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The topic of presentation is

- Lecture 5: Carbon benefit analysis for FLR intervention

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Carbon Benefit Analysis for Forest Landscape Restoration Intervention

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Background

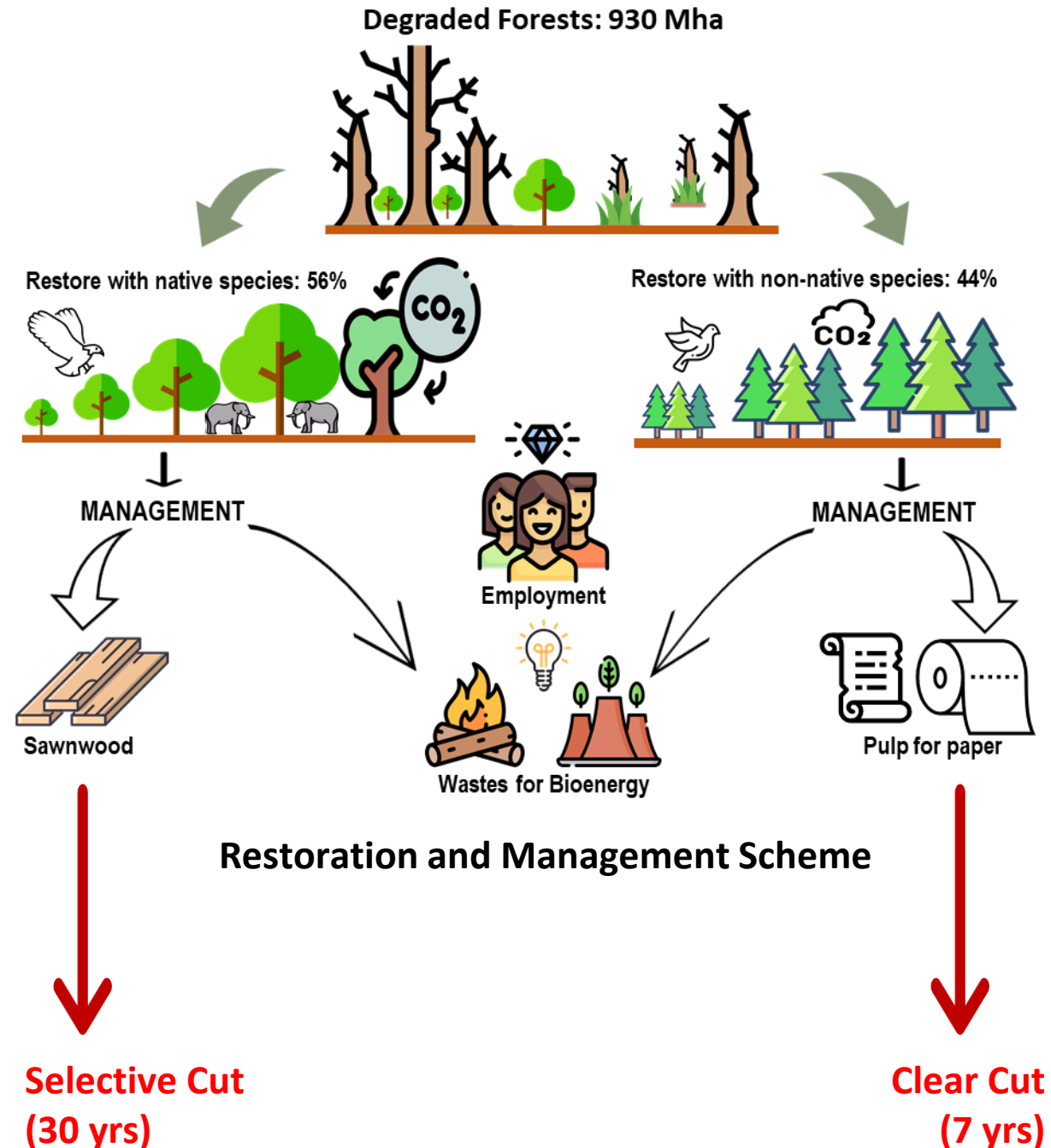
- Since 1990, we lost 420 million ha (FAO, 2020). With **500 tCO₂/ha**, this loss emitted **211 billion tCO₂** [about 23% of all carbon stocks in tropical forests (Saatchi et al. 2011)]
- Total area of degraded forests: **930 million ha** (ITTO, 2020)
- Carbon emissions from degradation 25%+ of total carbon emissions from deforestation (Pearson et al. 2017)
- Deforestation and forest degradation impacted 1.6 billion people and biodiversity
- New Hope: The New York Declaration on Forests: restore 350 million ha by 2030 and Paris Agreement's REDD+ Scheme (2020-2030)
- **IF all 930 million ha are restored, how much carbon can we remove from the atmosphere and how much \$?**



Photo by Royal Academy of Cambodia

Study Methods

- Timeframe: 2021-2060 (350 Mha by 2030, remaining by 2060)
- Tree species for restoration
 - **Native species** for biodiversity conservation, watershed protection and timber production: *Casuarina* spp., *Dalbergia sissoo*, *Gmelina arborea*, *Swietenia macrophylla*, *Terminalia* spp., *Tectona grandis*, and other hardwoods
 - **Fast-growing species** for pulpwood production: *Eucalyptus* (26%), *Pinus* (22%), *Acacia* (6%), and others (46%)
- Assumptions:
 - 10% of native species are harvested at 30th year for timber production
 - 100% of fast-growing species are harvested and replanted at 7th year



Total carbon stocks at any given time can be obtained by:

RF(1), RF(2), .. RF(t): Area of restored forests in 2021, 2022, ..., 2060 (million ha) by native or fast-growing species, respectively.

CS(t): Carbon stocks in the restored forests by native or fast-growing species (MgC/ha). CS(t) was obtained using the logistic model

Area of degraded forests to be restored (**RF**)

2021-2030: 350 / (2030-2021)

2031-2060: (930-350) / (2060-2031)

Proportion of forests to be restored with

Native species: 56%

Fast-growing plantation: 44%

t: Time after restoring, corresponding to year n (year)
a, b, c: Constant values for both native species and fast-growing species.

For native species, various sources of data (Ruslim et al., 2021) were used and the values of a, b, and are a = 150.6077, b = 22.0118, c = 0.1454, and R² = 0.9906

For fast-growing species, data of plantation forests in four forest districts in Indonesia (Widhanarto et al., 2016) were used and the values of a, b, and are a = 171.5007, b = 17.8996, c = 0.4538, R² = 0.9854

Production of pulpwood from fast-growing species



PW(t): Annual pulpwood production (million tons)
TCS_{harvest}(t): Total carbon stocks of all restored forests reaching the age of harvesting (i.e., 7 years after planting)

0.47: Carbon fraction in the wood biomass (IPCC 2006)

0.15, 0.10, 0.05: Percentage of bark, branch, and foliage biomasses taken as average percentage based on Magnago et al. (Magnago et al., 2016), Sirijaroonwong et al. (Sirijaroonwong and Kiratiprayoon, 2017)

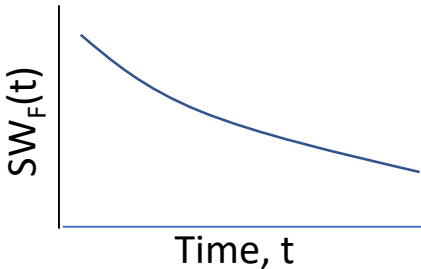
Production of sawnwood from native species

1.74: Biomass expansion factor in tropical forests (Brown, 1997)
0.5: Only 50% of roundwood (logs) is processed to sawnwood (FAO et al., 2020).
TCS_{harvest}(t): Total carbon stocks the age 30th for harvesting



k: is the decay rate ($k = \ln(2)/\tau$)
 τ is time to decay half of its volume or half-life time in year = 50 years for sawnwood) as per IPCC Guidelines

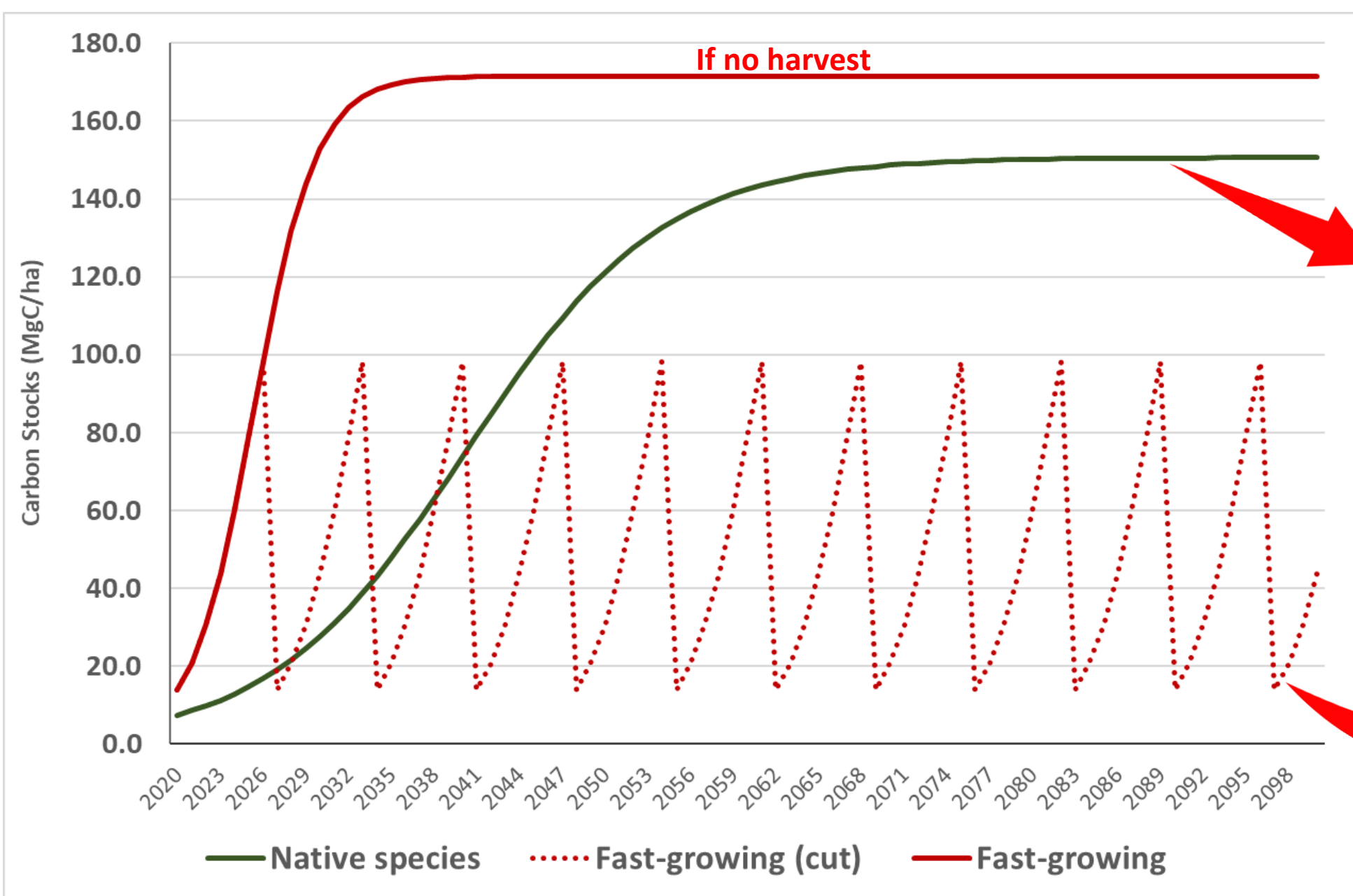
$SW_F(t) = SW(t) \times e^{-k \times t}$



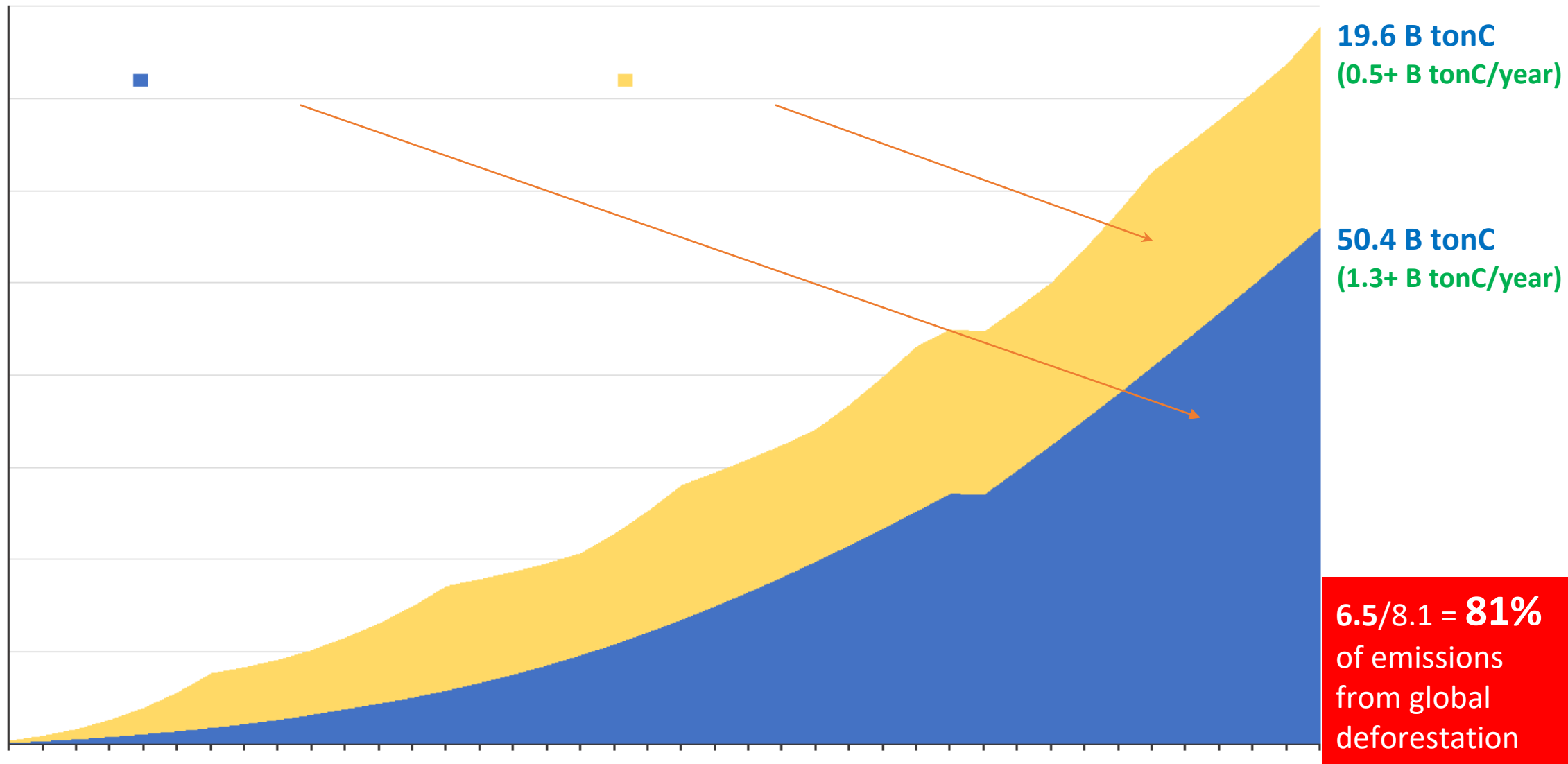


Results and Discussions

Sasaki et al. (in Prep)



Growth and Yield of the Restored Forests by Species Group (2021-2100)



Restored forests with native species:
Annual Removals: 4.7 B tCO₂ (2021-60)
Carbon revenues: \$186-372 billion



Fast-growing species:
Annual Removals: 1.8 B tCO₂
Carbon revenues: \$91-183 B



Total
Removals: 6.5 B tCO₂
C revenues: \$327-655 B



Production, Revenues and Costs (2021-2060)

Production

- Pulpwood: 1.5 B ton in 2027 & 4.8 B ton in 2060
- Sawnwood: 0.7 B m³ in 2050 & 1.3 B m³ in 2060 (Wood consumption in developing world 1.2 billion m³ in 2018, developed world: 1.1 in 2005 (Gresham House, 2020))

Revenues

- Pulpwood: \$246 billion (2027-2060) at \$45 per ton
- Sawnwood: \$1.4 trillion (2050-2060) at 500 per m³

Total Costs for Restoration and Management: 930 million ha

- About \$93.4 billion annually between 2021-2060 (\$4000/ha)

Conclusion and Way Forward

- Restoring the 930 million ha have multiple benefits: Carbon stocks, Carbon revenues, Pulpwood and revenues, Sawnwood and revenues at affordable costs
- Restoring the forests can also improve the ecosystem services and jobs, and above all, mitigating the climate change in much shorter time
- No more excuse on costs as we face more loss from all aspects
 - Climate change and its impacts
 - Biodiversity loss and impacts on global economy
 - Habitat loss and more diseases (COVID-19, more are likely)
 - Costs of COVID-19 outbreak were US\$82 trillion for 5 years
- Some challenges: Species selection, land allocation, and maintenance
- Governments introduce the enabling environment such as tax incentives, access to fair market and carbon price, and other supporting policies



Thank You
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