Legally and Illegally Logged out

Extent and Drivers of Deforestation & Forest Degradation in Myanmar

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Plate 1: Over-logging: Continuing logging in an evidently over-logged forest, Katha Forest Management Unit, Sagaing, Spring 2015. This area has been the primary 'timber basket' for the country for a century and is still under heavy utilisation. The National Code of Forest Harvesting Practice prescribes that '*over-logged areas will be excluded from harvesting.*'

Acknowledgments

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Contents

Summary

This report presents findings of a research project conducted for EcoDev/ALARM in 2015. It is one of two complementary papers by the authors, the other, entitled 'The status of Myanmar's timber sector and options for reform' presents findings relating to the forestry and timber sector. The present report should be considered together with Bhagwat's et al.'s (2016) report, entitled 'Myanmar Forest Cover Change 2002-2014', which, based on satellite image analyses, presents findings on forest and land cover status (2014) as well as changes over the period, 2002-14. The main additional contribution of the present report is that it distinguishes between deforestation and forest degradation inside vs. outside forest reserves and protected areas, and links this to the apparent dominant features of the underlying political economy that drives land cover and land-use changes within these two broad tenure categories.

Over the period 2002-14, Myanmar lost a total of 2.07 million ha or 11.3% of its intact forest. Approximately two thirds of this was lost from non-reserved areas. However in relative terms, the loss of intact forest was almost as high inside forest reserves (10.3%) as that of non-reserved areas (11.7%) while this loss was 'only' 0.09 million ha or 2.3% within protected areas (national parks, wildlife sanctuaries and the like). Overall, the area of degraded forest has increased by 1.8% (0.47 million ha), distributed as 2.0%, 1.4%, and 1.8% increases within non-reserved, forest reserves, and protected areas, respectively. Non-forest areas increased by an overall 4.7% (0.99 million ha), which was distributed as 4.1%, 9.1%, and 11.6% increases with non-reserved, forest reserves, and protected areas, respectively. The national area of plantations increased by a dramatic 58.4% (0.54 million ha), which was distributed as 58.6%, 57.8%, and 95.7% increases within non-reserved, forest reserves, and protected areas, respectively. As a result of hydro dam constructions, the total area of waterbodies increased by 9.27% (0.73 million ha), which was distributed as 3.0%, 61.9%, and 3.7% increases within non-reserved, forest reserves, and protected areas, respectively.

By 2014, forest reserves carried only 27.0% intact forest while degraded forest accounted for 55.2%, non-forest 14.9%, plantations 2.1%, and water bodies 0.8%. Protected areas, by contrast, are covered by 68.8% intact forest, 20.5% degraded forest, 6.8% non-forest, 1.1% plantation, 1.2% waterbodies, and 1.5% snow. Thus, it must be concluded that, while intact forest and the general forest cover has been comparatively well-conserved within protected areas, forest reserves have in general been as poorly conserved as unreserved areas. Accordingly, forest reserves are now generally exhausted and most of these are dominated by degraded forest while many carry no trees at all or exhibit large areas of non-forest.

Despite the general trend of deforestation and forest degradation in non-reserved areas and within forest reserves, large tracts of continuous intact forest are still found in remote parts of particularly Kachin state and Tanintharyi region. In all parts of the country, deforestation and conversion of forest to other land-uses appears driven by rationales of maximising financial returns as this happens most intensively along rivers streams, major roads, and land borders to neighbouring countries, particularly China and India.

Inside forest reserves, excessive timber extraction primarily of teak but presumably also other high value species seems to be the major underlying driver of forest degradation. This is supported by data on recorded harvest vs. estimated annual allowable cuts as well as time series of forest inventory data, which point to a systematic and long-term overharvesting of teak while the aggregate group of 'other hardwoods' appear less or not overharvested. This failure of the Forest Department to live up to its primary responsibility is, however, no great mystery. The underlying reasons might be summarised as follows:

1. Systematic 'revenue-target' driven over-extraction at the orders of successive central governments. Formerly this was mainly legal extraction, but substantial illicit practices as well as high wastage have occurred under political favouritism in relation to Myanmar Timber Enterprise and 'crony' subcontractor companies.
2. Expansion of agriculture and 'land grab' agri-business concessions into forests.
3. A disempowered and somewhat demoralised Forest Department with inadequate staffing, monitoring capacity, enforcement powers, and inadequate salary necessitating petty corruption.
4. Unregulated and partly criminalised domestic timber and wood extraction without an effective management or regulatory regime.
5. Insecure land and tree tenure for local people, marginalising civil society and undermining incentives to conserve, protect and plant trees, and to work with the Forest Department to do so.
6. A conflict economy in many upland areas bordering neighbouring countries provoked and maintained by the Tatmadaw Union Military, allowing them to indulge in illegal timber trading and taxation (amongst other sectors) for personal gain

In light of the changing political climate towards democracy and given the fact that substantial and very valuable (financially as well as environmentally) intact and degraded forest resources still exist, it is high time for Myanmar to review and reform its overall forest sector. Concrete suggestions on how this could/should be approached are given in 'The status of Myanmar's timber sector and options for reform' (Springate-Baginski et al., 2016).

In addition to the above mentioned mechanisms of deforestation and forest degradation, surface mining seems a very rapidly expanding phenomenon. National-level data is still wanting, but analyses of Kachin state and Sagaing region document that, over the period 2002-14, the area of mines increased by 141.7% and 743.6%, respectively. These mines are mainly established outside forest reserves and protected areas. Yet their location along main rivers and tributaries of these suggest that their impact on water quality and hence food-chains could be devastating. Accordingly, a national-level assessment of mines combined with a ground-truthing of their environmental impact seems urgently needed to bring this potentially out-of-control sector under environmentally sound regulation.

1. Introduction to Myanmar's forest and timber sector

The context:

Myanmar's forest and timber sector has been central to the country's economy and society, particularly over the last century. Since the colonial era, timber has been a major export revenue earner to Burma/Myanmar and thus subject to much political debate (Bryant 1996). In addition to timber export revenues, the forests of Myanmar have always provided timber and non-timber forest products for domestic consumption as well as a range of environmental services including water catchment, habitat for flora and fauna, carbon storage, and soil nutrient recovery in rotational agriculture.

Myanmar's forests have contained some of the most valued timbers in the world – particularly rosewoods and teak. Now, amidst unprecedented political reforms in Myanmar, the forest and timber sector is currently undergoing a process of reform. This is indicated by a number of policy changes, most significantly:

1. The 2014 Log Export Ban – which has made it illegal to export unprocessed logs
2. The Government's engagement in a Voluntary Partnership Agreement (VPA) process with the European Union's Forest Law Enforcement Governance and Trade (FLEGT) initiative, requiring transparency and compliance improvements that are mutually agreed upon between the government, the timber sector and civil society.

This policy redirection is essential, although long overdue. Practical implementation is inevitably going to take time and face obstacles as powerful political-economic interests allied to the former military regime will seek to maintain their access to timber and land as well as control over revenue flows associated with the commercial utilisation of these national resources.

Meanwhile the Ministry of Environment Conservation and Forestry (MOECAF) is under strong pressure from international timber traders to increase supply, more evidently recent pressure from China, and also missions from European and US timber sector representatives. This pressure is due to a combination of factors; growing demand around the world, declining supply of tropical hardwood from shrinking forests, and growing stringency around compliance concerning illegal sourcing.

In order to respond to these pressures the authors have tried to clarify the status of the timber industry, the status of the forest resource including its management, and the challenges for reform.

This study:

Under an EU-funded project managed by EcoDev/ALARM, the authors have conducted a detailed field study in Spring 2015 on the current status of the timber trade and forest change. We sought to answer two simple questions:

1. What is the current status of the timber and forest sectors and actual processes ongoing in relation to?
   - forest condition, management & planning
   - land use, land use change, forest degradation & deforestation
   - the timber industry, legality, enforcement, and governance
2. What should the reform agenda be?
   - What policy measures can promote democratic governance processes, sustainability of the resource, and equity in distribution of the costs and benefits?

This report focusses on forest change, timber production, and land use change. A companion report, Springate-Baginski et al. (2016), considers the timber industry and forest management for timber.

Our **method** involved interviews with a wide range of stakeholders nationally and regionally, field study of forests at timber extraction sites in three state/regions, visits to log depots and processing factories in Kachin, Tanintharyi, Sagaing, Mandalay and Yangon, analysis of previously unreleased Ministry of Environmental Conservation and Forestry data. In addition, this report has greatly benefited from an ongoing EcoDev/ALARM coordinated project on remote sensing-based mapping of forest condition and change, Bhagwat et al. (2016). Furthermore, for the purpose of this report, data from the Ministry of Environmental Conservation and Forestry showing the geographical boundaries of forest reserves and protected areas was kindly shared with EcoDev/ALARM. For the first time in Myanmar's forest history this has allowed for a detailed national-level assessment of the past (2002) and present (2014) land cover and forest condition within and outside the country's designated permanent forest estate.

Our approach has involved four different data collection methods:

1. interviews with key informants at national, region/state, field levels, and workshops;
2. field site observation in a range of sites including 'good' sites where timber extraction is occurring; also at timber flow locations (Map 1);
3. assessment of official data provided by MOECAF;
4. review of secondary literature.

Map 1: Study sites

We sampled 3 'hotspot' state/regions & townships, as listed in Table 1 below and illustrated in Map 1. At each we visited a range of field sites. Field research was conducted over a five week period in February March 2015.

Table 1: Data collection: types of data and the three state/regions

Types of data:	Sagaing	Kachin	Tanintharyi
State-Region level ➢ *FD Asst Director MTE manager*	Monywa	Myitkyina	Dawei
FMU / township level ➢ *FD/MTE officials* ➢ *Field extraction sites* ➢ *Transport* ➢ *Depots* ➢ *Domestic extraction & use*	Katha dist. FMU 1. Pinlebu township 2. Katha township	Myitkyina dist. FMU 1. Monyin township 2. Myitkyina township	Dawei dist. - FMU 1. Dawei township 2,3. Tanintharyi township Myeik dist –FMU 4. Myeik Kyunsu township

2. Myanmar's forest and land cover

The extent and canopy cover of forests has steadily declined in recent years and, as depicted in Figure 1, the national cover of closed forest has gone down from 45% to 18% during the period 1990-2010

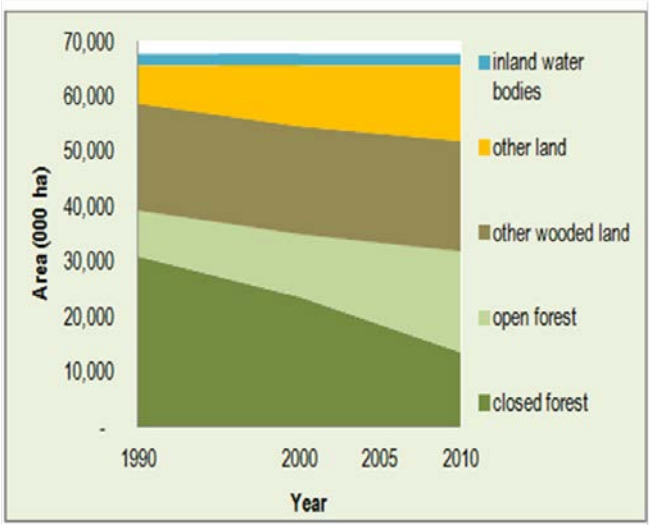


Figure 1 Forest cover development in Myanmar
Source: FAO (2010)

Recent Landsat-based forest cover analyses show that the remaining large areas of intact forest (above 80% crown coverage) in Myanmar are found in the extreme Northern and Southern parts of the country (Map 2, see Bhagwat et al. (2016) for further details). Other areas of forest are patchy and mostly confined to hilly and mountainous parts of the country which are dominated by degraded (open canopy) forest (10-80% crown coverage). Table 2 summarizes the current (2014) and 2002 national-level land cover categories including the land cover categories to which intact forest has been converted over this timespan (top row in Table 2). Due to resource constraints and technical limitations in the interpretation of the satellite images, it has not been possible to produce a fully-fledged land cover change matrix that would, e.g. account for a possible but probably limited re-growth of degraded forest into intact forest or for the, more likely, conversion of degraded forest into non-forest (agriculture, mines, infrastructure, etc.), plantations, or water bodies (artificial lakes). Accordingly, the trend represented in Table 2 as well as in this report's other land cover change matrices may to some extent overstate the degree of intact forest degradation while the apparently less dramatic change in the area of degraded forest is likely to be somewhat understated. For example, the conversion of primary forest to agriculture or plantation will often include a process of forest degradation where the most valuable and large size timber is extracted. This stated, the 2002 and 2014 areas of land cover categories presented in this report are, to our knowledge, by far the most up-to-data, detailed, and reliable data on land cover in Myanmar. In this respect Bhagwat et al. (2016) offers a comparison between this and FAO's 2015 FRA report on Myanmar.

Table 2: Myanmar land cover categories in 2014 and 2002

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	Categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	16.192.952	471.534	987.841	535.838	72.775		18.260.940	- 2.067.988	-11,32
	Degraded Forest (10%-80%*)		25.701.243					25.701.243	471.534	1,83
	Non-Forest (<10%)			21.134.373				21.134.373	987.841	4,67
	Plantation				917.361			917.361	535.838	58,41
	Water					785.337		785.337	72.775	9,27
	Snow / Ice						108.684	108.684	-	
	Total in 2014	16.192.952	26.172.777	22.122.214	1.453.199	858.112	108.684	66.907.938		
	% change of intact forest		2,58	5,41	2,93	0,40				

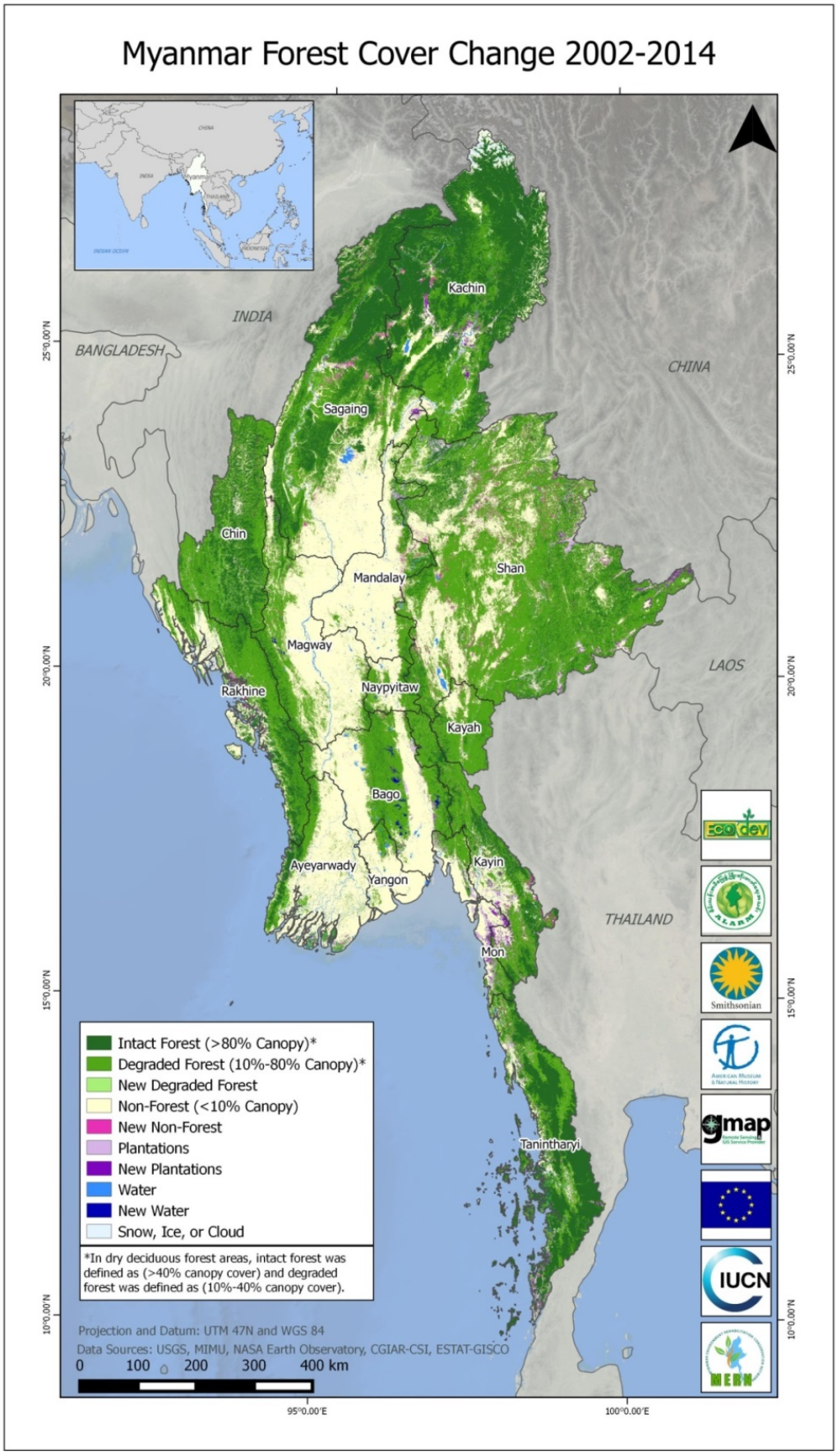
* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Source: Bhagwat et al. (2016), EcoDev/ALARM

As Table 2 shows, the area of intact forest (crown cover >80%) has declined by 2.07 million ha or 11.3% from 18.26 to 16.19 million ha over the relatively short period of 13 years from 2002 to 2014. In absolute figures this is by far the most dramatic land cover change. The area of degraded forest (crown cover of 10-80%) has 'only' increased by 1.8% or 0.47 million ha. Non-forest, i.e. the area of mainly agriculture and mines experienced the most dramatic increase in absolute figures from 21.13 to 22.12 million ha while plantations had the most dramatic relative change of 58.41% from 0.99 to 1.45 million ha. The area of water bodies increased by 9.27% from 0.79 to 0.88 million ha, presumably due to the construction of dams.

The overall land cover changes summarised in Table 2 are not evenly distributed across the country. Appendix 1 provides change matrices for each state/region. Furthermore the on-line version of Map 2 allows for the following qualitative description of the current and recent developments in Myanmar's land cover (see Bhagwat et al. (2016) for further details):

- Intact forest is found in the country's most remote, hilly, and mountainous areas. Large tracts of continuous intact forest are only found in the northern parts of Kachin State and Sagaing Region as well as in the hilly parts of Tanintharyi Region. More fragmented intact forest situated within larger tracts of degraded forest is mainly found in the mountainous parts of Chin State, Rakhine State, Magway Region, Ayeyarwady Region, Shan State, Bago Region, and Kayin State.
- Degraded forest is, with the exception of the dry zone, found throughout the country in hilly as well as in remote areas with limited road access.
- In terms of forest cover changes over the period 2002-14, new degraded forest (mint-green pixels on the on-line version of Map 2) are generally found along the boundaries between non-forest (ivory colour pixels) and degraded forest (light green pixels). In turn, these boundaries between non-forest and degraded forest are often found along rivers and streams indicating that clearings for agriculture have generally spread up-stream and thus up-hill as an extension of existing non-forest. In addition, there are comparatively high concentrations of new degraded forest around non-forest land along the national borders to India, China, and to some extent Thailand.
- New non-forest (pink pixels) is concentrated mostly; along major rivers and roads in the southern part of Kachin State; along rivers and roads in the northern part of Sagaing region; In Shan state, degraded forest gives way to new non-forest land on a very large and more scattered scale. Scattered new non-forest is also found on a much smaller scale in the hilly parts of Sagaing Region and Chin State. Furthermore clusters of new non-forest are found on the coast in Rakhine State (particularly around Koungbarmia bay) and the southernmost part of Tanintharyi Region. In Kayin State, clusters of new non-forest are found on the border to Thailand close to the main road connection between the two nations.
- Plantations (light and dark purple pixels) are often found in the boundary areas between non-forest and degraded forest. New plantations (dark purple pixels) are generally concentrated around existing plantations (light purple pixels). The largest plantation areas are found in Kachin State (184,000 ha), Sagaing Region (42,000 ha), Shan State (558,000 ha), Bago Region (62,000 ha), Kayin State (158,000 ha), Mon State (181,000 ha), and Tanintharyi Region (173,000 ha).
- New large-scale plantations are clustered and have in general been established close by or as extensions of existing plantation areas; in the southern part of Kachin State, around Myintgyina Town; in Shan State, close to the borders of China, Laos, and Thailand; in Sagaign Region, one large area across the Ayeyarwadi river from Katha town (replacing a degraded forest reserve, see below); in Kayin and, Mon States, in all transition areas between non-forest (cropland) and forest; and in Taninthary Region along the coast, rivers, and road connections to Thailand as well as in the extreme south.



Map 2. Forest cover in Myanmar 2002-14

Source: Bhagwat et al. (2016), Map available at: ftp://glcf.umd.edu/glcf/Myanmar_ForestChange/

3. Forest cover inside vs. outside forest reserves and protected areas

Deforestation and forest degradation is usually bad for biodiversity conservation and well as carbon storage and reduces the flow of environmental benefits. Historically, however, deforestation has, up to a point, been associated with economic development in forest rich countries because sustainable extraction of timber and non-timber forest products from natural forests cannot financially compete with more intensive forms of land-use like agriculture and plantations, not to mention the extraction of minerals, oil, and gas. Yet in addition to timber and other products natural forests provide significant economic albeit mostly non-marketed services as well as existence values to society. This is the overall political justification for nations' establishment of intended permanent forest estates through legal reservation of geographically specified areas.

In Myanmar, forest areas are legally protected in the form of (i) Reserved Forests (RF), (ii) Public Protected Forests (PPF), and (iii) Protected areas (National Parks, Wildlife Sanctuaries, and Nature Conservation Areas). Forested areas that are not included in any of these legal categories are termed Unclassified Forests (UCF) by the Forest Department. In addition to this, large areas of 'low' dipterocarp forest form part of rotational agricultural systems. Originally, Reserved Forests were intended for sustainable timber production while providing non-market environmental services to society. Public Protected Forests were intended to satisfy local people's subsistence needs for forest products and might be legally converted to Reserved Forests. Unclassified Forests were kept as a 'land bank' for other land uses or possible reservation. No extraction of timber or other products is supposed to take place in National Parks, Wildlife Sanctuaries, and Nature Conservation Areas.

Accordingly, when analysing the development of forest cover change it matters where deforestation and forest degradation has geographically taken place. If this has happened mainly in Unclassified Forests, it may be ecologically, environmentally, and politically problematic, due to associated changes in official and unofficial land tenure arrangements, but not in conflict with the current policy of long-term forest conservation within designated areas. If, on the other hand, deforestation and forest degradation occurs within reserved areas, this would be a clear sign that the official forest and nature conservation authorities have been unable or unwilling to implement the letter and spirit of official forest policy and legislation.

To this end we obtained shapefiles of all forest reserves from the Ministry of Environment and Forestry. These were superimposed on the above mentioned satellite images, c.f. Map 2 after which all land cover change analyses were run within and outside forest reserves (Reserved Forests & Public Protected Forests) as well as within and outside protected areas. The national-level results are summarised in Table 3 and Figure 2

In absolute figures, the 2002-14 loss of intact and increase of degraded forest has been much higher outside than inside forest reserves and protected areas (Table 3). However in relative terms, the 10.3% loss of intact forest inside forest reserves has been almost as high as that for areas outside forest reserves (11.7%) while the loss inside protected areas was considerably less (2.3%). The relative increase in degraded forest has been modest both outside (2.1%) as well as inside forest reserves (1.4%) and protected areas (1.8%). Quite disturbingly the area of non-forest within forest reserves has increased by 217,000 ha or 9.1% bringing the total non-forest area within forest reserves to almost 2.6 million ha or 14.9% of the area of forest reserves. Within protected areas, the area of non-forest has also increased, albeit in much smaller absolute terms (39,000 ha), and non-forest 'only' covers 6.8% of this category's area. The increasing area of plantations represents the most dramatic relative change outside forest reserves (58.6%), a development that is almost entirely mirrored inside forest reserves, where the area of plantations increased by 57.8%. Alarmingly the area of plantations almost doubled from 30,000 to 59,000 ha within protected areas. In principle, plantation species inside forest reserves could be quite different from those used on agricultural land, e.g. teak/timber species vs. rubber trees, banana, betel nut, and oil palms, but this is hardly the case in practice although field inspections would be needed to establish this with certainly.

Moreover, we do not know to which degree the analytically applied shapefiles include forest reserves that have been wholly or partly de-gazetted. According to Woods (2015, p.8), 1.77 million acres (equalling 0.72 million ha) of forest reserves were de-gazetted in 2004 and 2005, presumably through formally legal yet rather opaque procedures. Unless protected areas have been de-gazetted, no legitimate conversion to plantation is possible. In both absolute and relative terms, the area of water has increased most radically within forest reserves. While this may be environmentally and ecologically problematic, it might be the politically preferable alternative to inundation of agricultural land, settlements, and areas set aside for nature protection.

Overall, these national-level analyses document that that the relative extent of deforestation and forest degradation inside vs. outside forest reserves are rather similar. While the underlying processes and cause-effect relations might differ between these two broad tenure categories, the data strongly suggests that the Forest Department, whose statutory duty it is to protect and conserve forests within its geographical area of jurisdiction, has been either unable or unwilling to fulfil its mandate. The result is that, by 2014, forest reserves are dominated by degraded forest, which covers 55.2%. About 27.0% of the forest reserves' area is covered by intact forest while 14.9% has no forest at all. Protected areas, on the other hand, appear to be better protected and contain the highest relative area of intact forest (68.8%). In comparison to forest reserves, protected areas are situated in more remote and thus inaccessible areas which is likely to offer a high, albeit with time increasingly uncertain, degree of 'protection by default'.

Table 3: Land cover categories outside and inside forest reserves as well as protected areas

	2002	2014	change (ha)	change (%)	2014 coverage (%)
Outside forest reserves					
intact forest	13,014,021	11,486,868	-1,527,153	-11.73	23.22
degraded forest	16,206,082	16,541,734	335,652	2.07	33.44
non-forest	18,756,097	19,526,596	770,499	4.11	39.47
plantation	682,818	1,082,988	400,170	58.61	2.19
water	701,467	722,299	20,832	2.97	1.46
snow	108,683	108,683	0	0.00	0.22
Forest reserves (RFs & PPFs)*					
intact forest	5,246,917	4,706,084	-540,833	-10.31	26.99
degraded forest	9,495,162	9,631,045	135,883	1.43	55.23
non-forest	2,378,275	2,595,615	217,340	9.14	14.88
plantation	234,544	370,211	135,667	57.84	2.12
water	83,870	135,813	51,943	61.93	0.78
snow	1	1	0	0.00	0.00
Protected areas**					
intact forest	3,845,338	3,755,768	-89,570	-2.33	68.80
degraded forest	1,100,605	1,120,223	19,618	1.78	20.52
non-forest	334,352	372,974	38,622	11.55	6.83
Plantation	30,237	59,174	28,937	95.70	1.08
Water	64,645	67,038	2,393	3.70	1.23
Snow	83,734	83,734	0	0.00	1.53

Source: EcoDev/ALARM

Notes: *Areas of green as well as blue and **areas of orange polygons in Map 3. Although some areas are fully or partly covered by orange and green or orange and blue polygons it was not possible to establish these areas' current tenure status. Accordingly, for reasons of analytical consistency, analyses of forest reserves' land cover has ignored protected areas and vice versa.

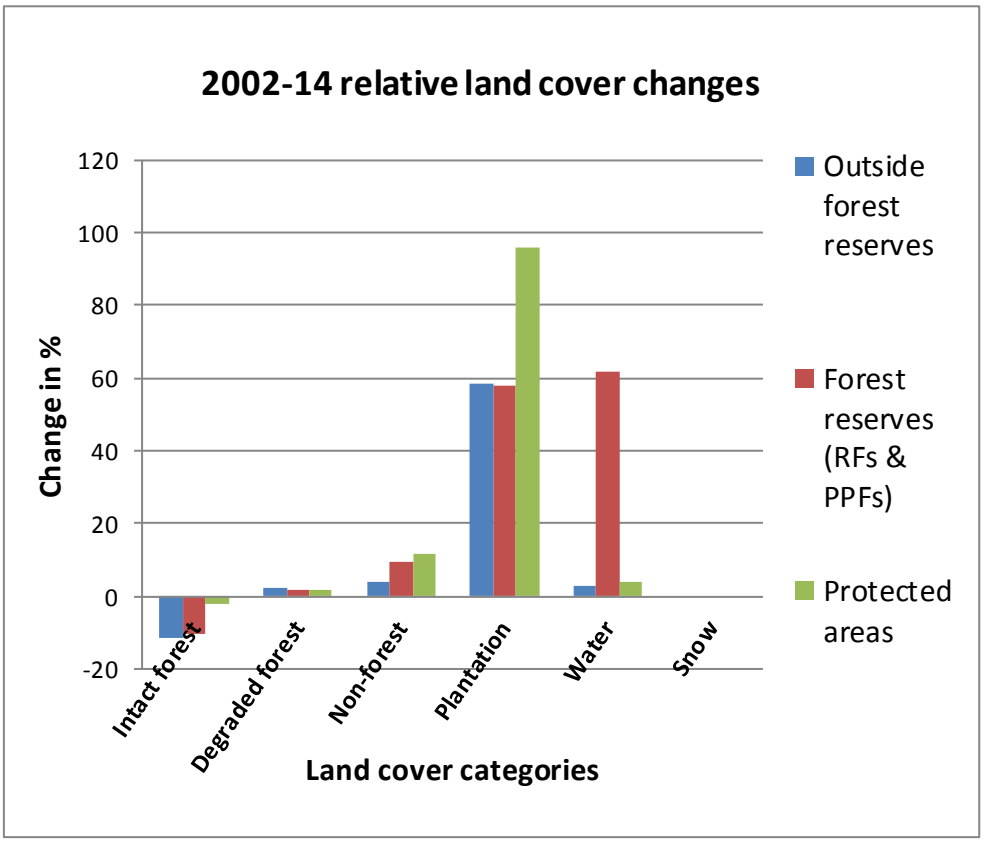
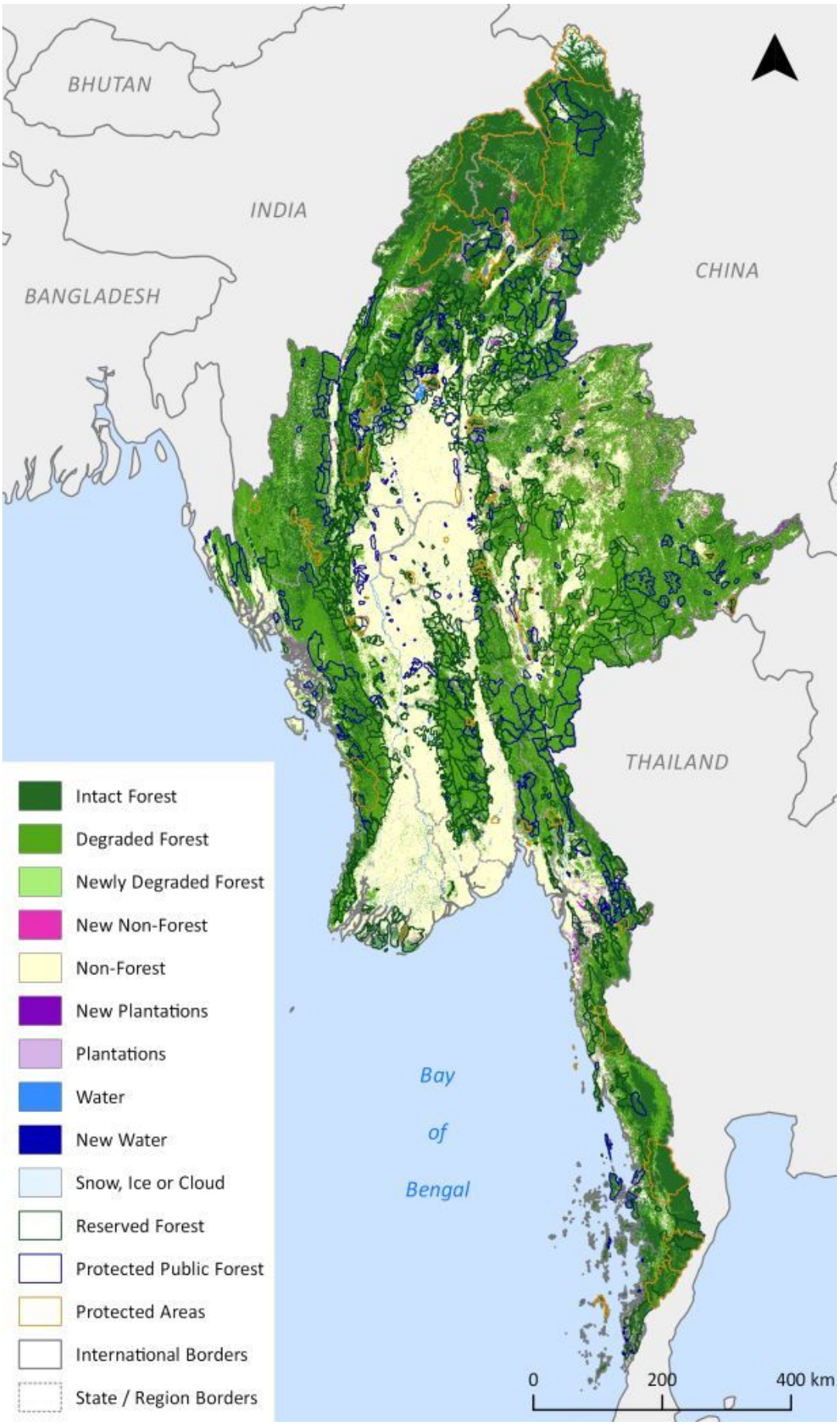


Figure 2: 2002-14 relative changes in land cover inside and outside forest reserves as well as protected areas.
Source: EcoDev/ALARM

Map 3 below shows the geographical location of Reserved Forests (green polygons), Public Protected Forests (blue polygons), and Protected Areas (orang polygons) across the country.



Map 3. 2002-14 Land cover and land cover changes including forest reserves and protected areas
Source: EcoDev/ALARM

Complementing the figures in Table 3, a qualitative assessment of Map 3 allows for a number of broad conclusions:

- The highest density of forest reserves is found around the country's dry zone and navigable rivers, which illustrates their colonial origin and economic importance to this and subsequent central administrations.
- Very large tracts of continuous intact forests in remote parts of Kachin State, Sagaing, and Tanintharyi Regions are today unreserved.
- Most of the remaining and very large tracts of scattered intact forest in Chin State are unreserved.
- Very large areas of degraded forests in Rakhine and Shan Stares are unreserved.
- Most forest reserves close to major rivers and roads are dominated by degraded forest while reserves with larger areas of intact forest are located in more remote hilly or mountainous areas.
- A large number of the forest reserves along major rivers in the country's dry zone contain no trees at all, or are dominated by no-forest areas.
- A number of forest reserves have been almost entirely replaced with plantations (dark and light purple pixels) while new non-forest (pink pixels) are found in many forest reserves.

Although each degraded or entirely cleared forest reserve has its own history, our field visits, supplemented by Google earth satellite images, suggests the following general process of forest reserve degradation and eventual conversion to other land-uses: First, the most valuable timber, often teak, is extracted from reserves that are located conveniently near major rivers or roads. Subsequently several rounds of commercial logging removes the remaining commercial timber known as 'other hardwoods' including possible re-grown teak. Concurrently, and in-between official logging interventions, local people and more organized timber 'poachers' illegally extract timber for subsistence, the domestic market, and for smuggling to neighbouring countries. At some point the forest reserves' commercial value in terms of standing timber has passed a threshold below which the Forest Department cannot justify spending resources on 'protecting' their boundaries from broad encroachment. This begins with commercial albeit illegal firewood cutting and ends up with permanent agricultural cultivation and/or plantations.

An up-stream 'journey' on Google Earth along the Ayeryarwady from Mandalay to Katha, where the river makes a sharp turn to the east, seems to exemplify a travel backwards in time quite well (Figure 3). Closest to Mandalay the nature reserve (orange polygon) and public protected forest (blue polygon) have been almost wholly replaced with permanent agriculture and only some shrub-land remains in the highest lying parts. Going further north, the tree cover within reserved forests (green polygons) extends further and further down the hill/mountain sides and high canopy forest begins to dominate, except along streams flowing from or along logging roads leading into these forests. An example of this is the forest reserves immediately south of Katha (Figure 3). Incidentally, a recent large-scale plantation establishment within a reserved forest (green polygon) is found on the eastern bank of the Ayeryarwady, immediately across from Katha. Here most of the otherwise non-forested reserve has been replaced by plantations (dark purple pixels on the map in Figure 3).

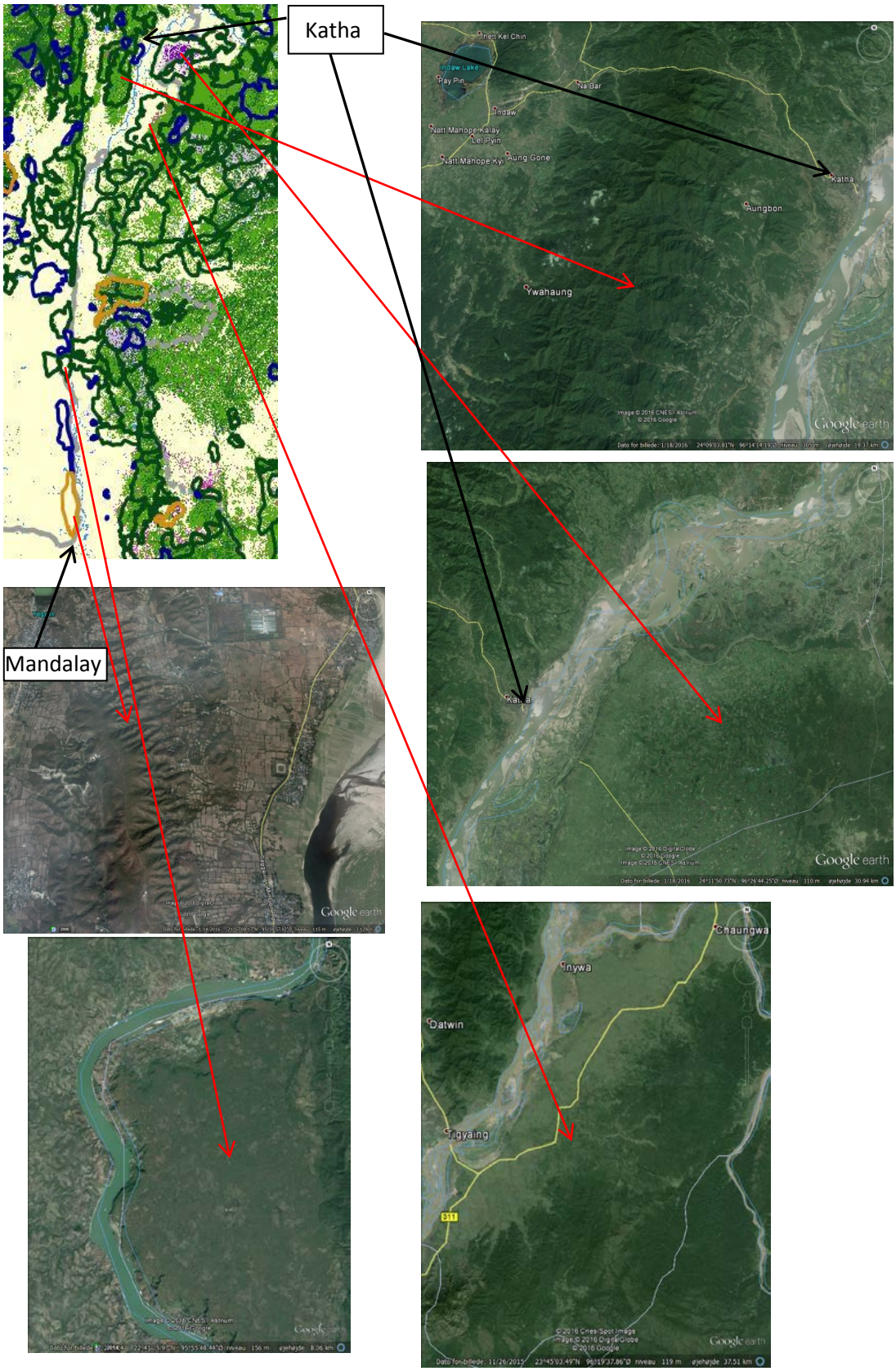


Figure 3 Goole earth illustrations of the current canopy closure within protected areas and forest reserves
Sources: EcoDev/ALARM and Google earth

4. Myanmar's timber harvest

As documented by Springate-Baginski et al. (2016) the timber harvesting intensity for teak has, for decades, exceeded the estimated annual allowable cut (AAC) while the recorded harvest of other hardwoods, mostly dipterocarps (*Dipterocarp spp).,* stayed well below the AAC until 2003 after which the harvest of this category also began to increasingly exceed the downwardly regulated AAC. Figures 4 and 5 summarise the historical development in the official and estimated additional harvest as well as the AACs for teak and other hardwoods, respectively (see Springate-Baginski et al. (2016) for further details).

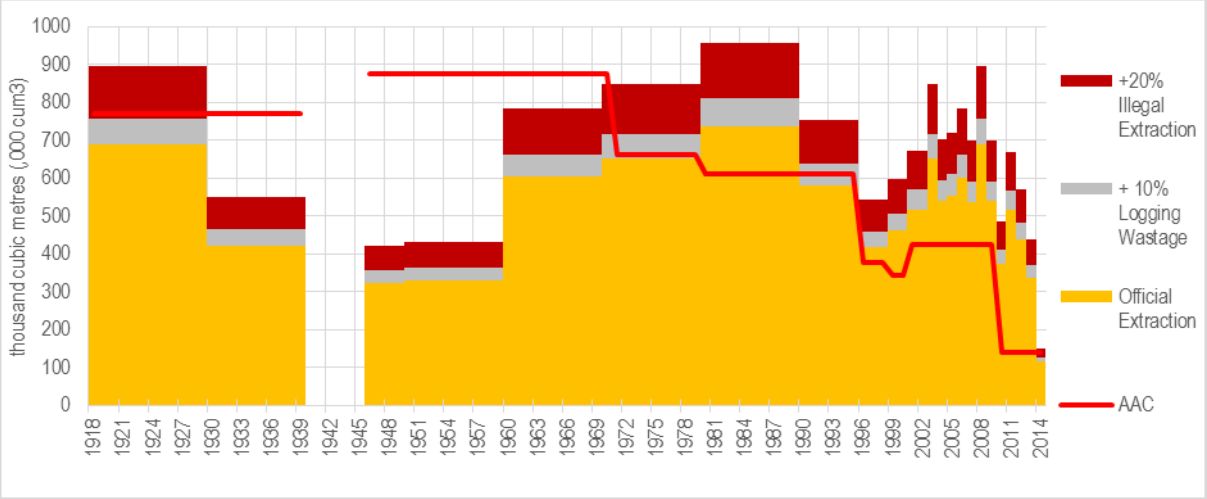


Figure 4: Teak AAC and production plus estimated wastage and estimated illegal extraction
Data: MOECAF 2011, Castrén 1999. Notes: Data is for harvesting season – so 1918 signifies the 1918-1919 season. Data unavailable for the period 1940-45; data for 2014-15 indicative only

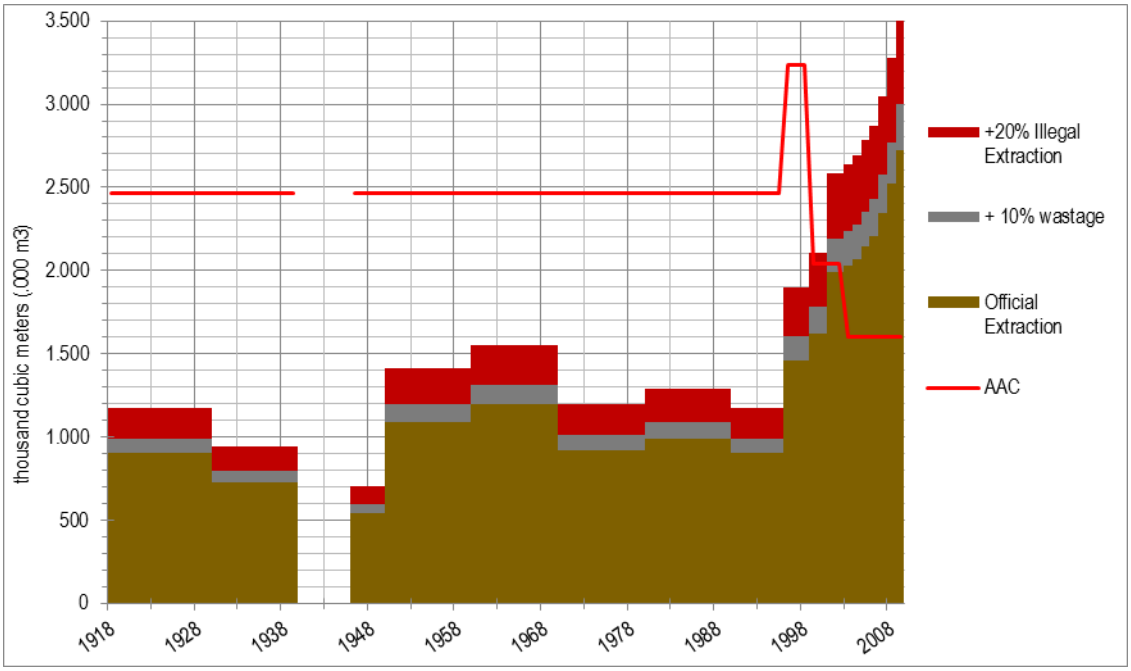


Figure 5: 'Other hardwoods': AAC, production plus wastage and estimated illegal extraction 1918-2008.
Data: MOECAF 2011. Note: Data unavailable for the period 1940-45.

Originally, the AAC was calculated from the estimated growing stock above felling limit for each Reserved Forest and summarised across districts and states/regions to yield a national figure. However, presumably to compensate for the dwindling stocks in Reserved Forests and in an effort to live up to the military governments' revenue targets, timber trees have also been marked for felling by the Forest Department in Public Protected as well as in Unclassified Forests (Springate-Baginski et al. 2016). Whether the successively revised AACs have been calculated by including areas of Public Protected and Unclassified Forests is unclear.

A more detailed account of the recent harvesting levels is offered in figures 6 - 8. It is seen that Sagaing Region has been the country's main 'timber basket' and that the recorded harvest of teak has persistently and significantly exceeded the AAC, while the recorded harvest of 'other hardwoods' has generally stayed below the AAC for this broad category of species (see Springate-Baginski et al. (2016) for further details).

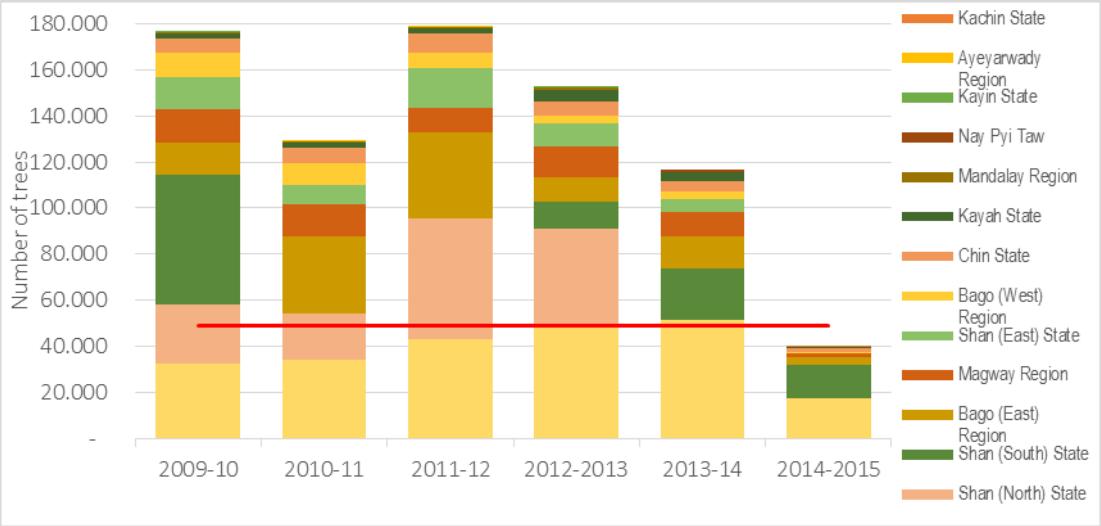


Figure 6: Teak – National aggregate AAC and Trees Marked for felling by FD for 2009-2015
Data source: MOECAF 2015 – note no wastage or illegal extraction estimates are shown.

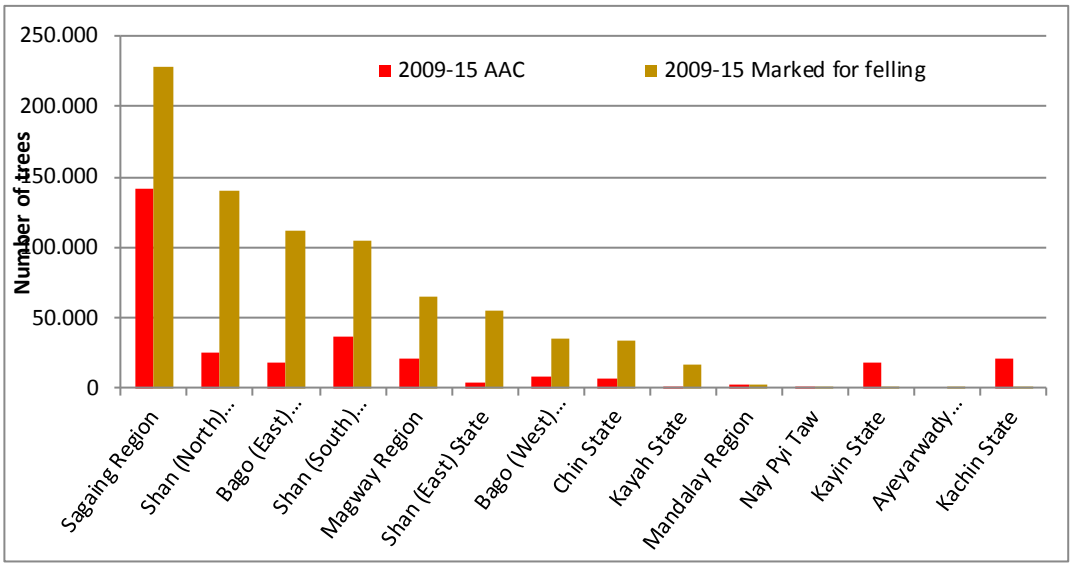


Figure 7: Teak: contrast between cumulative AACs and actual number of trees marked for felling 2009-15, by state.
(Data: MOECAF 2015)

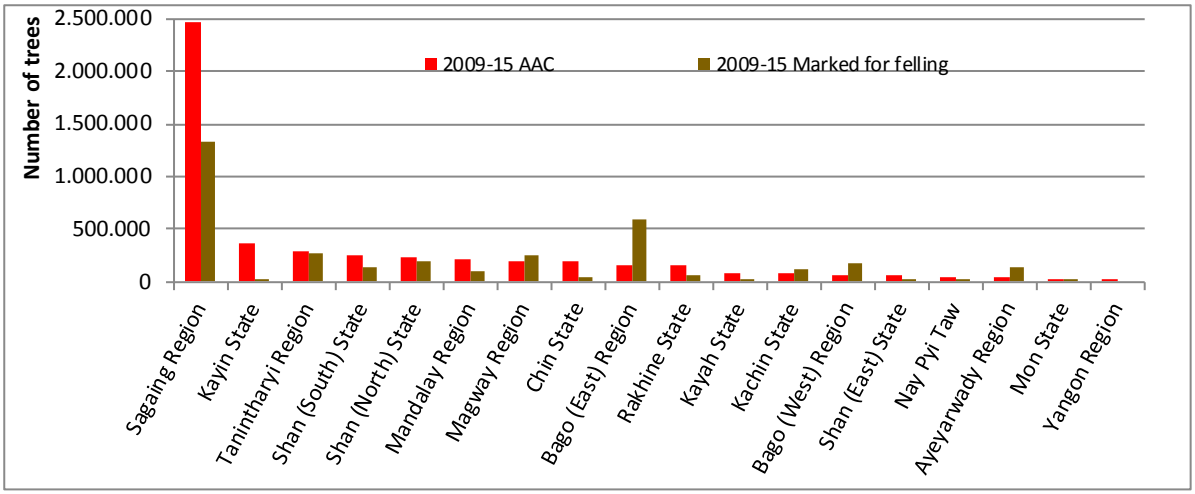


Figure 8: 'Other hardwoods' – Cumulative AACs and number of trees marked for felling 2009-15.
(Data: MOECAF 2015)

The recorded timber harvest vs. AAC data in Figures 6-8 also show that Kachin State and Tanintharyi Region play a much smaller role than Sagaing region as sources of timber. Yet as mentioned by Springate-Baginski et al. (2016), all states and regions have had to shoulder their part of the annual timber revenue target set by the military governments. The local environmental impacts of timber over-exploitation could, therefore, be severe even in regions that do not count much in the national statistics.

Given the political significance of the AAC as a proxy for the sustainable level of timber harvesting (see Glossary of terms used, below) it seems reasonable to make the underlying basis for and actual calculations of AACs by species, forest districts, and forest reserves publicly available. As indicated in Springate-Baginski et al (2016) such AACs by forest management units are actually available within in the Forest Department. Since the environmental sustainability of timber harvesting depends on the specific logging intensity in individual forests rather than the average logging intensity within a district, region, or the whole country, AACs, including how they are calculated as well as the recorded (and ideally verified) volume of timber harvested, should be made publicly available (see also below).

5. Causes of deforestation and forest degradation

As summarized by Geist and Lambin (2002) the proximate (results of direct human interventions) and underlying causes of deforestation and forest degradation are many and not all of these are necessarily illegitimate or socially undesirable although the environmental and ecological consequences are generally negative.

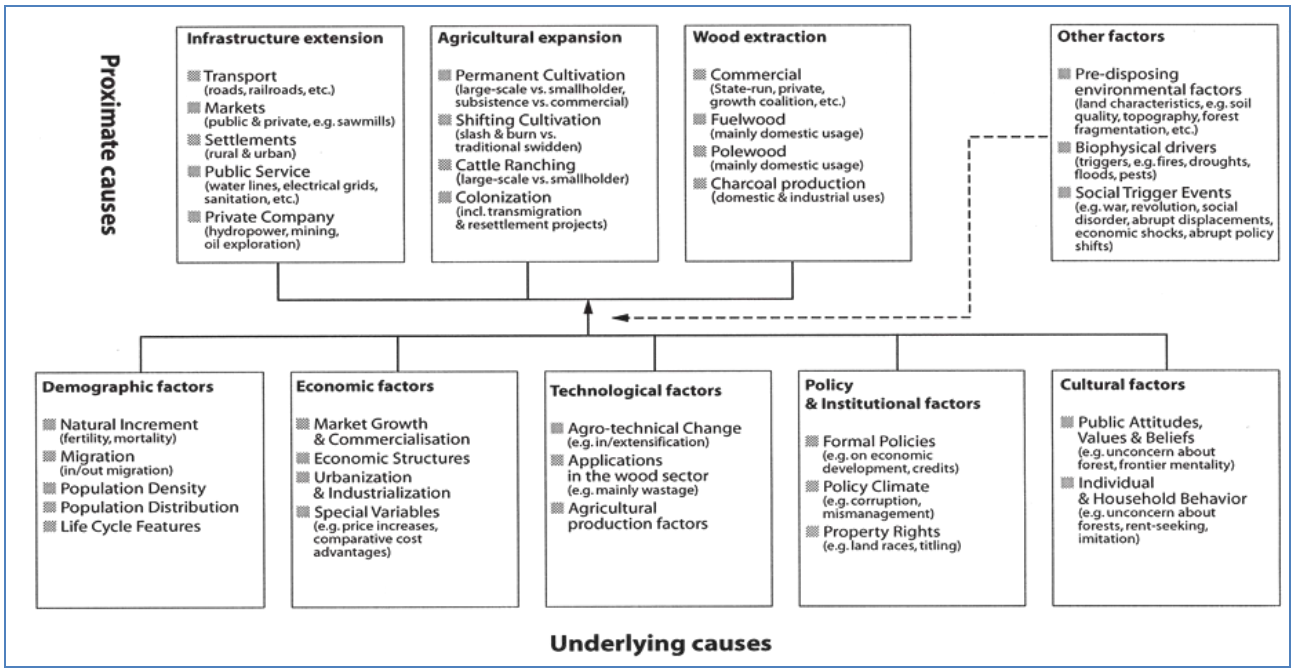


Figure 9 Proximate and underlying causes of tropical deforestation and forest degradation
Source: Geist and Lambin (2002)

Due to limitations in data availability, time, and resources this section will not attempt to cover all aspects mentioned in Figure 9 but rather concentrate on timber extraction and to some extent include conversion of forest to agriculture, plantations and mining.

5.1 Timber exploitation

In combination, the data, on forest cover status, forest cover changes, the timber harvest, and the AACs, strongly suggest that a major reason for forest degradation in Myanmar is systematic over-exploitation of Reserved as well and Public Protected Forests at the political orders of former governments. This is also supported by our field observations in forest reserves in Kachin and Sagaing where; (i) harvested logs in natural teak forests were only just above the minimum girth of 6'6" at breast height (1.3m above ground level), (ii) compartments that were cleared for teak 7-10 years ago have not been allowed to recover for the prescribed 30 years but recently re-entered for extraction of 'other hardwoods', and (iii) former mixed-species forests that had been cleared for teak and 'other hardwoods' were used for unplanned and apparently uncontrollable commercial firewood production, seemingly the final stage before permanent conversion to agriculture or plantations.

While the satellite image-based forest cover change analyses support a generalisation of our limited number of field observations, the former may actually conceal the extent of degradation as changes in species composition, e.g. from mixed teak-dipterocarp to dipterocarps only, cannot be detected by the applied technology (Landsat

images). In other words, the modest relative increase in the already large areas of degraded forest within forest reserves (Table 3) might conceal rather big changes in the composition of tree species. With present day technology the only way to know whether the composition of species and size class has changed is through time series of forest inventories. Tables 4a – 4c depicts the results of doing this for Sagaing region, Kachin state, and Tanintharyi region over the period 1996-2010.

The massive amount of raw data underlying the Tables has not been available, and unfortunately the sampling intensity within each forest area in 2010 was less than in 1996. This precludes rigorous statistical calculations of confidence intervals for the estimated number of trees within each species and girth class. Accordingly, the differences between 2010 and 1996 estimates of the growing stock should be treated with a lot of caution and *only* considered as indicative of the actual development.

Table 4a: Sagaing Region forest inventories 1996 and 2010

Sagaing Region Stand Table (1996) No of trees

Species	GBH classes					Total	Composition (%)
	From 2'0'' to 5'5''	From 5'6'' to 6'5''	From 6'6'' to7'5''	From 7'6'' to 7'11''	8' and above		
Teak	33.392.892	4.914.949	3.138.628	978.868	1.349.061	43.774.398	7,35
G1	50.533.983	4.620.805	2.425.827	1.080.032	6.981.093	65.641.740	11,02
G2	9.183.368	1.313.341	790.642	279.990	1.071.140	12.638.481	2,12
G3	97.368.888	9.738.101	6.202.355	5.961.847	10.531.335	129.802.526	21,79
G4	8.840.777	973.090	433.840	331.947	958.583	11.538.237	1,94
G5	287.279.982	15.691.501	7.256.880	4.626.303	17.416.490	332.271.156	55,78
Total	**486.599.890**	**37.251.787**	**20.248.172**	**13.258.987**	**38.307.702**	**595.666.538**	**100,00**

Sagaing Region Stand Table (2010) No of trees

Species	GBH classes					Total	Composition (%)
	From 2'0'' to 5'5''	From 5'6'' to 6'5''	From 6'6'' to7'5''	From 7'6'' to 7'11''	8' and above		
Teak	7.356.211	789.916	284.990	83.094	146.146	8.660.357	8,45
G1	6.595.792	666.555	324.744	67.234	131.875	7.786.199	7,60
G2	23.201.418	3.807.257	2.457.499	954.019	3.280.513	33.700.706	32,89
G3	15.556.876	2.125.217	843.364	141.956	487.586	19.154.999	18,69
G4	8.358.361	1.076.189	410.271	105.876	190.313	10.141.010	9,90
G5	20.485.202	1.367.372	425.190	126.891	617.261	23.021.915	22,47
Total	**81.553.861**	**9.832.505**	**4.746.056**	**1.479.070**	**4.853.694**	**102.465.186**	**100,00**

Sagaing Region Stand Table (1996-2010) No of trees

Species	GBH classes					Total	Change (%)
	From 2'0'' to 5'5''	From 5'6'' to 6'5''	From 6'6'' to7'5''	From 7'6'' to 7'11''	8' and above		
Teak	-26.036.681	-4.125.033	-2.853.638	-895.774	-1.202.915	-35.114.041	-80,22
G1	-43.938.191	-3.954.250	-2.101.083	-1.012.798	-6.849.218	-57.855.541	-88,14
G2	14.018.050	2.493.916	1.666.857	674.029	2.209.373	21.062.225	166,65
G3	-81.812.012	-7.612.884	-5.358.991	-5.819.891	-10.043.749	-110.647.527	-85,24
G4	-482.416	103.099	-23.569	-226.071	-768.270	-1.397.227	-12,11
G5	-266.794.780	-14.324.129	-6.831.690	-4.499.412	-16.799.229	-309.249.241	-93,07
Total	**-405.046.029**	**-27.419.282**	**-15.502.116**	**-11.779.917**	**-33.454.008**	**-493.201.352**	**-82,80**

* See Appendix 2 for a specification of G1-5 species known together as 'other hardwoods'.

Judging from the figures in Table 4a, teak in all size classes has been drastically reduced. This is also the case for G1, G3, G4, and G5 species while the stock of G2 species, which include the dipterocarps, seem to have increased considerably in all size classes. Biologically such an increase of especially the large size G2 species is not possible over 15 years. Accordingly, one may speculate whether species other than teak, which is easily recognisable, have been incorrectly identified during one or both rounds of inventory. Clerical errors and/or data manipulation are alternative/complementary explanations.

Table 4b: Kachin State forests inventories 1996 and 2010

Kachin State Stand Table (1996) No of trees

Species*	GBH Classes					Total	Composition (%)
	from 2'0'' to 5'5''	from 5'6'' to 6'5''	from 6'6'' to 7'5''	from 7'6'' to 7'11''	above 8'		
Teak	4.297.988	781.777	358.173	91.100	127.738	5.656.776	15,68
Gp(1)	1.717.423	175.768	82.639	20.313	27.519	2.023.662	5,61
Gp(2)	186.067	14.133	14.797	6.954	9.706	231.657	0,64
Gp(3)	4.517.239	511.996	430.647	163.068	332.109	5.955.059	16,50
Gp(4)	1.021.744	161.213	103.362	107.462	96.927	1.490.708	4,13
Gp(5)	18.197.431	1.249.041	622.426	214.282	446.529	20.729.709	57,44
Total	**29.937.892**	**2.893.928**	**1.612.044**	**603.179**	**1.040.528**	**36.087.571**	**100,00**

Kachin State Stand Table (2010) No of trees

Species*	GBH Classes					Total	Composition (%)
	from 2'0'' to 5'5''	from 5'6'' to 6'5''	from 6'6'' to 7'5''	from 7'6'' To 7'11''	above 8'		
Teak	283.704	27.185	13.797	23.406	5.995	354.087	10,40
G1	83.990	11.626	1.581	0	7.803	105.000	3,08
G2	369.828	35.290	17.281	12.258	8.810	443.467	13,02
G3	206.730	28.385	12.257	1.740	10.146	259.258	7,61
G4	121.466	28.434	20.364	1.899	2.406	174.569	5,13
G5	36.498	1.230	72	0	0	37.800	1,11
Other	1.056.519	55.067	38.839	838.704	42.698	2.031.827	59,65
Total	**2.158.735**	**187.217**	**104.191**	**878.007**	**77.858**	**3.406.008**	**100,00**

Kachin State Stand Table (1996-2010) No of trees

Species*	GBH Classes					Total	Change (%)
	from 2'0'' to 5'5''	from 5'6'' to 6'5''	from 6'6'' to 7'5''	from 7'6'' to 7'11''	above 8'		
Teak	-4.014.284	-754.592	-344.376	-67.694	-121.743	-5.302.689	-93,74
Gp(1)	-1.633.433	-164.142	-81.058	-20.313	-19.716	-1.918.662	-94,81
Gp(2)	183.761	21.157	2.484	5.304	-896	211.810	91,43
Gp(3)	-4.310.509	-483.611	-418.390	-161.328	-321.963	-5.695.801	-95,65
Gp(4)	-900.278	-132.779	-82.998	-105.563	-94.521	-1.316.139	-88,29
Gp(5)	-18.160.933	-1.247.811	-622.354	-214.282	-446.529	-20.691.909	-99,82
Total	**-28.835.676**	**-2.761.778**	**-1.546.692**	**-563.876**	**-1.005.368**	**-34.713.390**	**-96,19**

* See Appendix 2 for a specification of G1-5 species known together as 'other hardwoods'.

It is evident from Table 4b that the above mentioned development in Sagaing was mirrored in Kachin state albeit at a much lower absolute level. Again, the stock of teak, G1, G3, G4, and G5 species seems drastically reduced while that of G2 species appear to have (mysteriously) increased, albeit only in the girth classes less than 8'. In addition, the 2010 inventory included a species class named 'other'. Why this new group was included is unclear but it might be that the dwindling stock of traditional timber species has enhanced the commercial value and thus relevance of estimating the growing stock of hitherto less desirable species.

Table 4c: Tanintharyi Region forests inventories 1996 and 2010

Tanintharyi Region 1996 (No of trees)

Species*	GBH classes					Total	Composition (%)
	From 2'0'' to 5'5''	From 5'6'' to 6'5''	From 6'6'' to7'5''	From 7'6'' to 7'11''	8' and above		
Teak	0	0	0	0	0	0	0,00
G1	2.010.817	143.026	75.242	21.778	27.291	2.278.154	1,99
G2	2.502.819	150.250	120.706	0	22.694	2.796.469	2,44
G3	4.863.821	563.286	193.237	119.866	208.105	5.948.315	5,20
G4	904.312	48.269	19.701	0	25.183	997.465	0,87
G5	79.578.328	15.116.620	2.985.578	1.086.803	3.613.966	102.381.295	89,49
Total	**89.860.097**	**16.021.451**	**3.394.464**	**1.228.447**	**3.897.239**	**114.401.698**	**100,00**

Tanintharyi Region 2010 (No of trees)

Species*	GBH classes					Total	Composition (%)
	From 2'0'' to 5'5''	From 5'6'' to 6'5''	From 6'6'' to7'5''	From 7'6'' to 7'11''	8' and above		
Teak	0	0	0	0	0	0	0
G1	40.705	5.081	1.318	0	2.617	49.721	0,27
G2	1.338.605	295.824	231.093	39.149	274.849	2.179.520	11,99
G3	1.575.944	138.365	39.037	20.219	56.016	1.829.581	10,06
G4	136.267	18.674	33.431	0	39.767	228.139	1,25
G5	3.711.651	319.894	66.595	0	1.978	4.100.118	22,55
Others	8.528.537	757.070	301.229	21.281	186.187	9.794.304	53,87
Grand Total	**15.331.709**	**1.534.908**	**672.703**	**80.649**	**561.414**	**18.181.383**	**100,00**

Tanintharyi Region 1996-2010 (No of trees)

Species*	GBH classes					Total	Change (%)
	From 2'0'' to 5'5''	From 5'6'' to 6'5''	From 6'6'' to7'5''	From 7'6'' to 7'11''	8' and above		
Teak	0	0	0	0	0	0	0,00
G1	-1.970.112	-137.945	-73.924	-21.778	-24.674	-2.228.433	-97,82
G2	-1.164.214	145.574	110.387	39.149	252.155	-616.949	-22,06
G3	-3.287.877	-424.921	-154.200	-99.647	-152.089	-4.118.734	-69,24
G4	-768.045	-29.595	13.730	0	14.584	-769.326	-77,13
G5	-75.866.677	-14.796.726	-2.918.983	-1.086.803	-3.611.988	-98.281.177	-96,00
Total	**-83.056.925**	**-15.243.613**	**-3.022.990**	**-1.169.079**	**-3.522.012**	**-106.014.619**	**-92,67**

* See Appendix 2 for a specification of G1-5 species known together as 'other hardwoods'.

As Table 4c shows, Tanintharyi region differs substantially from Sagaing region and Kachin state. Here, teak is entirely absent as it was logged out during the early phases of British colonisation. Furthermore, the overall growing stock of all species groups appears to have been reduced. This stated, the estimated growing stock of G2 species above 5'5" girth has also (mysteriously) increased in this region.

To sum up, the available bio-physical evidence (satellite image analyses), data on official timber exploitation, forest inventory data, and our field observations all suggest that teak has been systematically as well as severely overharvested. Further, our interview-based information strongly suggests that the primary underlying reason has been top-down political pressure to generate export revenue. In addition to the official teak harvest, unknown and largely unrecorded but undoubtedly very large, volumes of teak are harvested to supply Myanmar's sizeable domestic market and for unaccounted export. The picture for 'other hardwoods' is less clear-cut. While some very valuable species like Padauk (*Pterocarpus macrocarpus*), and especially Tamalan (*Dalbergia oliveri*), both belonging to the G1 group, are likely to be severely overharvested, other more abundant species like Kanyin (*Dipterocarpus spp.*), which belong to the G2 group, seem only to have become over-harvested in the most recent years, or not overharvested at all (Figures 5 and 7).

Overall, however, the nationally aggregate data on growing stock, AACs and recorded extraction levels are too coarse to offer sufficiently meaningful information on the sustainability of past and present timber harvesting levels. Today, standardised IT technology offer hard and software solutions that would allow for electronic recording (on tablets) and immediate processing as well as centralized storage and sharing (through the cell phone network and standardised algorithms) of forest inventory data.

Accordingly, for every forest, the estimated growing stock including statistically sound 95% confidence intervals could be specified at species and girth class levels. AACs might then be calculated for each and every harvested species instead of only for teak and 'other hardwoods' and an IT-based recording of the actual harvest, e.g. when logs are measured and hammer-marked before being transported to depots for auctioning, would allow for sustainability assessments at species level for each and every forest. Yet such technical upgrading of the level and quality of forest inventory and harvesting data is unlikely to be adequately and wholeheartedly implemented by the Forest Department and the Myanmar Timber Enterprise unless it forms part of a wider reform process, which changes the current political ecology and economy of deforestation and forest degradation towards an incentive structure that promotes sustainable and equitable forest utilisation.

As outlined in some detail by Springate-Baginski et al (2016), it is likely that the combination of (i) top-down political pressure, (ii) political patronage by military governments of certain timber companies, (iii) insufficient official salary levels within the Forest Department and Myanmar Timber Enterprise, (iv) an administrative culture that blocks or limits information sharing with the public to a minimum, (v) a criminalised and largely unregulated supply of timber to the domestic market, and (vi) a general lack of rule of law, form the underlying reasons for a host of illicit practices and non-compliance in the timber sector that a sector reform would need to address to counter forest degradation and deforestation. In addition, political and economic structures outside the forestry sector, which promote conversion of forest to other land-uses, need to be addressed (see below).

5.2 Conversion to agriculture, plantation and mining

As indicated, conversion of forested areas to non-forest is significant and widespread across Myanmar, both outside and within forest reserves. During the process of satellite image analyses it became clear that areas of non-forest included large areas of mining. Since time and resource constraints prohibited a national-level analysis, areas of mining were identified in Kachin state, and Sagaing region, only. In addition, further analyses were made in Tanintharyi region to distinguish between different kinds of plantation. Table 5 and Maps 4-6 summarise the results and changes from 2002 to 2014 (se also Bhagwat et al. (2016)).

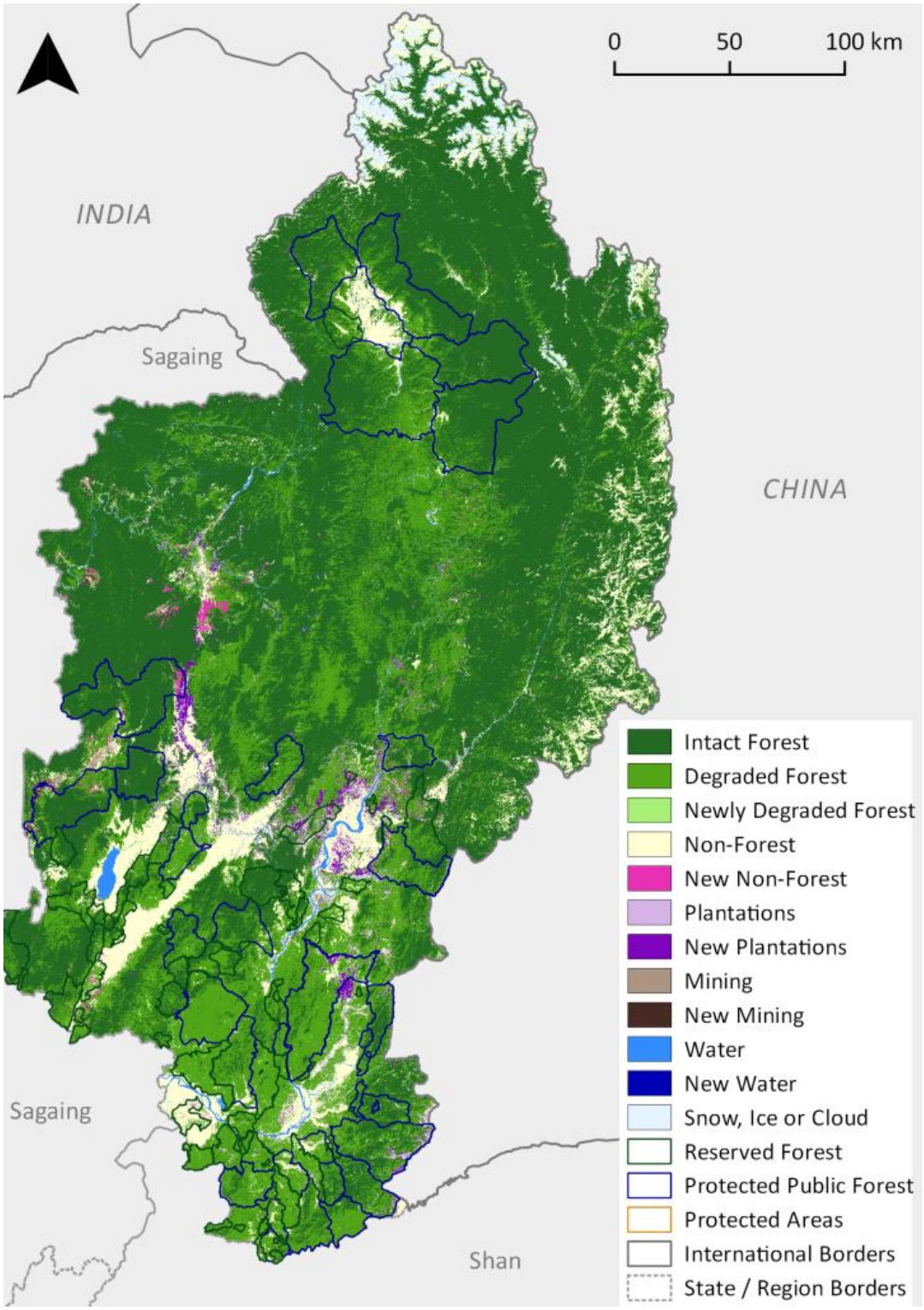
Table 5: Land cover types in Kachin, Sagaing and Tanintharyi 2002 and 2014

	2002	2014	change in ha	change in %
Kachin state				
Intact forest	5.341.463	5.132.416	-209.047	-3,91
Degraded forest	2.355.689	2.423.322	67.633	2,87
Non-Forest	877.977	926.373	48.396	5,51
Plantation	109.291	183.622	74.331	68,01
Mining	12.736	30.778	18.042	141,66
Water	90.964	91.609	645	0,71
Snow/Ice	108.684	108.684	0	0,00
Total	8.896.804	8.896.804		
Forest	7.697.152	7.555.738		
Sagaing region				
Intact forest	3.471.532	3.191.671	-279.861	-8,06
Degraded forest	2.648.527	2.747.481	98.954	3,74
Non-Forest	3.115.864	3.225.838	109.974	3,53
Plantation	24.126	42.370	18.244	75,62
Mining	7.082	59.742	52.660	743,58
Water	119.608	119.637	29	0,02
Snow/Ice	0	0	0	0,00
Total	9.386.739	9.386.739		
Forest	6.120.059	5.939.152		
Tanintharyi region				
Intact forest	2.487.026	2.301.074	-185.952	-7,48
Degraded forest	1.159.375	1.234.686	75.311	6,50
Non-Forest	280.728	315.929	35.201	12,54
Plantation	56.311	90.047	33.736	59,91
Oil Palm Plantation	40.923	82.627	41.704	101,91
Water	67.535	67.535	0	0,00
Snow/Ice	0	0	0	0,00
Total	4.091.898	4.091.898		
Forest	3.646.401	3.535.760		

Source: Bhagwat et al. (2016)

In Kachin state, plantations (mostly rubber) have increased by 74,000 ha, or 68.0%, while in comparison non-forest (presumably mostly agriculture) has increased by only 48,000 ha, equalling 5.5%, and the area of mining has increased by 18,000 ha, which in relative terms amounts to 141.7%. As discussed, new non-forest and new plantations are established primarily as extensions of existing agriculture and plantations along rivers on the edge of degraded and intact forest areas. Woods (2015) concludes that some deforestation is driven by agribusiness development controlled by local political elites and/or various armed ethnic groups, often in collaboration with Chinese investors, who facilitate the export of crops to the Yunnan province, and to some extent supported by China's opium substitution programme. Plantations are established in accordance with largely similar financial rationales. Furthermore, Woods (2015) find several overlapping and conflicting land claims involving forest reserves within which large areas for agribusiness appear to have been granted. The mines are concentrated along the main rivers in the south western part of the state (Map 4). The specific nature of these surface mines is unknown but their rapid growth and geographical location, together with inspections of recent high resolution

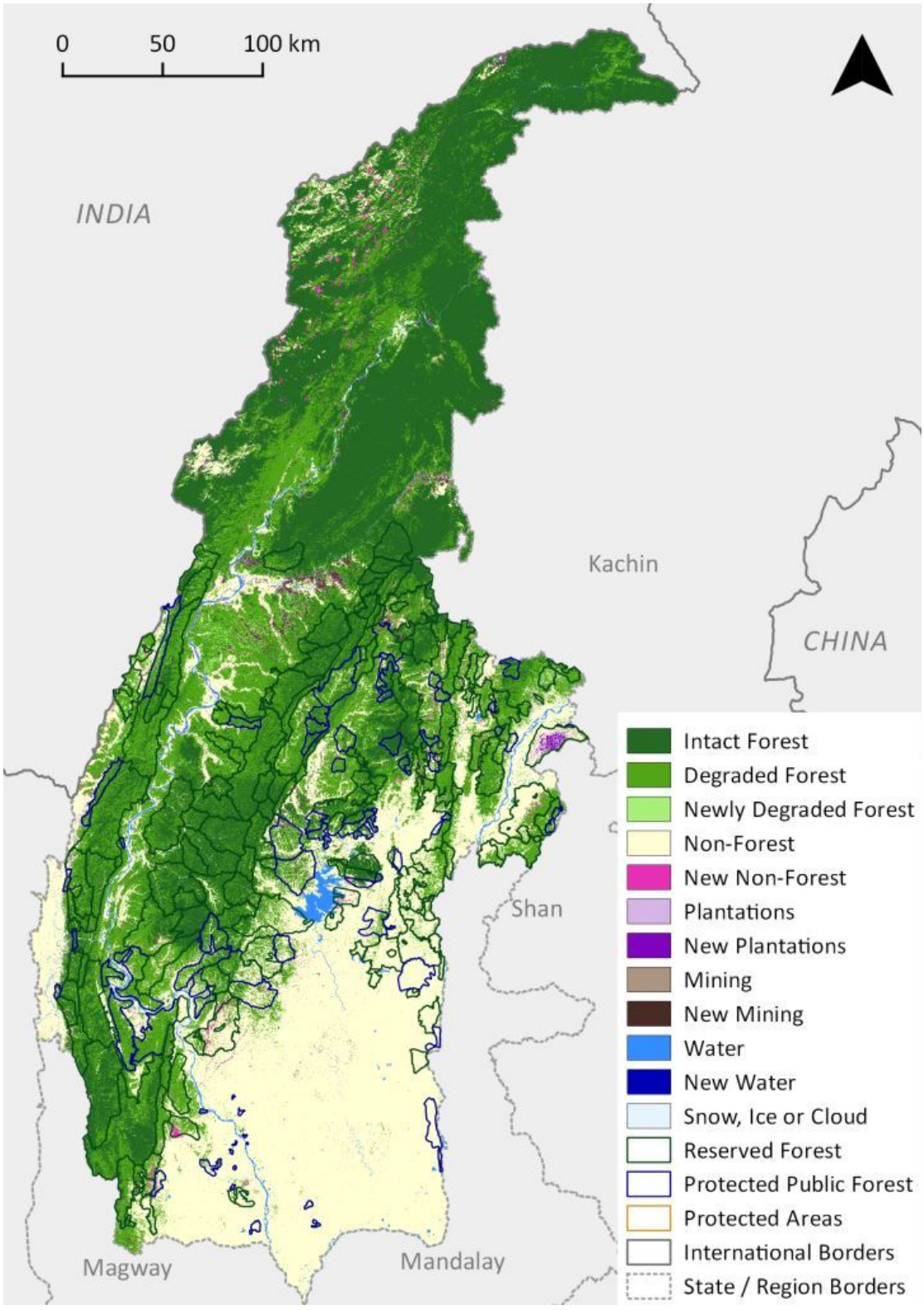
satellite images, suggests that the negative environmental impact on affected river systems could be extremely severe.



Map 4: Kachin state 2014 land cover including 2002-14 changes
Source: EcoDev/ALARM

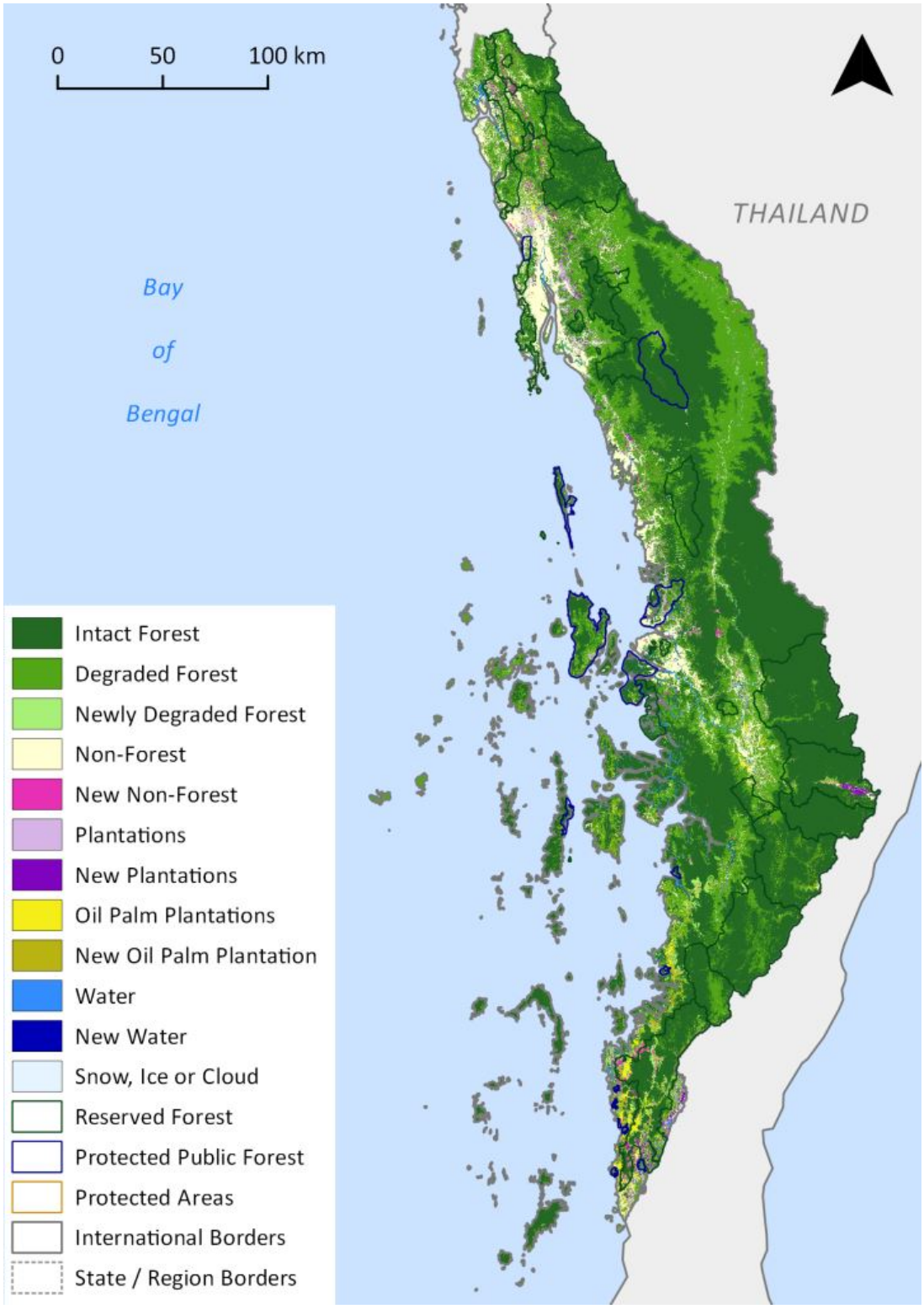
In Sagaing region, we see a similar kind of development with a modest (3.5%) expansion of the already large agricultural area, a rapid expansion of plantations (75.6%) and an explosive increase of mining by 743.6% from 7,000 to almost 60,000 ha. The expansion of mining takes place along the major rivers outside forest reserves and protected areas in the north western part of this region. By contrast, the expansion of agriculture and plantations

is concentrated *within* a few Reserved and Public Protected Forests (Map 5). Contrary to Kachin state and Tanintharyi region, Sagaing region is not an armed conflict area. Military tactics are thus an unlikely reason for the conversion of forest reserves to other land-uses and further ground-truthing is needed to establish the actual underlying reasons and rationales.



Map 5: Sagaing Region 2014 land cover including 2002-14 changes
Source: EcoDev/ALARM

In Tanintharyi region, the relative expansion by 12.5% (from 280,000 to 316,000 ha) of non-forest has been three to four times that of Kachin and Sagaing. However, with reference to Woods (2015), a significant part of this could be the result of commercial timber exploitation in areas officially allocated for plantations that were never fully established. The most rapid relative expansion has nevertheless been in the area of established oil palms (101.9%, from 41,000 to 83,000 ha) followed by 'plantation', a large share of which is betel nut palms, the area of which has increased by 59.9% from 56,000 to 90,000 ha.



Map 6: Tanintharyi Region 2014 land cover including 2002-14 changes
Source: EcoDev/ALARM

The new non-forest and new non-oil palm plantations tend to be extensions of existing agricultural and plantation areas along rivers and main roads mostly outside forest reserves. New and existing oil palm plantations are concentrated in the southern part of the region and in the extreme south along the coast and on costal islands, mainly outside forest reserves. Woods (2015) and our field visit observations suggest that large scale agribusinesses rather than smallholders are behind the conversion of forest to other land uses. Furthermore, Woods (2015) documents that very large land areas in Tanintharyi are subject to overlapping land-use claims as plantation concessions appear to have been allocated within existing or proposed forest reserves and protected areas thus raising doubts about their actual legal status and thus about the political commitment to forest conservation. In this respect it is well established that at least the former military government has deliberately used plantation concessions and associated forest clearings as a strategy to enrich supporters and expand control over territory in the armed conflict with the Karen National Union (e.g. Woods, 2015 and Gravers and Ytzen, 2014). Finally, our field visits confirm that mining is also a cause of deforestation in Tanintharyi region its extent and development remains unknown until high resolution satellite image analyses have been conducted.

In sum, agricultural expansion (new non-forest) has in absolute as well as relative terms been the biggest cause of deforestation over the period 2002-14. The largest expansion of non-forest has taken place outside forest reserves. Yet inside forest reserves this has *also* been the main cause of deforestation. As Table 3 shows, the loss, in relative terms, of intact forest from forest reserves almost equals the relative loss of intact forest outside forest reserves. Furthermore, the relative increase in the area of non-forest inside forest reserves (9.1%) is much higher than that outside forest reserves (4.1%). In total, the area of non-forest inside forest reserves is today around 2.6 million ha and many reserves are either entirely or partly cleared (Map 3). Many forest reserves seem to be in different stages of a process that begins with several rounds of official timber extraction followed by unofficial timber and firewood extraction after which agriculture or plantations become permanent. Disturbingly, the area of plantations inside forest reserves has, in relative terms, increased as rapidly as outside forest reserves and several forest reserves have, lawfully or not, been almost wholly converted to plantations. In Kachin state and Tanintharyi region, the conversion of reserves to agriculture and/or plantations have formed part of military tactics/strategies of territorial control and revenue generation. Furthermore, huge areas are, according to Woods (2015), characterised by overlapping and competing land-use claims. Mining appears the most recent and fastest increasing cause of deforestation and although this appears to take place mainly outside forest reserves in Kachin State and Sagaing region (national-level analyses are still to be completed), their negative environmental impact on river systems could be devastating.

6. Conclusion and recommendations

As indicated, this report should be considered together with Bhagwat et al. (2016) and Springate-Baginski et al. (2016) including these two reports' recommendations. The main additional contribution of the present report is that it distinguishes between deforestation and forest degradation inside vs. outside forest reserves and protected areas, and links this to the apparent dominant features of the underlying political economy that drives land cover and land-use changes within these two broad tenure categories.

Over the period 2002-14, Myanmar lost a total of 2.07 million ha or 11.3% of its intact forest. Approximately two thirds of this was lost from non-reserved areas. However in relative terms, the loss of intact forest was almost as high inside forest reserves (10.3%) as that of non-reserved areas (11.7%) while this loss was 'only' 0.09 million ha or 2.3% within protected areas (national parks, wildlife sanctuaries and the like). Overall, the area of degraded forest has increased by 1.8% (0.47 million ha), distributed as 2.0%, 1.4%, and 1.8% increases within non-reserved, forest reserves, and protected areas, respectively. Non-forest areas increased by an overall 4.7% (0.99 million ha), which was distributed as 4.1%, 9.1%, and 11.6% increases within non-reserved, forest reserves, and protected areas, respectively. The national area of plantations increased by a dramatic 58.4% (0.54 million ha), which was distributed as 58.6%, 57.8%, and 95.7% increases within non-reserved, forest reserves, and protected areas, respectively. As a result of hydro dam constructions, the total area of waterbodies increased by 9.27% (0.73 million ha), which was distributed as 3.0%, 61.9%, and 3.7% increases within non-reserved, forest reserves, and protected areas, respectively.

By 2014, forest reserves carried only 27.0% intact forest while degraded forest accounted for 55.2%, non-forest 14.9%, plantations 2.1%, and water bodies 0.8%. Protected areas, by contrast, are covered by 68.8% intact forest, 20.5% degraded forest, 6.8% non-forest, 1.1% plantation, 1.2% waterbodies, and 1.5% snow. Accordingly, it must be concluded that while intact forest and the general forest cover has been comparatively well-conserved within protected areas, forest reserves have in general been as poorly conserved as unreserved areas. Accordingly forest reserves are now generally exhausted and most of these are dominated by degraded forest while many carry no trees at all or exhibit large areas of non-forest.

Despite the general trend of deforestation and forest degradation in non-reserved areas and within forest reserves, large tracts of continuous intact forest are still found in remote parts of particularly Kachin state and Tanintharyi region. Apparently, the conflict between the central state and armed ethnic groups in these two regions, which, among others, have resulted in slower infrastructural development, seem to be the main underlying reasons why these forests have remained intact. In all parts of the country, deforestation and conversion of forest to other land-uses appears driven by rationales of maximising the financial returns as this happens most intensively along rivers streams, major roads, and land borders to neighbouring countries, particularly China and India.

Inside forest reserves, excessive timber extraction primarily of teak but presumably also other high value species seems to be the major underlying driver of forest degradation. This is supported by data on recorded harvest vs. estimated annual allowable cuts as well as time series of forest inventory data, which point to a systematic and long-term overharvesting of teak while the aggregate group of 'other hardwoods' appear less or not overharvested although highly valuable species like rosewood (*Dalbergia oliveri*) within this category are clearly over-utilised. This failure of the Forest Department to live up to its primary responsibility is, however, no great mystery. The underlying reasons might be summarised as follows (see also Springate-Baginski et al. (2016)):

1. Systematic 'revenue-target' driven over-extraction at the orders of successive central governments. Formally this was mainly legal extraction, but substantial illicit practices as well as high wastage have occurred under political favouritism in relation to Myanmar Timber Enterprise and 'crony' subcontractor companies.
2. Expansion of agriculture and 'land grab' agri-business concessions into forests.
3. A disempowered and somewhat demoralised Forest Department with inadequate staffing, monitoring capacity, enforcement powers, and inadequate salary necessitating petty corruption.
4. Unregulated and partly criminalised domestic timber and wood extraction without an effective management or regulatory regime.
5. Insecure land and tree tenure for local people, marginalising civil society and undermining incentives to conserve, protect and plant trees, and to work with the Forest Department to do so.
6. A conflict economy in many upland areas bordering neighbouring countries provoked and maintained by Union Military, allowing them to indulge in illegal timber trading and taxation (amongst other sectors) for personal gain

This vicious spiral of forest degradation is summarised in in Figure 10

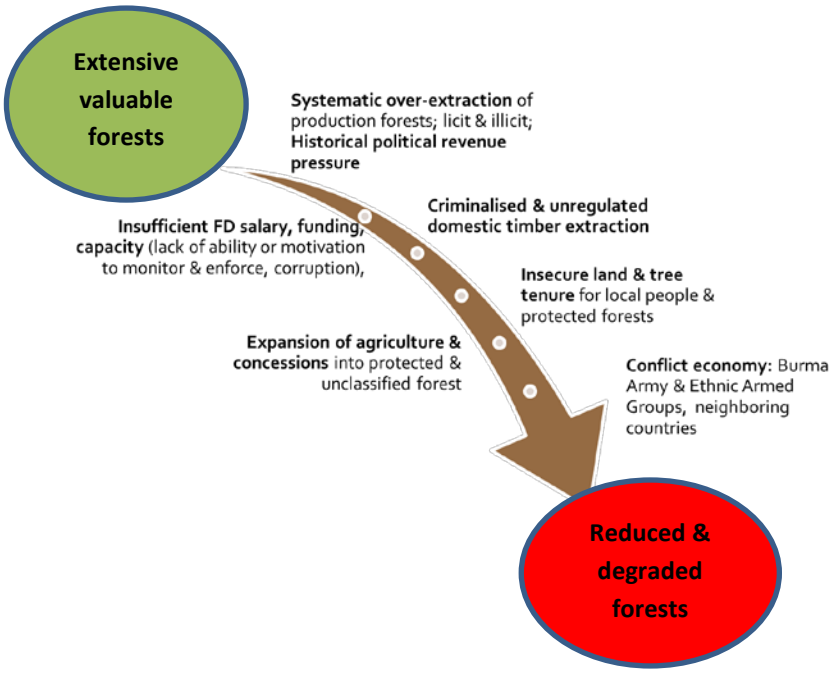


Figure 10 Political economy of forest and timber decline

To reverse the spiral of forest degradation and deforestation, several interrelated steps must be taken. It would be important to focus on how the political economy/ecology can be fundamentally changed. New technology like satellite images, tablets for data collection, and standard algorithms for meaningful data processing should become tools in the process but they should not be confused with 'technical fixes'. Political commitment and continued support from the top will be needed to actually reform the sector. Figure 11 summarises the proposed main elements of such a sector reform.

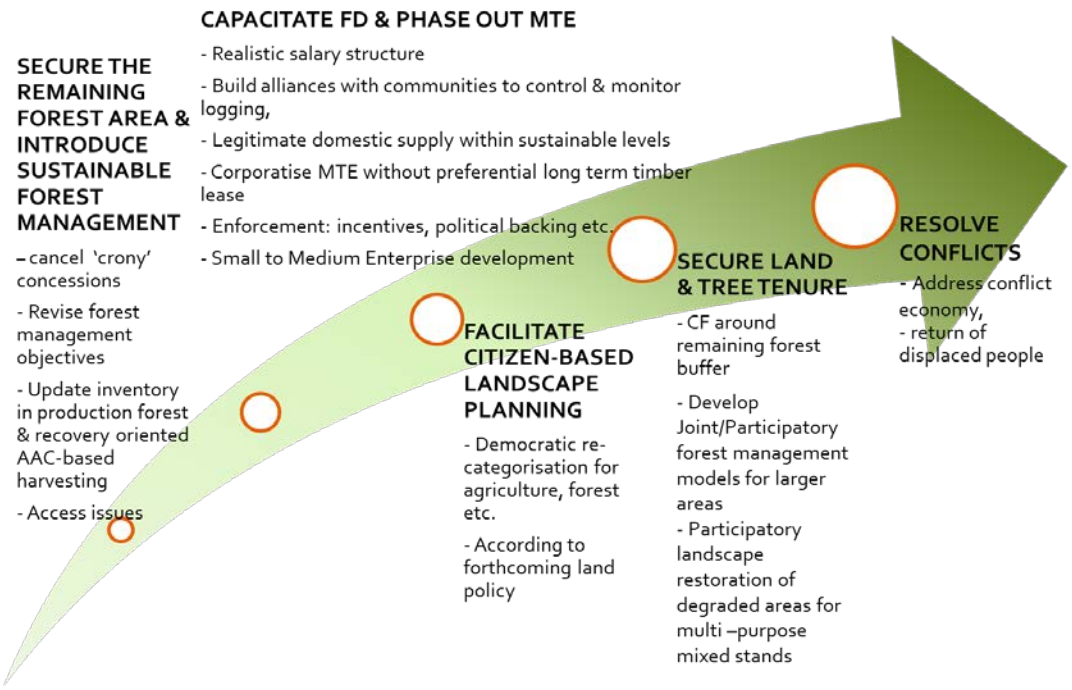


Figure 11 Reform agenda for forest stabilisation and recovery

Secure and assess the remaining forest areas, gazette remaining unclassified forests as appropriate, review existing concessions, stop any further land use change away from forest, and update inventory data for forests with apparent timber production potential. This overall re-assessment of the nation's forest cover within and outside current forest reserves and protected areas as well as an updating of the management objectives and management approaches would involve the following:

- A detailed review of the forest condition within and outside existing forest reserves and protected areas
- Securing of the remaining large tracts of intact but unclassified forest through gazetting these with due consideration to the livelihoods and interests of local communities as well as objectives of nature conservation
- Based on the actual forest condition within forest reserves, clarify and as necessary re-define their current multi-purpose management objectives, i.e. revisit the relative importance of timber production, provision of subsistence as well as commercial non-timber products for local livelihoods, biodiversity conservation, and ecosystem services. A possible de-gazetting of entire forest reserves or parts of these where there are no trees must to take the needs and interests of local people into account so as to prevent possible forced eviction of many small holders in favour of e.g. large scale agribusiness investments
- Review and resolve issues of land concessions that overlap with current forest reserves and protected areas as well as with areas that should be included in the permanent forest estate.
- Secure land tenure of communities and citizens around areas designated for permanent forest cover
- Update inventories in timber production forests through the use of new technology and standard statistical methods to allow for scientifically sound estimates of AACs by species and for monitoring of the forest condition through time series of inventories.

Timber Extraction and Sustainable Forest Management: Introduce sustainable forest management in collaboration with local communities. Much of the forest should be treated as 'logged-out' and allowed to recover for many years ahead. A shift to long term forest recovery and restoration for multiple environmental and social benefits needs to be the overriding forest sector policy. This would involve:

- A closing of degraded areas for logging while less devastated areas are lowed to improve through harvesting intensities well below the estimated current regeneration level

- That timber harvest is planned and implemented according to 'bottom-up' and technically sound site level plans that the Forest Department prepares independent of political/revenue pressures but in collaboration with local communities (see below)
- A moratorium of timber harvesting in absence of a management plan context, e.g. in Public Protected and Unclassified Forests
- A commitment not to transfer timber harvesting on an ad hoc basis when political conflict between the central state and ethnic groups obstructs otherwise planned harvesting
- A promotion of minimum damage on remaining forest stands through enforcement and possible updating of rules on reduced impact logging and minimal road construction

Regulatory capacity: Capacitate the Forest Department to be 'fit for purpose' and phase out the Dictatorship-era Myanmar Timber Enterprise. This would involve a:
- Capacitation of the Forest Department with proper funding, salary structure, and resources to develop and enforce sustainable forest management planning.
- Corporatization / phasing out of Myanmar Timber Enterprise's current position and establish transparent non-preferential logging concession tenders
- Empower Forest Department enforcement in relation to Myanmar Timber Enterprise and subcontractors infractions
- Building of alliances between the Forest Department and civil society to strengthen monitoring, regulation and enforcement. This must involve a development of mechanisms through which civil society organisations including local communities will actually benefit from improved conservation of production forests

Corruption, Compliance and Rule of Law: Enforce rule of law; rules and guidelines, assure transparency and introduce third party monitoring of logging, transport and export of timber and wood products. This would involve:
- That culpability of illegal logging is established and rules actually enforced, starting with the largest culprits.
- That bribe taking is considered a criminal act to reverse the current culture of tolerance of corruption within the Forest Department
- That Forest Department staff have dignified salaries and adequately punished for irregularities
- That logging subcontracts are scrutinised and irregularities punished.
- That transparency of land and timber allocation systems is introduced in a way that is possible for civil society to understand
- That credible independent third party civil society monitoring is promoted as part of a democratic governance system within and around forests

Facilitate citizen-led multi-stakeholder landscape planning and build multi-stakeholder alliances between citizens, public servants and private sector enterprises. This would involve:
- That logging operators become guests under the manager (Forest Department) instead of long term licensees holding exclusive timber rights.
- A conservation of remaining 'good' forest for nature conservation, ecosystem services and provision of livelihood benefits to local communities
- A restoration of natural forest areas to mixed species timber plantation through new management arrangements that involve and secure local communities a fair share of the timber revenue as well as rights to livelihood forest benefits.
- A containment of agri-business plantations
- Legal provision for ownership of products from private and community timber including teak

Domestic timber supply: Promote a sustainable timber supply - through secure private / community land and tree tenure and fair marketing conditions. This would involve the establishment of a regulated basis for domestic timber supply through:
- Facilitation of citizen-based landscape management planning, where local communities get meaningful and enforceable rights to local forest resources and revenues from these through fair marketing and taxation rules
- Promotion of Community Forestry and other Participatory Co-Management models for larger forest areas

From conflict economy to peace dividend: Resolve political conflicts in ethnic areas equitably through democratic decentralisation. In relation to forestry and other land-uses this would involve that conflicts are equitably resolved through ceasefire process in which military business interests are cancelled. Furthermore this should:

- Facilitate a return of displaced people
- Introduce devolved forest governance in ethnic areas
- Agreements with neighbouring countries to introduce border checkpoints and joint enforcement of Myanmar laws on wood exports such as the ban on export of logs.

Surface mining is, in addition to the above mentioned mechanisms of deforestation and forest degradation, a recent and seemingly very rapidly expanding phenomenon. National-level data is still wanting, but analyses of Kachin state and Sagaing region document that, over the period 2002-14, the area of mines increased by 141.7% and 743.6%, respectively. These mines are mainly established outside forest reserves and protected areas. Yet their location along main rivers and tributaries of these suggest that the main concern should be their impact on water quality and hence food-chains, which might be very severe. Accordingly, a national-level assessment of mines combined with a ground-truthing of their environmental impact is urgently needed such that this potentially out-of-control sector can be environmentally regulated.

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Glossary of Terms used

Annual Allowable Cut (AAC): The amount of timber extraction which the Forest Department estimates is within sustained yield levels. The AAC is difficult to precisely gauge as it requires detailed inventory of the growing stock in the forest, and also accurate prediction for growth rates over time, both of which are hard to know reliably. Normally the AAC is also founded on the aim of maintaining the forest in its initial condition (which may already be degraded) rather than improving or degrading the condition, i.e. an enforced AAC below/above the actual annual growth would over time increase/decrease the growing stock. Accordingly it is a political decision whether the AAC aims at maintaining, increasing, or decreasing the growing stock. Yet the general, but rarely spelled out, understanding of the AAC is that is it the Forestry Department's and forester's basic planning tool for identifying the maximum level of sustainable extraction in a given forest area. If actual extraction exceeds this level, the growing stock declines and the AAC in subsequent years must also decline to prevent further degradation. Hence a successively declining AAC is an unambiguous indicator of unsustainable harvesting in the past, assuming the calculation method is stable.

Border Guard Forces (BGF): Dissident Ethnic Armed Groups in border areas which have made bilateral peace agreements with the Tatmadaw Union Military in return for control of their territories. There seems to be a 'divide and conquer' strategy to co-opt factions of Ethnic Armed Groups.

Chain of Custody (CoC): The control of logs and timer between felling and market. A safe CoC allows exporters and buyers to be confident there has not been illegality or corruption, and that shipments do not contain unaccounted timber.

Community Forest (CF): The control management and use of forests by local people. Community Forestry has been a worldwide policy process for post-colonial reform of colonial appropriation of village common property. In Myanmar CF was introduced with the 1995 CF Instruction. CF has spread slowly so far, due to a range of factors: for the villagers the deal can be somewhat unattractive as relations with under-paid government staff normally involve the expectation of bribes. Additionally the effort to establish the management has attracted limited interest from forest department staff.

Forest Law Enforcement, Governance and Trade (FLEGT): a policy initiative of the European Union which seeks to ensure timber traded in the EU has not been supplied illegally. To comply with rules agreed under the World Trade Organisation, this requires bilateral voluntary partnership agreements (VPAs, see below) with timber exporting countries.

Forest Management Unit (FMU): The administrative unit for forest department. FMUs are approximate to districts but can vary and are not aligned, even crossing state boundaries.

General Administration Department (GAD): Established in 1957 under Ministry of Home Affairs which came under formal military control due to the 2008 Constitution, the GAD oversees main bureaucratic activities: tax collection, land registration and management. In practice it is one of the main mechanisms through which the Military permeate and control government at all levels, and its overhaul is a high priority for democrats.

Hammer marking: The traditional method for marking trees to be felled or logs once felled. A 'hammer' with code letters and numbers is imprinted on a debarked section of the tree base (marking for felling) or at timber bole ends (marking for transportation and to indicate entry into felling records).

Harvesting Guidelines: MOECAF guidelines to appropriate methods for extraction of timber (to minimise damage and hence facilitate recovery/productivity of the remaining forest stands

International Timber Trade Association (ITTO): Based in Japan the ITTO monitors the international timber trade, shares information and promotes the timber industry's commercial interests.

Log Export Ban (LEB): Introduced in spring 2014 by MOECAF. It prohibited legal export of unprocessed logs

Modified Procedure (MP): In conflict areas where the Union Forest Department staff would be at risk subcontractors are permitted to enter the forest at their own risk (or more realistically with their own negotiation with ethnic armed groups), and extract timber within estimated sustainable harvesting levels. The harvest is then accounted at a depot outside of the conflict area. The system has been vulnerable to abuse, and has finally been discontinued in 2015.

Ministry of Environment Conservation and Forestry (MOECAF): The responsible bureaucratic organisation for the management of Myanmar's 'Permanent Forest Estate' (see below). Within MOECAF resides the Forest Department; Nature Wildlife Conservation Division; Myanmar Timber Enterprise.

Myanmar Timber Enterprise (MTE): The state agency for extracting and marketing of timber.

Myanmar Timber Merchants Association (MTMA): The state convened association which timber merchants are obliged to register with.

Myanmar Selection System (MSS): The silvicultural system, originally developed by Brandis for application in Myanmar. It involves selection of specific larger timber bearing trees for harvesting without clearing the whole stand. Compartments in production forests where timber extraction has not taken place for at least 30 years (the felling cycle) are subjected to a 100% stock survey during which only trees above the species specific minimum girth limit are marked for felling by Forest Department staff. This is done by slashing bark off at the base of such trees after which a Forest Department hammer mark is applied. The marking of trees stops when the AAC for that particular forest has been reached. It follows that the sustainability of the system depends on whether the duration of the felling cycle allows for enough trees below the minimum girth limit to replace the ones harvested. In turn the number and survival rate of trees just below the minimum girth depends on a compartment's logging history, the composition of species (which may be altered due to logging interventions) and the level of damage to the remaining stock during logging operations.

Permanent Forest Estate (PFE): Areas of originally and intended forested landscapes, which nations reserve to be covered by forest in perpetuity. The PFE fall under three main categories: Reserved Forest, Public Protected Forest, or Protected Area (for biodiversity conservation)

Public Protected Forest (PPF): Areas of forested landscapes containing lower value timber stands or that have not yet gone through the reservation process for other reasons. These are allocated for domestic supply, although timber is also extracted by the state (MTE) and its agents.

Reserved Forest (RF): Areas of forest landscape reserved by the government as they contained higher value timber stands at that time, and were allocated for state timber production under a Forest Management plan.

Timber Legality Assurance System (TLAS): A system to verify that the timber value chain does not contravene laws, and therefore that timber offered on the market is fully legal.

Unclassified Forest (UF): Areas of forests not yet reserved by the Forest Department, and therefore by default under the Ministry of Agriculture and Irrigation, which classify them as 'Virgin Fallow and Vacant Land (VFV) areas, suitable for conversion to other land use such as plantation.

Virgin Fallow and Virgin land (VFV): The Ministry of Agriculture and Irrigation's classification for what the Forest Department consider 'Unclassified Forest'. Although millions of rural people use VFV land for agriculture and agroforestry, without tenure security, the land can be allocated for other purposes. Therefore they are vulnerable to destitution and food insecurity.

Voluntary Partnership Agreement (VPA): a bi-lateral agreement between the EU and timber exporting countries. The main policy instrument for FLEGT. The VPA process involves verifying the timber value chain is free from illegality and corruption. Further, it insists that the criteria for legality as well as the mechanisms for monitoring, reporting and verifying their actual implementation are mutually agreed upon between the government, the timber sector and civil society.

Note on timber statistics: several different units are used for timber and extraction levels: tree, log, hoppus tonne, cubic tonne, cubic meter and so on. Conversion factors are approximate as each tree, log and cubic meter has

different size and density, and size of trees is generally declining over time. Logs are also differentiated by sawing grade, so that sawing grade 1 is the best quality, and SG 8 the worst.

Appendix1. Land cover change matrices by States and Regions

Ayeyarwady

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	206.935	28.776	26.171	4.681	454		267.017	- 60.082	-22,50
	Degraded Forest (10%-80%*)		526.594					526.594	28.776	5,46
	Non-Forest (<10%)			2.427.368				2.427.368	26.171	1,08
	Plantation				23.073			23.073	4.681	20,29
	Water					124.055		124.055	454	0,37
	Snow / Ice						0	0	0	
	Total in 2014	206.935	555.370	2.453.539	27.754	124.509	-			
	%change intact		10,78	9,80	1,75	0,17				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Bago

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	233.062	12.669	25.175	12.388	53.936		337.230	- 104.168	-30,89
	Degraded Forest (10%-80%*)		1.486.584					1.486.584	12.669	0,85
	Non-Forest (<10%)			1.959.292				1.959.292	25.175	1,28
	Plantation				49.335			49.335	12.388	25,11
	Water					51.777		51.777	53.936	104,17
	Snow / Ice						-	-	-	
	Total in 2014	233.062	1.499.253	1.984.467	61.723	105.713	-			
	%change intact		3,76	7,47	3,67	15,99				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Chin

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	1.338.413	73.147	40.090	283	10		1.451.943	- 113.530	-7,82
	Degraded Forest (10%-80%*)		1.935.239					1.935.239	73.147	3,78
	Non-Forest (<10%)			226.537				226.537	40.090	17,70
	Plantation				450			450	283	62,89
	Water					9.341		9.341	10	0,11
	Snow / Ice						-	-	-	
	Total in 2014	1.338.413	2.008.386	266.627	733	9.351	-			
	%change intact		5,04	2,76	0,02	0,00				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Kachin

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	5.132.416	67.633	66.438	74.331	645		5.341.463	- 209.047	-3,91
	Degraded Forest (10%-80%*)		2.355.689					2.355.689	67.633	2,87
	Non-Forest (<10%)			890.713				890.713	66.438	7,46
	Plantation				109.291			109.291	74.331	68,01
	Water					90.964		90.964	645	0,71
	Snow / Ice						108.684	108.684	-	
	Total in 2014	5.132.416	2.423.322	957.151	183.622	91.609	108.684			
	%change intact		1,27	1,24	1,39	0,01				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Kayah

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	96.161	249	17.690	-	135		114.235	- 18.074	-15,82
	Degraded Forest (10%-80%*)		859.540					859.540	249	0,03
	Non-Forest (<10%)			194.361				194.361	17.690	9,10
	Plantation				3.100			3.100	-	0,00
	Water					4.238		4.238	135	3,19
	Snow / Ice						-	-	-	
	Total in 2014	96.161	859.789	212.051	3.100	4.373	-			
	%change intact		0,22	15,49	0,00	0,12				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Kayin

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	670.901	1.348	49.437	91.285	963		813.934	- 143.033	-17,57
	Degraded Forest (10%-80%*)		1.580.559					1.580.559	1.348	0,09
	Non-Forest (<10%)			537.805				537.805	49.437	9,19
	Plantation				66.365			66.365	91.285	137,55
	Water					785.337		785.337	963	0,12
	Snow / Ice						108.684	108.684	-	
	Total in 2014	670.901	1.581.907	587.242	157.650	786.300	108.684			
	%change intact		0,17	6,07	11,22	0,12				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Magway

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	219.734	19.318	25.615	10.864	7.754		283.285	- 63.551	-22,43
	Degraded Forest (10%-80%*)		1.228.461					1.228.461	19.318	1,57
	Non-Forest (<10%)			2.934.902				2.934.902	25.615	0,87
	Plantation				1.608			1.608	10.864	675,62
	Water					53.442		53.442	7.754	14,51
	Snow / Ice						-	-	-	
	Total in 2014	219.734	1.247.779	2.960.517	12.472	61.196	-			
	%change intact		6,82	9,04	3,84	2,74				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Mandalay

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	141.161	2.127	31.420	4.444	2.390		181.542	- 40.381	-22,24
	Degraded Forest(10%-80%*)		535.224					535.224	2.127	0,40
	Non-Forest (<10%)			2.302.632				2.302.632	31.420	1,36
	Plantation				29.151			29.151	4.444	15,24
	Water					50.965		50.965	2.390	4,69
	Snow / Ice						-	-	-	
	Total in 2014	141.161	537.351	2.334.052	33.595	53.355	-			
	%change intact		1,17	17,31	2,45	1,32				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Mon

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	74.731	4.010	3.353	73.692	329		156.115	- 81.384	-52,13
	Degraded Forest (10%-80%*)		353.992					353.992	4.010	1,13
	Non-Forest (<10%)			495.988				495.988	3.353	0,68
	Plantation				107.473			107.473	73.692	68,57
	Water					10.644		10.644	329	3,09
	Snow / Ice						-	-	-	
	Total in 2014	74.731	358.002	499.341	181.165	10.973	-			
	%change intact		2,57	2,15	47,20	0,21				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Rakhine

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	747.448	50.162	57.502	1.154	206		856.472	- 109.024	-12,73
	Degraded Forest (10%-80%*)		1.605.135					1.605.135	50.162	3,13
	Non-Forest (<10%)			956.861				956.861	57.502	6,01
	Plantation				4.621			4.621	1.154	24,97
	Water					78.613		78.613	206	0,26
	Snow / Ice						-	-	-	
	Total in 2014	747.448	1.655.297	1.014.363	5.775	78.819	-			
	%change intact		5,86	6,71	0,13	0,02				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Sagaing

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	3.191.671	98.954	162.634	18.244	29		3.471.532	- 279.861	-8,06
	Degraded Forest (10%-80%*)		2.648.527					2.648.527	98.954	3,74
	Non-Forest (<10%)			3.122.947				3.122.947	162.634	5,21
	Plantation				24.126			24.126	18.244	75,62
	Water					119.608		119.608	29	0,02
	Snow / Ice						-	-	-	
	Total in 2014	3.191.671	2.747.481	3.285.581	42.370	119.637	-			
	%change intact		2,85	4,68	0,53	0,00				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Shan

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	1.778.238	35.468	434.553	162.534	51		2.410.844	- 632.606	-26,24
	Degraded Forest (10%-80%*)		8.968.212					8.968.212	35.468	0,40
	Non-Forest (<10%)			3.704.167				3.704.167	434.553	11,73
	Plantation				395.919			395.919	162.534	41,05
	Water					64.951		64.951	51	0,08
	Snow / Ice						-	-	-	
	Total in 2014	1.778.238	9.003.680	4.138.720	558.453	65.002	-			
	%change intact		1,47	18,02	6,74	0,00				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Tanintharyi

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	2.301.074	75.311	35.201	75.440	-		2.487.026	- 185.952	-7,48
	Degraded Forest (10%-80%*)		1.159.375					1.159.375	75.311	6,50
	Non-Forest (<10%)			280.728				280.728	35.201	12,54
	Plantation				97.234			97.234	75.440	77,59
	Water					67.535		67.535	-	0,00
	Snow / Ice						-	-	-	
	Total in 2014	2.301.074	1.234.686	315.929	172.674	67.535	-			
	%change intact		3,03	1,42	3,03	0,00				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Yangon

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	12.754	2.362	2.042	3.045	-		20.203	- 7.449	-36,87
	Degraded Forest (10%-80%*)		130.187					130.187	2.362	1,81
	Non-Forest (<10%)			796.084				796.084	2.042	0,26
	Plantation				4.629			4.629	3.045	65,78
	Water					23.223		23.223	-	0,00
	Snow / Ice						-	-	-	
	Total in 2014	12.754	132.549	798.126	7.674	23.223	-			
	%change intact		11,69	10,11	15,07	0,00				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Naypyitaw

		2014 (ha)						Total in 2002	Forest Change	2002-14 Change (%)
	categories	Intact Forest(>80%)	Degraded Forest (10%-80%*)	Non-Forest (<10%)	Plantation	Water	Snow/ice			
2002 (ha)	Intact Forest (>80%)	48.253	-	10.520	3.453	3.260		65.486	- 17.233	-26,32
	Degraded Forest (10%-80%*)		327.925					327.925	-	0,00
	Non-Forest (<10%)			303.988				303.988	10.520	3,46
	Plantation				986			986	3.453	350,20
	Water					8.490		8.490	3.260	38,40
	Snow / Ice						-	-	-	
	Total in 2014	48.253	327.925	314.508	4.439	11.750	-			
	%change intact		0,00	16,06	5,27	4,98				

* In dry deciduous forest areas, intact forest was defined as >60% canopy cover and degraded forest was defined as 10%-60% canopy cover

Appendix 2. List of G1-G5 timber species

Group (1)

Sr.	Myanmar Name	Botanical Name
1	Pyinkado	*Xylia dolabriformis*
2	Padauk	*Pterocarpus macrocarpus*
3	Thingan (Thingan-Net)	*Hopea odorata*
4	Thitya	*Shorea oblongifolia*
5	Ingyin	*Pentacame siamensis*
6	Tamalan	*Dalbergia oliveri*

Group (2)

Sr.	Myanmar Name	Botanical Name
1	Anan	*Fagraea fragrans*
2	Binga	*Mitragyna rotundifolia*
3	Hmanthin	*Cinnamomum iners*
4	Hnaw	*Adina cordifolia*
5	In	*Dipterocarpus tuberculatus*
6	Kanyin	*Dipterocarpus spp*
7	Karawe	*Cinnamomum inunctum*
8	Kashit (Thitka)	*Pentace burmanica*
9	Kokko	*Albizzia lebbek*
10	Kyana	*Xylocarpus molluccensis*
11	Magyipway	*Diospyros pendula*
12	Pinle-Kanazo (Kanazo)	*Heritiera fomes*
13	Sagawa (Saga)	*Michelia champaca*
14	Sit	*Albizzia procera*
15	Taung-tama	*Cedrela serrata*
16	Thadi	*Protium serratum*
17	Thinwin	*Mellettia pendula*
18	Thitkado	*Cedrela toona*
19	Thitkhaya	*Diopyros oblonga*
20	Thitmagyi	*Albizzia odoratissima*
21	Thitsho	*Pentace griffithii*
22	Thitsi	*Melanorrhoea usitata*
23	Tinyu	*Pinus spp*
24	Yemane	*Gmelina arborea*
25	Yindaik	*Dalbergia cultrata*
26	Yinma	*Chukrasia tabularis*

Group (3)

Sr.	Myanmar Name	Botanical Name
1	Aukchinsa-ni	*Amoora wallichii*
2	Gangaw	*Mesua ferrea*
3	Kanyaung	*Shorea thorelii*
4	Kaunghmu	*Anisoptera scaphula*
5	Kyilan	*Shorea assamica*
6	Maniawga	*Carallia brachiata*
7	Nyan	*Quercus serrata*
8	Panga	*Terminalia chebula*
9	Peinne-bo	*Palaquium polyanthum*
10	Pyinma	*Lagerstroemia speciosa*
11	Sandawa	*Cardia fragrantissima*
12	Talainggaung	*Madhucalongifolia var latifolia*
13	Taukkyan	*Terminalia tomentosa*
14	Taung-Peinne	*Artocarpus chaplasha*
15	Taung-Thayet	*Swintonia floribunda*
16	Taw-Thayet	*Mangifera caloneura*
17	Thabye	*Eugenia spp*
18	Tharapi	*Calophyllum kunstleri*
19	Thingadu	*Parashorea stellata*
20	Thitcha	*Quercus spp*
21	Thit-E	*Castanopsis spp*
22	Yingat	*Gardenia coronaria*
23	Yon	*Anogeissus acuminata*

Group (4)

Sr.	Myanmar Name	Botanical Name
1	Baing	*Tetrameles nudiflora*
2	Chinyok	*Garuga pinnata*
3	Didu	*Salmalia insignis*
4	Gwe	*Spondias pinnata*
5	Kokhe	*Salmalia anceps*
6	Letkok	*Sterculia foetida*
7	Letpan	*Salmalia malabarica*
8	Linlun	*Sapium baccatum*
9	Ma-U-Lettan-She	*Anthocephalus cadamba*
10	Myaukngo	*Duabanga grandiflora*
11	Nabe	*Lannea coromandelica*
12	Odein	*Ailanthus triphysa*
13	Sawbya	*Pterocymbium tinctorium*
14	Setkadon	*Trewia nudiflora*
15	Thitto	*Sandoricum koetjape*
16	Wetshaw	*Erythropsis colorate*
17	Other softwood	

Group (5)

Sr.	Myanmar Name	Botanical Name
1	Kuthan	*Hymenodictyon excelsum*
2	Kyun-bo	*Premnu pyramidata*
3	Lamu	*Sonneratia caseolaris*
4	Leza	*Lagerstroemia tomentosa*
5	Myaukchaw	*Homalium tomentosum*
6	Myouklok	*Artocarpus lakoocha*
7	Ondon	*Litsaea glutinosa*
8	Pyaukseik	*Holoptelea integrifolia*
9	Tayaw	*Grewra tiliaefolia*
10	Thitpyu	*Wendlandia glabruta*
11	Other Hardwood	