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*Article*

# Climate Change Mitigation Through Reduced-Impact Logging and the Hierarchy of Production Forest Management

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**Abstract:** The proposed hierarchy of production forest management provides modus operandi for forest concessions to move incrementally towards Sustainable Forest Management (SFM) via Reduced-Impact Logging (RIL) and forest certification. Financial benefits are sourced in the "Additionality Zone", financing the rise in the hierarchy and offsetting prohibitive forest and carbon certification costs. RIL carbon registration components consist of developing credible baseline, additionality and leakage arguments around the business-as-usual scenario through the quantification of historical forest inventory and production records, forest infrastructure records and damage to the residual forest. If conventional harvesting is taken as a baseline, research indicates RIL can potentially reduce emissions by approximately 1–7 $tCO_2e$ $ha^{-1}yr^{-1}$. The current market price of USD $7.30 per $tCO_2e$ may result in over USD $50 $ha^{-1}yr^{-1}$ in additional revenue, well above the estimated USD $3–5 $ha^{-1}$ in carbon transaction costs. Concessions in Sabah Malaysia demonstrate the financial viability of long-term RIL and certification planning. This may act as a basis for future planned forest management activities involving RIL, carbon and forest certification through the hierarchy of production forest management.

**Keywords:** reduced-impact logging; carbon offset; sustainable forest management; hierarchy of production forest management

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## 1. Introduction

In the past century, forestry literature discussed at length the ideals of Sustainable Forest Management (SFM) in-line with population, infrastructure, economic and climate dynamics [1–3]. Incremental benefits consisting of holistic environmental, social and economic elements may move the sector closer to SFM at the local, national and international level [4,5].

The benefits associated with national development strategies include the long-term planning and implementation of the forest sector. Due to slower diameter growth, many developed countries experience longer periods between harvest rotations [6]. In the tropics, growth is faster and the peak in mean increment is earlier, leading to shorter rotations in plantations and potentially shorter cutting cycles in selective harvesting of natural forests [7]. Compounded with high levels of biodiversity and essential ecosystem services (carbon, water, biodiversity), tropical forests are recognized as essential ecosystems to assist in the maintenance of environmental stability [4,5,8].

The emergence of forest certification and its related principles and criteria were envisioned to be the tools to identify, recognize, rehabilitate, safeguard and promote SFM globally. However low levels of participation (10% certified globally) indicate many challenges are yet to be overcome [9,10]. Extensive research defined Reduced-Impact Logging (RIL) as recognized tool to reduce excessive harvest damage while maintaining comparable extraction volumes [11–13]. However implementation of both RIL and certification has been limited and additional incentives are required to reach the goal of SFM [7].

Recognizing the importance of such a challenge, the global carbon market has developed modalities to provide financial benefits for the implementation of "additional" project activities designed to reduce levels of global Greenhouse Gas (GHG) emissions [14,15]. Carbon reduction strategies in "forests remaining as forests" are currently limited to forest plantations and harvesting "avoidance" activities [16]. However, emerging modalities such as RIL are gaining increased recognition. It may be possible to register carbon projects through RIL yet to-date no modalities exist. Through the carbon markets, the authors propose RIL can act as a vehicle to rise in the Hierarchy of Production Forest Management towards achieving SFM in the tropics.

## 2. Hierarchy of Production Forest Management

The hierarchy of production forest management a modular approach using carbon as the key mechanism for progression and development. Each step is a direct function of the previous tier(s) that involves practical steps through demonstrable financial benefits. Four main tiers define progress through the hierarchy: (1) Business As Usual; (2) Reduced Impact Logging; (3) Forest Certification, and (4) Sustainable Forest Management.

The hierarchy stems from basic legal and regulatory frameworks that govern forest management, including prevailing timber harvesting and monitoring practices. These practices maintain minimal legal, environmental and social levels of compliance that are otherwise known as "Business As Usual" (BAU). This does not imply current practices are negative, illegal or unsustainable, rather identifies that there is room for operational improvement.

The second tier is a more efficient and systematic approach to harvesting that reduces damage to the residual harvest stand using management planning, mapping and training systems of controls. RIL

represents practical steps to improve operational efficiency and the impacts of extractive harvest strategies. Such measures may bring about significant economic gains, but the investment, particularly in human resource development is too often a barrier to its adoption.

The third tier goes beyond RIL to encompass holistic forest management as focused by forest certification schemes. Forest certification involves the implementation of actions that explicitly confer environmental protection and social benefits and operates through internationally agreed principles and criteria of recognized international standards. Conforming to certification requirements requires changes to the operational management of the forest concession resulting in additional costs.

The highest level in the hierarchy is SFM, the ideology, vision and founding principle of forest management designed to recognize and address the differentiation of forest management approaches through balanced, sound, holistic environmental, social and economic values which contribute to sustainable development. This is achieved through public and or private partnerships and supporting government policies in education, training and technical assistance at the national or sub-national level.

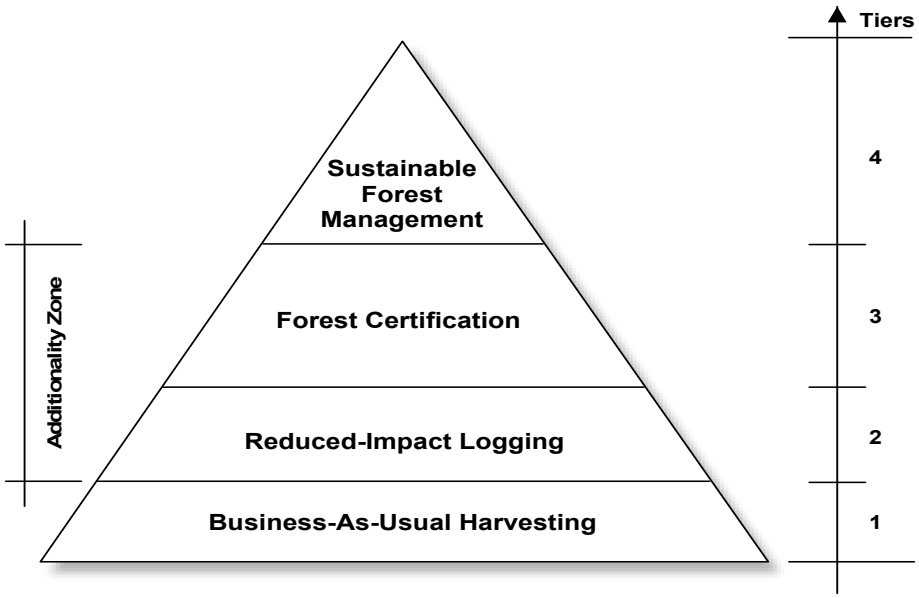
However, SFM is not utopia. In developed countries, forests are usually managed in a way that they will still provide benefits for the grandchildren of the current land managers. In boreal zones, trees like beach or oak may take 60 to 100 years to reach maturity. Forestry is considered a slow but steady business. Why is SFM not common in tropical countries? Potential barriers against the rise in the hierarchy include the following:

- **Competition:** Legal forestry competes with illegal felling on state forest and other unprotected lands. Legal landowners shy away from high investment, because competition drives sales prices down.
- **Ownership:** Concessions grant land rights for a limited period only. It is economically rational for a leaseholder to over-exploit the resource during the concession period. Only a long-term landowner (ideally permanent or over several generations) will take over stewardship for the property.
- **Capital availability:** Closely linked to the above, banks will not give loan on a concession area, because concessions can be revoked by the state at any time. In general terms, capital costs are higher in developing countries. This is no environment for slow and sustainable business.
- **Skills:** In most developing countries, the rural workforce has a low general education level and lacks training for specialized labour.

Barriers against the rise in the hierarchy are found at the national, sub-national and local levels. Graphically, difficulties are demonstrated in the uneven height of each tier to the right of the Figure 1. Each project and area is specific to the region and country therein and proportionally, their difficulties.

The hierarchy focuses on registering harvesting activities through the carbon market. Financial benefits received can offset the cost of operational improvements and cushion market externalities beyond the control of forest concessions. It is essential to understand fundamental components of RIL in relation to the carbon market, additionality arguments and financial structures. Considering the barriers against SFM, the "additionality zone" is forest management that goes beyond BAU to include RIL and forest certification. SFM, as the ideological and en mass extension of forest certification, can only be achieved once global forests are well managed and is therefore, excluded from the additionality zone.

**Figure 1.** Hierarchy of production forest management.




## 3. Reduced-Impact Logging

RIL emerged "en masse" in the 1990s and became a recognized international approach to reducing the environmental impact of timber harvesting in tropical forests. Concessions in Sabah, Malaysian Borneo, provided much of the initial practical research and experience of RIL. Through a highly controlled process of planning, recording, felling, extracting and monitoring of forest operations, damage to timber and the forest structure can be significantly reduced while increasing the regrowth volume of the residual stand [13,17–19]. However, these findings have not had the hoped-for impact on the forest industry globally. Two decades on, conventional harvesting (CNV) involving unsustainable timber extraction is still the most widely implemented forest practice carried out throughout most tropical countries [20], regardless of scarce tropical forest resources remaining [5].

RIL has shown to reduce damage to soils and residual stands up to 50% when compared with conventional harvesting [12,21–23]. Compared to CNV, RIL has demonstrated a reduction in canopy loss by 90–120% [24], and reduced ground disturbance per stem harvested [23,24]. RIL activities have been found to result in 41% less damage to residual stands when compared to CNV [25]. Directional felling is more intensive and time consuming which means that RIL is 10–58% less productive compared to CNV in terms of harvested volume per unit of time [24], however this is offset by higher wood recovery resulting from higher efficiency in operations [23]. Skidding operations under RIL were shown to be more efficient due to direct skid trail planning and reduced tractor production hours. The area taken up by roads in RIL operations is reduced by approximately 40% when compared to CNV [25].

## 4. RIL Carbon Finance

RIL carbon benefits are measured in timber production activities, the construction of roads, landings, feeder roads and skid trails as well as damage and mortality to residual stand [12,19] and quantified through the 5 carbon pools consisting of aboveground, belowground, lying dead wood, litter

and soil organic carbon [26]. Projects are developed around methodologies, which in turn are bound to the frameworks to which they are applied [27]. Both the compliance and voluntary carbon markets have similar requirements that include the establishment of credible **additionality**, **baseline** and **leakage** arguments.

Carbon projects are required to prove "**additionality**" if its benefits, in terms of GHG emissions, are demonstrably supplemental to the BAU scenario [14,28–30]. There are more than a dozen interpretations, tests and criteria proving additionality of emission reductions, according to the various emerging global carbon standards [31]. Whichever means is used to justify additionality, the aim is to provide evidence that RIL is a legitimate and pragmatic climate change mitigation technique that provides long-term emission reductions through improvements in forest operations. Table 1 highlights potential additionality tests available to a carbon project developer. Those in **bold** may be used to justify RIL carbon projects.

**Table 1.** Carbon additionality tests [28].

| Category | Type of additionality | Test |
|---|---|---|
| Environmental | ***GHG additionality*** | Activity results in GHG emission reductions or removals compared to the baseline scenario |
| | ***Unit additionality*** | Activity reduces GHG emissions below levels of technologies normally used to produce the same product |
| | Project additionality | Activity happens because of carbon finance |
| Financial and investment | ***Investment additionality*** | Activity needs to be economically viable, or an attractive investment proposition, only when taking carbon finance into account |
| | Sales or capital additionality | Activity would not have been undertaken without revenues from the sale of carbon |
| Legal, regulatory and institutional applying to regulators and states | Reporting additionality | Accounting on national level avoids double crediting of emission reductions or removals |
| Legal, regulatory and institutional applying to non-state actors | Compliance additionality | Activities need to be additional to statutory requirements |
| | Incentive additionality | Activities need to go beyond existing incentives (e.g., subsidies) |
| | Technological additionality | Activities need to apply a particular technologies |
| | Barrier additionality | Activity overcomes particular implementation barriers |
| | ***Common-practice additionality (Prevailing-Practice)*** | Activity employs technologies or practices that are not in common use. |
| | ***Institutional additionality*** | Activity is undertaken outside of statutory emission reduction targets |
| | Date additionality | Activities starts after a particular date |
| | Jurisdiction additionality | Activities are implemented in a particular area or by a particular group |

*Institutional additionality* can be claimed where RIL activities are undertaken in addition to statutory emission reduction targets [31]. This can be applied in most tropical countries where there are no binding national commitments to emission reductions.

To demonstrate additionality through *common or prevailing practice* a project developer must show that the forest sector in general (in the relevant geographical and socio-economic context) resists changing to more environmentally sustainable practices, even though alternatives are available. Some of the most stringent forestry acts, laws and articles in the world are found in the tropics [32]. However, malpractice and/or negligent monitoring of such requirements are commonplace so additionality may stem from this argument.

Additionality may be demonstrated through a projects' financial non-viability without the additional carbon revenue. Such "*investment additionality*" requires the project developer to demonstrate that the project activity is less financially viable than the legal alternatives available [28]. In the case of RIL, high levels of upfront capital (training, planning, verification) entail long periods between initial investment and returns that may demonstrate financial barriers and prove additionality [29].

Additionality is however, a moving target. As law enforcement improves and other barriers are removed under particular situations or in countries as a whole, RIL may over time become BAU.

Climate change mitigation benefits are measured against a "non-project" or BAU scenario (**baseline**) and calculated in the quantity of emissions that would happen in the absence of the carbon project [28,33]. Baselines can be determined through the quantification and projection of BAU levels into the future [27]. Baseline formulation may be project specific or derived at the sub-national, national, regional or sector-based levels.

To develop a credible RIL carbon baseline, project developers are required to quantify the annual historic emission levels of the proposed area, determined through the examination of **historical forest inventory**, **harvest records**, the established **forest infrastructure** and the **damage to the residual forest**. Theoretically, one could also quantify these data from other managed forests in a similar situation, yet maintaining permanent sample plots on areas managed by other landowners can be difficult.

**Historical harvest inventories** (if available) are only partially acceptable for carbon purposes due to their focus on merchantable timber (restricted to upper diameter classes). Therefore carbon developers are required to examine localized stand tables, forest research and other growth and yield data to estimate the lower diameter classes within the harvest compartment.

Similarly, **historical harvesting records** are a reflection of the harvest inventory and only record harvested stems that meet or exceed the minimum diameter requirements. Frequently, historical harvest records are unavailable [34,35] which creates a gap in the collection of the required information.

The carbon developer is required to quantify the **existing forest infrastructure** including skid trails, feeder roads, landing and stumping points. This poses yet another unusual challenge as historically, forest infrastructure is unplanned prior to execution [24,36–38]. Based on the infrastructure, the baseline will reflect the **damage and regrowth of the residual stand**.

To generate data for the identified gaps, carbon developers should examine localized historical forest research, maps and harvest records to estimate the forest stand, structure, diameter class distribution, damage, mortality and regrowth including the established infrastructure.

**Leakage** refers to the displacement of carbon emissions or loss of carbon stocks outside of the project boundary, which occurs as a direct result of the implementation of the project itself [29,33,39,40].

Identifying the sources of leakage and demonstrating how these are addressed is crucial for project acceptance. Projects that entail a change of land-use are particularly prone to leakage [29,39,41] yet the leakage risk is different for each modality. Carbon leakage under RIL is considered minimal due to similar harvest volumes extracted and the controlled nature of the activities taking place in licensed harvest concessions (forests staying as forests),which are not under threat from deforestation or agriculture expansion [17,39].

While the rationale behind RIL is clear from an ecological point of view, a number of financial challenges in its implementation remain. In economic terms, RIL has mixed conclusions. The body of research over the past 20-year demonstrates the financial viability of RIL is dependent on the size and stocking of the forest area [42–49] and contractors are not motivated to change their harvesting approach [21].

Recent research (2009) found RIL operational costs per hectare rise as high as 46% compared to CNV and as high as 57% per cubic meter (USD \$90/$m^3$) [50]. This research, consistent with past research findings [43,45–47,49,51] indicates applying RIL changes the financial distribution associated with harvesting practices.

Registering RIL through carbon markets may provide the necessary financial incentive to promote sector wide implementation. Research demonstrates RIL implementation may reduce carbon emissions by approximately 1–7 $tCO_2ha^{-1}yr^{-1}$ [12,17,52,53]. At the prevailing2010 carbon price of USD \$7.30 per $tCO_2e$ [54], RIL carbon projects can potentially generate an additional USD \$50 $ha^{-1}yr^{-1}$which can add long-term financial stability to forest concessions to compete with global markets.

Carbon offsets complying with a recognised verification standard can attract higher average value than those stemming from other project types. In 2010, prices for carbon projects accredited to the CarbonFix Standard were recorded at USD \$10.90/$tCO_2$ [54], which is directly attributed to the willingness of investors to pay a premium for higher environmental and social benefits, and reduce the risk associated with non-permanence of forest carbon. Voluntary emission offsets are used in two ways; (1) to reduce the carbon footprint of activities that are (currently) not subject to emission control regulation and (2) in advancement of expected future emission control. For the first option, a standardized emission reduction unit provides higher credibility. Standardization of voluntary carbon mitigation activities in the second option is unavoidable, because the market has experienced that voluntary standardization schemes have the highest chance to anticipate future regulation activities acting in advancement of Reduction of Emissions from Deforestation and Land Degradation (REDD) regulation find themselves under intense public scrutiny. In the voluntary market, we observe a race to the top. The voluntary markets bridge the interim gap towards compliance markets and provide a preliminary platform for the development and dissemination of carbon methodologies.

Carbon transaction costs (project development, validation and verification) for RIL are considered to cost an average of USD \$2–4 $ha^{-1}yr^{-1}$ [55,56]. Due to the incremental carbon savings from the various RIL components, higher monitoring frequency is recommended (Table 2) in the early stages of the project to ensure measurement accuracy.

**Table 2.** Proposed Reduced-Impact Logging (RIL) carbon monitoring schedule.

| Monitoring type | Time frame |
|---|---|
| Verification | Immediately following harvest |
| Post-Harvest Monitoring | Years 1, 2, 3, 5 and every 5-years thereafter |

RIL will ultimately be contingent on the implementation and enforcement of RIL policies at the national or sub-national level. The international community has called for the enforcement of regulated frameworks for many years without fruition [57].

The success of the compliance *versus* voluntary carbon markets clearly demonstrates the effectiveness of legally binding regulatory instruments. In 2009, the size of the voluntary carbon market represented only 0.27% that of the regulated markets. It is worth noting within the voluntary carbon market, forest-based activities represent a negligible 0.005% of transacted volume relative to the global voluntary carbon trade [54].

Avenues exist to integrate RIL into the carbon market for wider inclusion into forest operations globally. Formally, progress was achieved at recent climate change negotiations (COP-15 and 16) and for the first time, the climate regulation function of forest ecosystems is widely discussed and policies are being designed to bring REDD into compliance markets [58]. Despite flaws within the global forest carbon market (compliance), trade in voluntary forest carbon market, by volume, continues to rise [54]. If such trends are maintained, the demand for RIL carbon may not lie so far ahead. While the past decade have seen the development of a credible forest carbon market primarily through the afforestation and reforestation sectors, the next decade may well dictate a global shift towards improved forest management of which RIL is a fundamental part.

Drawing a parallel to the timber trade, illegal timber demonstrates the insufficiency of market forces and the need for stringent policies to modify BAU practices. Regulations such as the US Lacey Act and the EU illegal timber regulations (operational by March 2013) require legality verification before products can enter the American or EU markets. Lessons learned from forest certification practices may help guide this progression.

## 5. Lessons Learned from Forest Certification

Efforts to provide financial incentives for responsible forestry practice revolved initially around forest certification. Forest certification emerged via the concerns of private interest groups, particularly consumers' groups and environmental NGOs, as a tool for the voluntary promotion of SFM. Certification was intended to confer a market advantage on companies, which adhered to set of standards, with or without the endorsement of national governments [59,60]. Certification monitors forestry management according to internationally recognized Principles and Criteria (P&C), which are independently verified [61,62]. The concept is widely seen as an important initiative to promote improved forest management, recognizing the importance of social equity, environmental integrity and economic viability [10]. It provides consumers with the guarantee that specific environmental, social and management standards have been met in the delivery of products from forest to market. Without such guarantees, consumers lack the means to make rational or sound purchases based on social and environmental concerns.

Accumulated research on certification demonstrates that timber certification does not necessarily offer financial incentives to implementing institutions [60]. Rather, certified products are primarily sold to developed countries with robust environmental policies, discouraging the import of forest products from unverified sources [10]. The average price premium that concessions receive from certification is 2–5%, which barely meets the unit area cost of USD \$3–32 $ha^{-1}$ [60,63–65]. This has had a dampening effect on the forest certification industry globally; in 2004–2005, the area of certified forest increased by 125 million ha in a single year but during 2006–2010, the area increased on average by just 23 million ha per year [66]. By the first quarter of 2011, the global certified forest area was approximately 355 million ha of the world's 3.9 billion ha [67].

Forest certification cannot, in its current form, incentivize SFM at the global level. The acknowledgement of this is one of the factors behind the ongoing revision of both the Forest Stewardship Council (FSC) and the Program of Endorsement of Forest Certification (PEFC) Standards. The FSC revision seeks closer accommodation between best practice in social and environmental terms and the economics of forest operations. The PEFC have tabled their revision exercise as "generalizing" the standard [68]. Some may see this as a deliberate act of "relaxation" to increase the number of eligible areas under forest certification. The authors believe the opposite is actually taking place. This exercise is a direct result of the greater understanding of holistic sustainable forest management which takes into account broader forest uses, the incorporation of community forests and forest stewards, the integration of agroforestry and agriculture land management schemes, the prospect of micro-financing as well as the unique biophysical characteristics forests intrinsically possess to host "additional" investment and financing strategies [69–71]. Similarly, this needs to be applied to the production forestry market.

Linking forest certification and the carbon market through a step-wise process of the hierarchy of production forest management may make both, including RIL, more accessible and attractive to the industry and global markets.

## 6. SFM in the Tropics: The Potential of Sabah Malaysia

In 1989, the Malaysian–German Sustainable Forest Management Project initiated the development of Sabah's first model forest concession; the Deramakot Forest Reserve (DFR). The intensive collaboration between the German Technical Agency (GTZ) and the Sabah Forestry Department (SFD) demonstrated innovative achievements for the management, planning, training and execution of the 55,086 ha concession (through RIL) that resulted in the achievement FSC certification (SGS-FM/COC-000065) in 1997 [72].

During the same year, the Sabah State government initiated a drive towards realizing SFM through the creation of privately operated Forest Management Units (FMUs). In total, 26 FMUs were created, each consisting of approximately 100,000 ha with a mandate to carry out responsible forest management for the duration of 99-year through the legally binding Sustainable Forest Management License Agreement (SFMLA). FMUs are required to undertake Forest Management Plans (FMP) every 10-years, subject to a mid-term review every 5-years, to ensure compliance of forest harvesting, restoration, plantation, community and conservation activities. All activities are reviewed and approved by the SFD prior to implementation and are documented in annual compliance reports.

After only 20-years of management, the SFD announced that DFR had not only maintained its forest certification certificate, but had become financially sustainable and profitable [73]. With renewed vigor, the SFD initiated a statewide approach to implement RIL and forest certification where by all forest concessions in the State have been given the target for compliance by the year 2014 [74]. In parallel, the State Government revised the 1968 Sabah Forest Enactment to include Payments for Ecosystem Services (PES) as taxable forest commodities paving the way for carbon forestry investments. The SFD have pledged to develop a state-level REDD strategy and challenged investors to demonstrate their confidence to deliver emission reductions, enhanced carbon stocks and forest conservation in Sabah [75].

Local, regional and international experts are now engaged in moving REDD and forest certification forward in Sabah. The SFD foresees both increasing the area of certified forests and wider implementation of RIL as central planks to their overall forest strategy [76]. At the recent FSC General Assembly in June 2011, Sabah announced it maintains over 400,000 ha of certified forests [77]. The SFD are exploring the possibilities of association with international REDD readiness and financial support programs such as UN-REDD and the Governors' Forest and Climate Taskforce (GFCT). As a first mover, additionality arguments may be satisfied to register RIL activities through the voluntary carbon market.

The fundamental backbone to the success of DFR was the implementation of RIL and through training and intergovernmental finance FSC certification was achieved. The authors believe the finance received through the additionality zone of the hierarchy of production forest management can provide the required capital to move additional forest concessions towards SFM.

The SFD and the State Government are supporting carbon research on the affects of the RIL forest policy in three FMUs. Pending fruition, the State may be poised to gain unparalleled access to the carbon markets and international finance. This achievement would mark a milestone achievement for both forest certification and carbon.

## 7. Conclusions

We have classified development of SFM practices in Malaysia along the Hierarchy of Production Forest Management, determining the reasons why SFM is currently not BAU, in spite of being a long-term profitable land use option. Moving from deteriorating forestry to SFM will require financial incentives, but also a conducive regulatory environment. The coming mechanism for REDD is expected to offer opportunities for RIL. Taken together with forest certification, it may provide an incentive to move up towards the target of long-term resource preservation under SFM.

The multi-disciplinary nature of SFM highlights the critical requirement to shift from traditional harvest based management towards broad, holistic and inclusive structures. The implementation of both RIL and forest certification can be facilitated through the binding of carbon financial incentives. The financial flows can mobilize further progress towards forest certification, pragmatic forestry management and holistic governance. It is hoped that the adoption of the hierarchy of production forest management can initiate financial considerations for the international investment sector, governments and forest concessionaires alike.

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