21.4%]	1[7.1%]	3[21.4%]	5[35.7%]	14
Grand Total	2	3	1	10	14	30



66% of the countries use the 30% minimum canopy cover threshold.

The tendency is for High Forest Countries to use 30% while Low Forest countries also select 10, 15, 20 and 25% min. canopy cover.

The use of 30% threshold has more impact on Low Forest Countries than High Forest Countries

	Min. Cover (%)					Grand Total
	10%	15%	20%	25%	30%	
HFHD	1[25%]	0	0	0	3[75%]	4
HFLD	0	0	0	0	2[100%]	2
HFMD	2[25%]	0	0	0	6[75%]	8
MFMD	0	0	1[50%]	1[50%]	0	2
LFLD	1[7.1%]	3[21.4%]	1[7.1%]	0	9[64.3%]	14
Grand Total	4	3	2	1	20	30

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Land Cover Classification for Sudan: Africover

Table 2. Africover data aggregated in 21 sub groups

SUB-GROUPS	Sudan	
	Hectares	%
Rainfed herbaceous crops (Large to medium continuous fields)	6 698 153	2.68
Rainfed herbaceous crops (Small, continuous fields and clustered and isolated fields)	7 577 080	3.03
Rainfed shrub crops, tree crops, forest plantations)	8 375	0
Irrigated and post flooding herbaceous crops	2 136 523	0.85
Irrigated and post flooding shrub crops, irrigated tree crops, irrigated forest plantations	459 936	0.18
Aquatic agriculture	0	0
Closed trees	582 529	0.23
Open to very open trees	25 312 762	10.11
Closed to open shrubs and woody vegetation	42 926 334	17.15
Aquatic closed to open trees, shrubs and woody vegetation (Brackish water) (Mangroves)	5 481	0.00
Aquatic closed to open trees, shrubs and woody vegetation (Fresh water, permanently or temporarily flooded).	5 377 154	2.15
Open to closed grass land	8 156 920	3.26
Tree and shrub savannah	42 158 823	16.84
Sparse vegetation	15 115 171	6.04
Aquatic closed to open grass inc. sparse trees and shrubs (Fresh water, permanently and temporarily flooded)	3 103 256	1.24
Aquatic floating forbs (Fresh water, permanently and temporarily flooded) and closed to open herbaceous (Brackish water)	5 843	0
Bare rock, bare rock with shallow sand and tidal areas, very stony and stony soil.	63 270 365	25.27
Loose and shifting sands, bare soil, dunes, sand banks and beaches	26 575 610	10.61
Urban areas	355 360	0.14
Water (natural and artificial)	544 828	0.22

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GLOBAL FOREST RESOURCES ASSESSMENT 2005

ESTIMATING FOREST COVER AND FOREST COVER CHANGE IN SUDAN

NAGLA DAWELBAIT, SALAH YOUSIF, ANNE BRANTHOMME, ABDURAHMAN GORASHI ELMAHI, ALBERTO DEL LUNGO AND HASSAN ABDELNOUR

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Sudan Forest Cover: Africover

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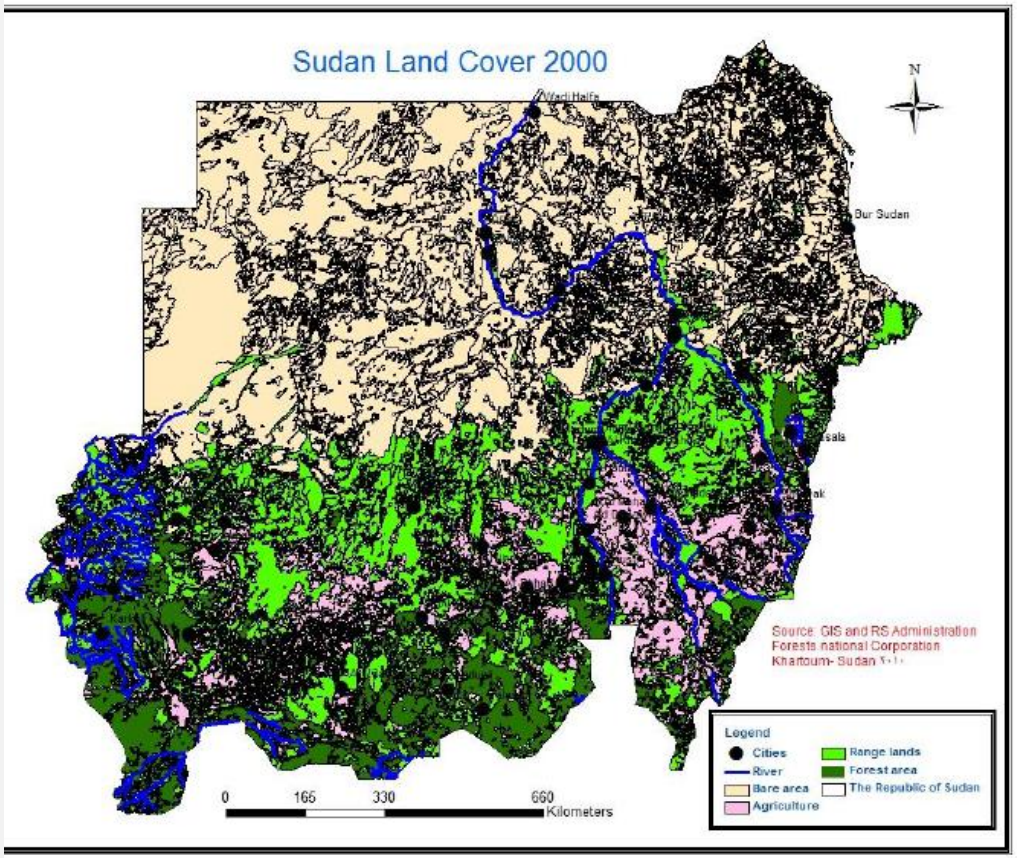
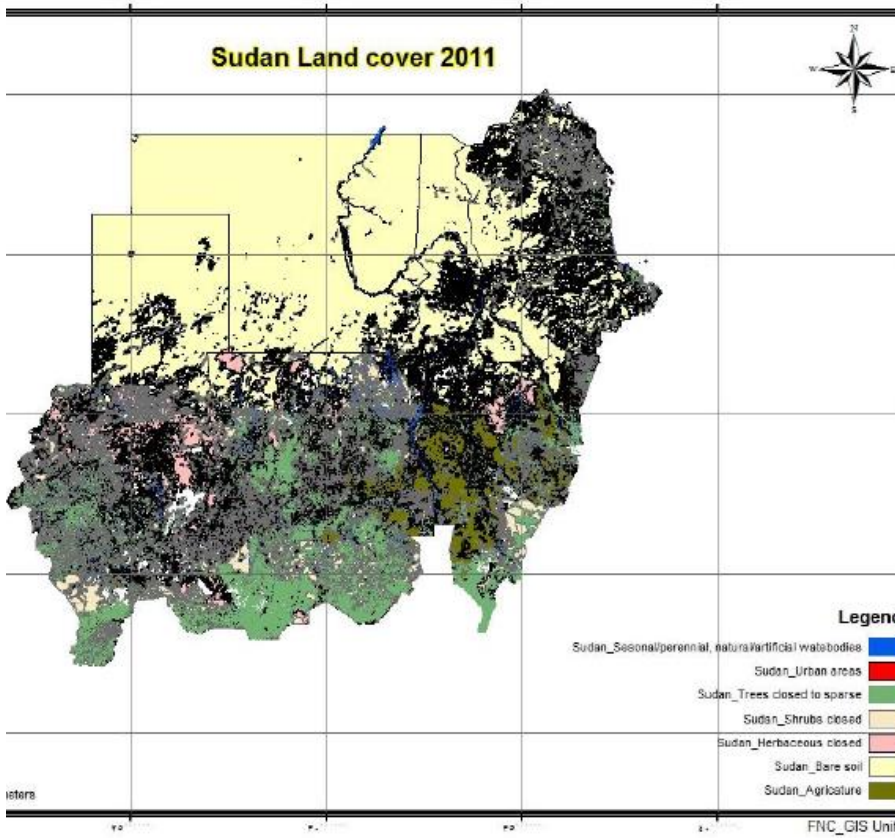


Figure III.1. Sudan Land Cover 2000 (Africover)



II.2. Sudan Land Cover 2011 (SIFSIA)

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Ecological Classification of Vegetation of the Republic of Sudan

Major Division	Subdivisions	RoS
Desert	NIL	716.8
Semi-Desert	1. *Acacia tortilis - M. crassifolia* scrub	184.3
	2. Semi-Desert grassland on Clay	102.4
	3. Semi-Desert grassland on Sand	84.5
	4. *Acacia mellifera* – Commiphora scrub	84.5
	5. *Acacia glaucophylla – A. etbaica* scrub	30.7
	Total	**486.4**

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Ecological Classification of Vegetation of the Republic of Sudan

Woodland Savanna	***A. Low Rainfall***	
	1. On Clay	
	(a) *Acacia mellifera* – thorn land	
	(i) On dark cracking clays, with grass area	94.7
	(ii) On *in situ* soils, with *Commiphora* and *Boscia* spp.	51.2
	(b) *A. seyal* – *Balanites aegyptica* savanna alternating with grass	100.1
	(c) *Anogeissus spp.-Combretum hartmannianum* Woodland	48.6
	Total on Clay	**294.6**
	2. On Sand	
	(a) *Acacia seyal* savannah	64.5
	(b) *Combretum hartmannianum- Albizzia sericpcephala-Dalbergia* spp. savannah woodland	84.5
	(c)*Terminalia - Sclerocarya - Anogeissus - Prosopis* spp. savannah woodland	63.2
	Total on Sand	**212.2**
	3. Special Areas	
	(a) Toposa Hills	-
	(b) Hill Catenas	69.1
	(c) Baqqara Catena	17.9
	(d) Raqaba Catena	31.6
	Total Special Areas	**118.6**
	Total Low Rainfall Woodland Savannah	***625.4***
	B. High Rainfall	
	(a) *Anogeissus – Khaya – Isoberlinia* spp. Savannah woodland	30.7
	(b) Woodland savannah recently derived from rain forest	-
	Total High Rainfall Woodland Savannah	***17.2***
Flood Region		7.3
Montane Vegetation		3.8

UN-REDD PROGRAMME

Republic of Sudan

Vegetation of Sudan

Vegetation	Description	Area
The desert	Desert areas cover the northern Sudan mainly north of latitude 16 extending eastwards from Darfur through northern Kordofan and further east to the intersection of latitude 20 with longitudes 34 and 36 East in the Red Sea area. The total area of the desert region is 725800 square kilometers approximately or 29 percent of the total area of the country. Annual rainfall is less than 75 mm and is insufficient to support any significant vegetation cover. Forest trees are confined to the banks of the River Nile in patches occupying lagoons and depressions in the form of forest reserves scattered among agricultural holdings.	
The semi-desert	The semi-desert forms a belt that lies immediately south of the desert boundary covering an area of approximately 491000 square kilometers or 19.6 percent of the country area. Rainfall varies between 75 mm to 300 mm annually and vegetation is confined to grasses with a scatter of bushes not more than two meters high interspersed with bare areas.	
Woodland savannah	The woodland savannah follows immediately south of the semi-desert zone south of latitude 14 N to cover the rest of the country except for small portions of the southern boundary which form part of the equatorial zone. Rainfall varies between 300 mm to 1500 mm per annum and vegetation is composed of a mixture of trees, bushes and grasses. Woodland savannah is divided according to precipitation levels into low rainfall woodland savannah covering an area of 691000 square kilometers or 27.6 percent of the country area and high rainfall woodland savannah covering an area of 347000 kilometers or 13.8 percent of the total area. Low rainfall woodland savannah is further divided according soil type into low rainfall woodland savannah on clay and low rainfall woodland savannah on sand. Clay soils in this subdivision carry associations of *Acacia mellifera* Thornland, A*cacia seyal – Balanites* woodland and *Anogieisus – Comboretum* woodland. Sandy soils in lesser rainfall areas carry mainly *Acacia senegal* often in pure stands whereas in wetter areas to the south taller larger tree association of *Terminalia*, *Sclerocaria* and *Anogeissus* woodlands occur. Within this subdivision various special types of forests exist important among which are the riverain forests, mangroves and palms. High rainfall woodland savannah includes forests classified as high rainfall woodland savannah and woodland savannah recently derived from high rain forests. The first type is found in areas of 800 – 1300 mm of rainfall while the latter exists under rainfall of over 1300 mm per annum. Gigantic timber trees are mixed with tall grass in this subdivision and production forestry was actively practiced before being abandoned due to conditions of insecurity in those areas.	
Montane	These include the Imatong Mountains on the boarder with Uganda with important production forestry derived from Rain Forests and the Didinga Mountains carrying similar woodlands.	

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Table No. 1- Land Use in the Sudan

Land Use Category	Projected Area (1000 ha)		
	2000	**2005**	**2010**
Forest Land >20% Crown Cover	3,069.5	2,939.0	2,808.5
Forest Land 10-20% Crown Cover	4,486.5	4,283.0	4,079.5
Scattered Trees/Shrub Rangeland	42,751.3	40,810.5	38,869.5
Grass Rangeland	20,110.0	20,110.0	20,110.0
Wasteland	15,882.0	16,065.5	16,249.0
Irrigated Agriculture	1,860.0	1,860.0	1,860.0
Mechanized Rain Fed Agriculture	7,599.5	8,949.0	10,298.0
Traditional Rain Fed Agriculture	8,561,5	9,303.0	19,944.5
Totals	**104,320.3**	**104,320.0**	**114,219.0**

Source: HCENR/IUCN 2001–Sudan Country Study on Biodiversity

Impact on changes in Canopy cover% on Forest Area & Carbon stocks in Sudan

Forest definition (canopy cover %)	10% tree cover	25% tree cover	30% tree cover
Forest Area (M ha)	25	13	6
Aboveground forest carbon (Mt C)	705	433	221
Belowground forest carbon (Mt C)	221	133	67
Total forest carbon (Mt C)	926	567	289
Average Carbon Density (t C/ha)	37	45	50

M=million, t=metric tons; all figures are mean carbon stock values

In May 2011, Sassan Saatchi of Caltech's Jet Propulsion Lab and colleagues published a paper in PNAS with new carbon stock estimates for global tropical forests

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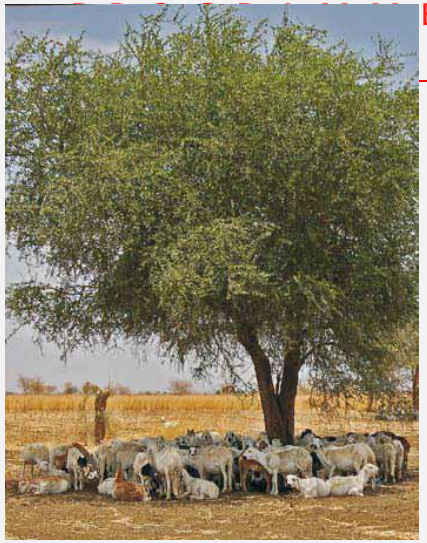
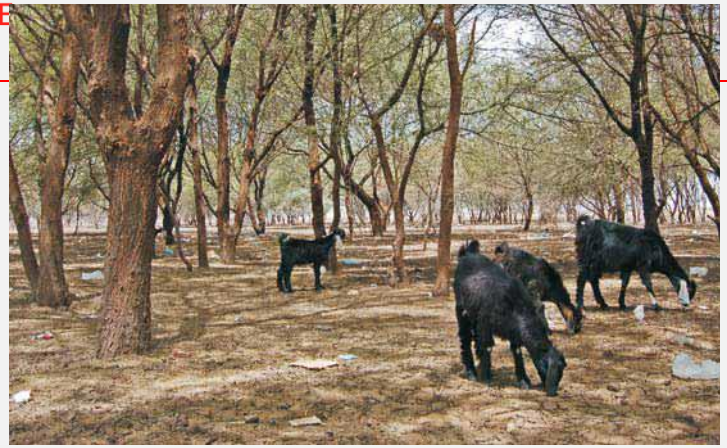


Balanites trees provide vital shade for livestock in 40₀C heat



Acacia nilotica in Sennar state.

Forest resources in the desert and semi-desert northern states

What constitute forest may vary from one to another

These teak trees have not been tended for 20 years

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5. Change rate based on 1972 forest survey and Africover 2000

Despite the shortcomings that indicate dissatisfaction with ground validation for the year 1972, when the satellite images were produced, 1972 should be taken as a reference or base year for forest cover comparisons. Data from the forest surveys of the NEA (1982) and the World Bank Report (1985), based on the 1972 imageries (Table 4) have been compared with the new results from the Africover (2000) classification (Table 3).

Table 4: Original Data 1972

Region	Forest (hectares)	Other (Scrub and Semi-Desert) (hectares)	Total area (hectares)
Eastern	2 748 065	700 000	3 448 065
Central	5 123 790	700 000	5 823 790
Khartoum	5 000	700 000	705 000
Kordofan	11 628 000	700 000	12 328 000
Darfur	17 693 300	700 000	18 393 300
Northern	0	700 000	700 000
Sub-total Northern Sudan	**37 198 155**	**4 200 000**	**41 398 155**
Buhayrat	6 525 400	0	6 525 400
Jonglei	11 863 900	0	11 863 900
B. El-Ghazal	11 733 900	0	11 733 900
E. Equatoria	10 808 150	0	10 808 150
W. Equatoria	6 982 783	0	6 982 783
Upper Nile	23 171 600	0	23 171 600
Sub-total Southern Sudan	**71 085 733**	**0**	**71 085 733**
Total	**108 283 888**	**4 200 000**	**112 483 888**

Source: Sudan National Energy Assessment (1982)
Sudan Issues and Options in Energy section (1983)