

Agroforestry: Tree-based Polycultures

Roger R. B. Leakey

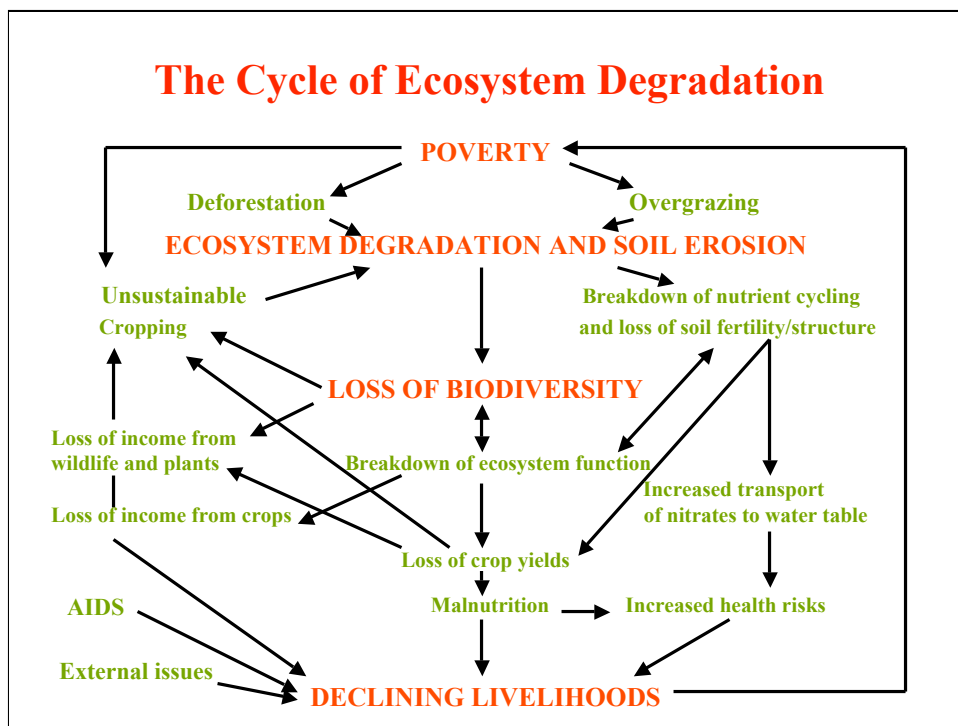
Agroforestry and Novel Crops Unit

School of Tropical Biology

James Cook University

Cairns, Australia





Concept of Agroforestry

The complexity of the interacting issues means that there is not a simple answer:

Solutions have to be equally interactive and address many individual problems simultaneously. Therefore need an INRM approach aimed at simultaneously restoring:

- biological resources,
- livelihoods, and so alleviating poverty,
- agroecological processes

= development of mature agroecosystems
which generate income for subsistence
farmers = AGROFORESTRY



Concept of Agroforestry

Agroforestry = an integrated landuse that:

- diversifies agroecosystems, promoting the formation of an agroecological succession,
- combines increases in productivity and income generation with environmental rehabilitation
- enhances livelihoods of subsistence farmers through the cultivation and domestication of traditionally important indigenous plants with commercial potential.

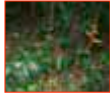


Traditional v. modern systems

Concept of Agroforestry



Each phase of the agroecological succession should be more biodiverse, as the the planted crops and agroforestry trees (the *planned* biodiversity) are enriched by the *unplanned* biodiversity, made up of all those organisms, above and below ground, that have found niches to fill among the planted trees and crops.



Plants producing different products can be used to create and fill different niches, thus the productive components of the agroecosystem are not tied to any one part of the agroforest.

Concept of Agroforestry

Not all parts of agroecosystems will be in the same temporal phase, so creating a mosaic of patches in the landscape, that make the system ecologically more stable and biologically and economically more diverse.

Further diversity on a landscape scale will be developed by farmers as they apply different management practices and implement different farming systems (*e.g.* food crops *versus* livestock).

Farms also will differ due to differences in farm sizes, the wealth of the farmer, access to market, the tenure systems, the availability and price of labour, other sources of income, etc.

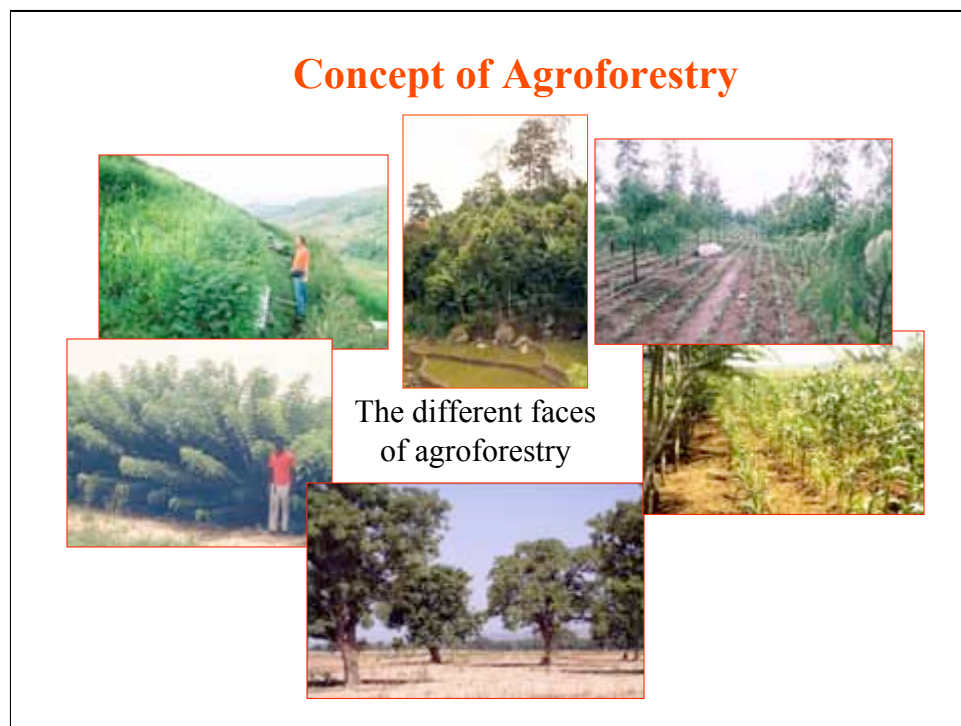
= 'agrodiversity' (Netting and Stone, 1996; Stocking, 2000).

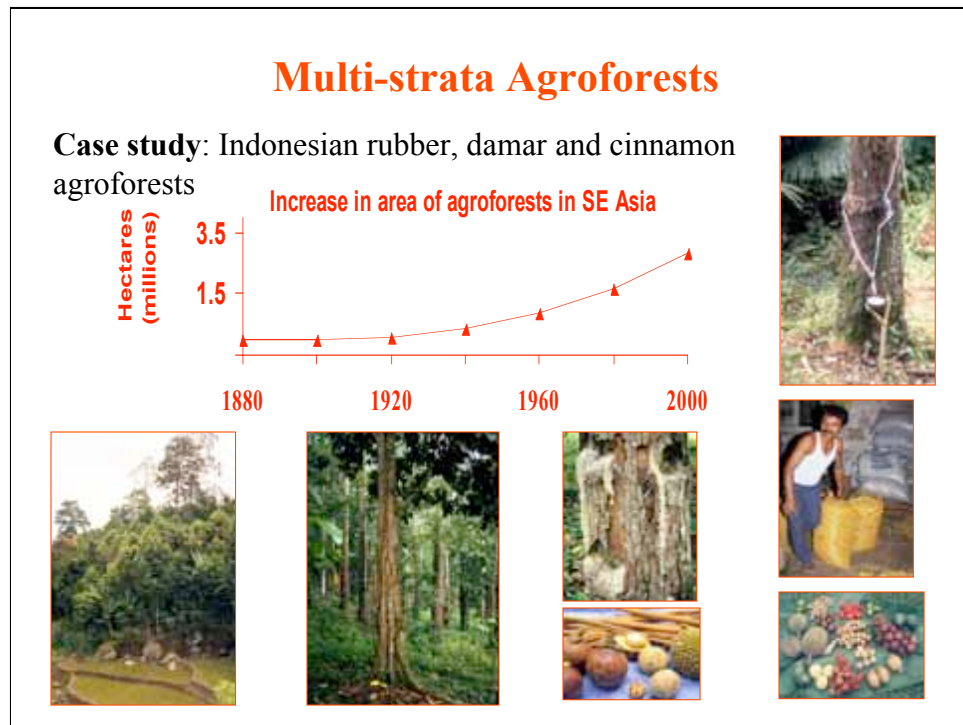
Concept of Agroforestry

This concept of 'Agroforestry' differs from:
'Farm Forestry', which is basically monocultural plantation
forestry done on-farm,
and
'Alley Farming' which is a permanent
agronomic approach to soil improvement.



Both these landuse systems do have a place in the landscape mosaic

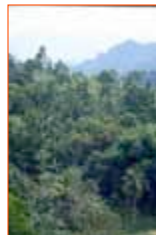




Multi-strata Agroforests

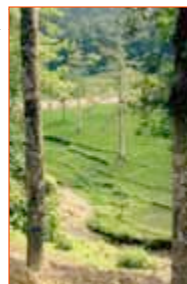
Production

70-80% of damar production
(paint and varnish industry),
95% of marketed fruits and nuts,
67% of cinnamon,
73% of Indonesia's rubber
(25% of world production).
In 1995, 1.3 million families farmed 2.5 million
produced rubber worth US\$1.9 billion.



Biodiversity = 60-70% of natural forest
(*cf.* Oilpalm = 3%)

Trace gases = sequestering carbon and methane



Multi-strata Agroforests

Income streams within year

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Rice	-	270	-	-	-	-	-	200	-	-	-	-	470
Damar	38	52	53	45	45	31	-	41	42	38	22	36	440

Others (fruits, medicinals, timber, herbs, etc)

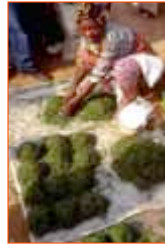
Multi-strata Agroforests

Income streams across rotation

Years 1-3	Rice and food crops
Years 4-10	Bananas, peppers, coffee, root crops, etc.
Years 11-80	Rubber, damar, cinnamon, fruits, etc.
Years 50-80	Timber

Multi-strata Agroforests

Case study: Cameroon cocoa agroforests



Multi-strata Agroforests

Cocoa agroforests: Economic evaluation and C sequestration (Gockowski and Dury, 1999)



Extensive cocoa



Intensive cocoa

Social profitability (*ie* returns per hectare adjusted for economic distortions using NPV approach) over a 30-year period with a discount rate of 10%

- Intensive cocoa with fruits (\$1755)
- Intensive cocoa without fruits (\$1236)
- Extensive cocoa with fruits (\$1136)
- Extensive cocoa without fruits (\$616)

Permanent conversion of short fallow to cocoa agroforest would remove 70 tons of carbon from the atmosphere

Potentially farmers could receive US\$700 ha⁻¹ from carbon trading.

Multistrata Agroforests

Species	Common names	Mature height (m)
<i>Anthocleista schweinfurthii</i>	Ayinda	15-20
<i>Antrocaryon micraster</i>	Aprokuma/onzabili	40-50
<i>Baillonella toxisperma</i>	Moabi	45-55
<i>Calamus spp</i>	Rattan	35-45
<i>Canarium schweinfurthii</i>	Aiele/African canarium/Incense tree	45-55
<i>Chrsophyllum albidum</i>	Star apple	30-40
<i>Cola acuminata</i>	Kola nut	15-25
<i>Cola lepidota</i>	Monkey Kola	10-20
<i>Cola nitida</i>	Kola nut	15-25
<i>Coula edulis</i>	Coula nut/African walnut	25-35
<i>Dacryodes edulis</i>	African plum/Safoutier	15-25
<i>Entandrophragma spp</i>	Sapele/Tiama/Utile/Sipo	50-60
<i>Garcinia kola</i>	Bitter Kola	20-30
<i>Gnetum africanum</i>	Ero	0-10
<i>Irvingia gabonensis</i>	Bush mango/Andok	20-30
<i>Khaya spp</i>	African mahogany	50-60
<i>Lovoa trichloides</i>	Bibolo/African walnut	40-50
<i>Milicia excelsa</i>	Iroko/Mvule/Odum	45-55
<i>Nauclea diderichii</i>	Opepe/Kusia/Bilinga	35-45
<i>Pentaclethra macrophylla</i>	Oil bean tree/Mubala/Ebe	20-30
<i>Raphia hookeri and other spp</i>	Raphia palm	5-15
<i>Ricinodendron heudelotii</i>	Groundnut tree/Nyangsang/Essessang	40-50
<i>Terminalia ivorensis</i>	Framiré/Idigbo	45-55
<i>Terminalia superba</i>	Fraké/a fra/Limba	45-55
<i>Tetrapleura tetraptera</i>	Prekese/Akpa	20-30
<i>Treculia africana</i>	African bread fruit/Etoup	20-30
<i>Trichoscypha arborea</i>	Anaku	15-25
<i>Triplochiton scleroxylon</i>	Ayous/Obeche/Wawa	55-65
<i>Vernonia amygdalina</i>	Bitter leaf	0-10
<i>Xylopia aethiopica</i>	Spice tree	15-25

Multi-strata Agroforests

Case study: East African highlands



Multi-strata Agroforests

Case study: Sahelian agroforests



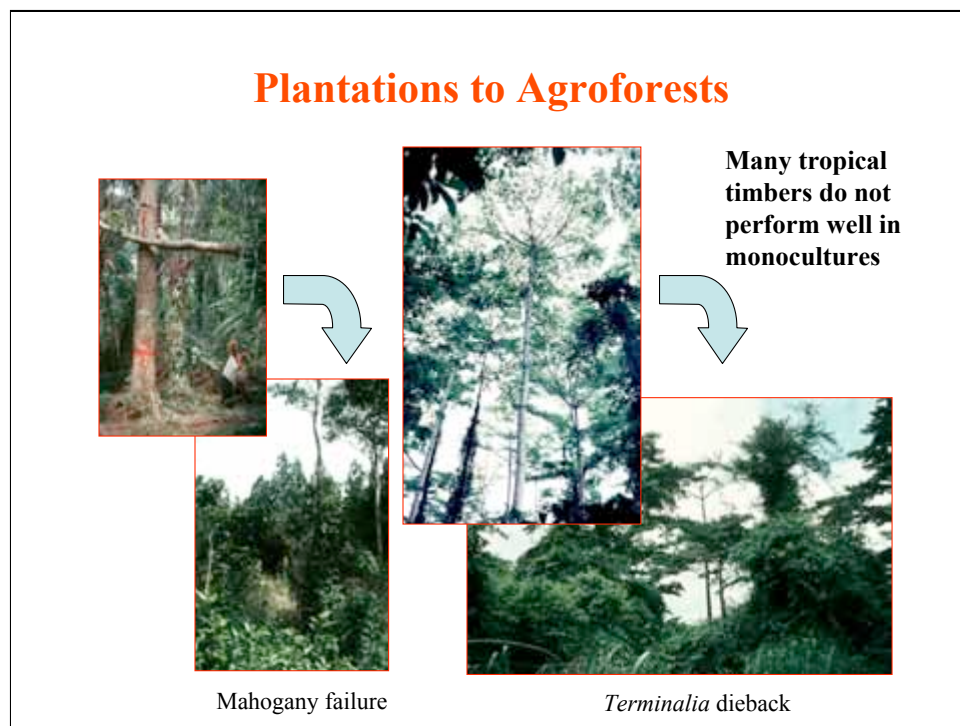
Multi-strata Agroforests



Plantations to Agroforests

Tropical monocultures being replaced by agroforests
(e.g. rubber, coffee, tea plantations, cocoa)





Cash Flow from Agroforests

Economics of farming systems: Peru (1991)

	Net present value (US\$ per ha)	Internal rate of return (%)
Agroforest	6727	831
Peach palm plantation	2061	64
Shifting agriculture	218	19
Low input agricultureNegative.....	
High input agricultureNegative.....	

Application to Ecosystems



Transfer of the
concept of mature
agroecosystems
from Moist
Tropics to Dry
Tropics:



Restore and Build
on the Parklands

Wide Range of Applications

Some of the opportunities

Medicinal plant market and hedged *Warburgia*

Living hedges around vegetable gardens

Resins and gums

Fruits for market

Fodder banks and livestock

'Pacifika' Integrated Mixed Cropping System



Are intensive, 'high-input' monocultures the best alternative?

Evidence from around the world indicates that in the tropics the answer is "No".

Advantages:-

- Diversity provides resilience and risk aversion from environmental and market failures,
- Low input expenditures maximize economic returns,
- Ecosystem services are protected and harnessed to maximize nutrient and water use efficiency, as well as to sustain the natural food chains and life cycles that regulate pests and diseases,
- Appropriate for traditional crops and amenable to the integration of tree crops (agroforestry)
- Opportunities for a diverse 'portfolio' of natural resource investments in a mixture of crops meeting domestic and market needs,
- Opportunities for inclusion of speciality crops for 'niche' markets as well as the staple foods,
- Perennial crops, especially trees for timber and indigenous fruits and nuts ('Agroforestry Tree Products'), provide a 'bank account' for the next generation,
- Suitable for marginal land and protection of hillsides and water catchments.

Constraints to Agroforestry

Constraints to developing mature agroecosystems:-

- Policies, or the lack of them
- Property rights
- Degradation of soil microflora
- Commercial opportunities for indigenous trees
- Improved germplasm of indigenous trees
- Availability of markets for tree products



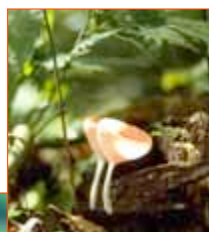
NB not land availability

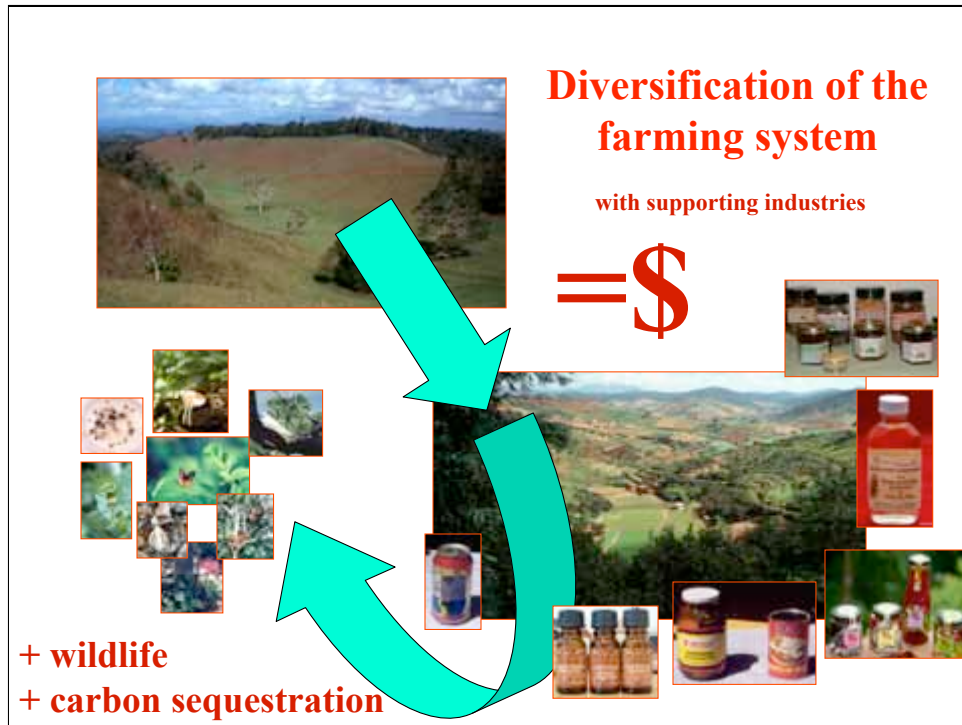


Public Good Benefits

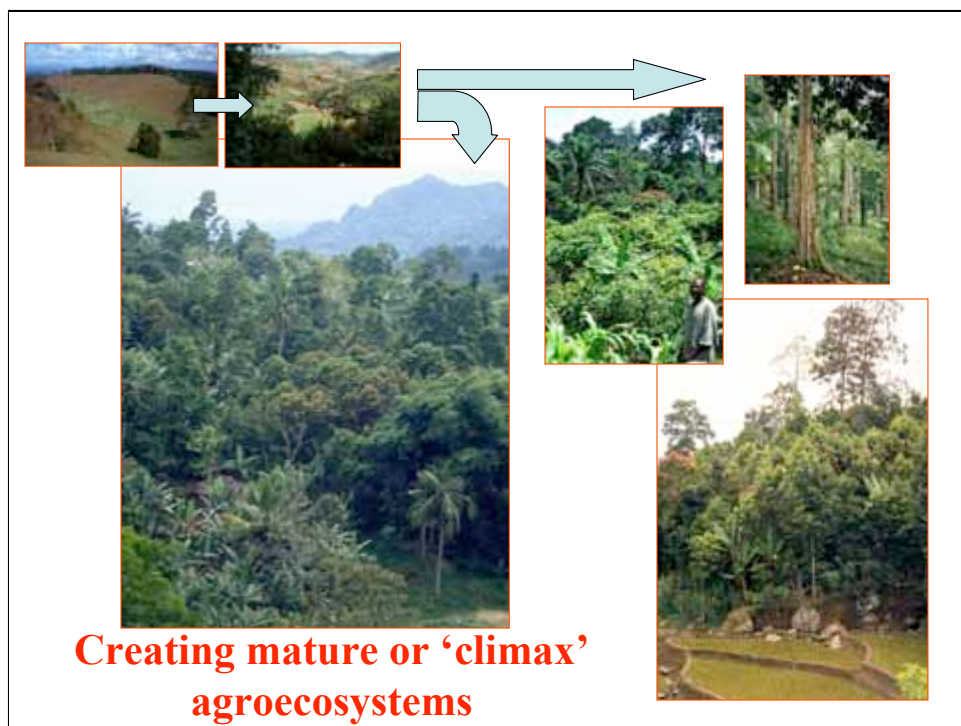
Global benefits:- Sequestration of trace gases for reduction of climate change

Biodiversity protection





Agroforestry: Tree-based Polycultures



Millennium Development Goals for 2015

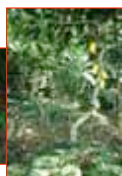
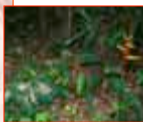
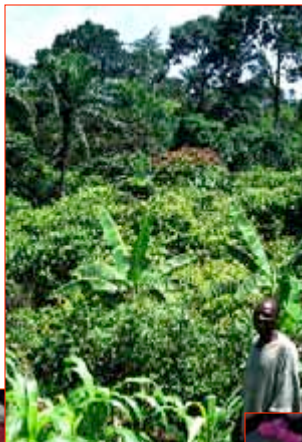
- Goal 1.** Eradicate extreme poverty (< \$1 per day) and hunger
- Goal 2.** Achieve universal primary education
- Goal 3.** Promote gender equality and empower women
- Goal 4.** Reduce child mortality – by 66% for children under 5 years old
- Goal 5.** Improve maternal health – by 75%
- Goal 6.** Combat HIV/AIDS, malaria and other diseases
- Goal 7.** Ensure environmental sustainability – integrate principles into country policies and programmes, and reverse the loss of environmental resources
- Goal 8.** Develop a global partnership for development

Concept of Agroforestry

Sustainable landuse:

1. Livelihoods of local people
2. Export commodities
3. International public goods and services

**PICK UP THIS THEME IN:
“AGROECOLOGY AND
SUSTAINABILITY”**



Cocoa agroforest
with maize

