Opportunity Cost Analysis of Land Use Changes in Karen Indigenous Community in Thailand

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Introduction and Rationale

- In the northern region of country, the forest land decreased from 113,595 sq. km in 1973 to 74,042 sq.km
- Areas of rice and vegetables decreased from 2007-2015, areas of maize increased to 1.14 million hectares in 2013

Conversion of rice and vegetables to corn

Open burning of maize residues could increase emissions at 0.08 ton CO2 and dust at 7.28 tonne (Arjhan, 2012)

Expansion of maize production in Thailand have increased the imports of chemical fertilizers, the use of chemical fertilizers increased to 2 million tonne in 2004 (Tirado et al., 2008)

More than 90 types of food plants were found tin the traditional rotational farming system of Karen communities in northern Thailand (NDF and Hin Lad Nai community, 2011)

Objectives of the Study

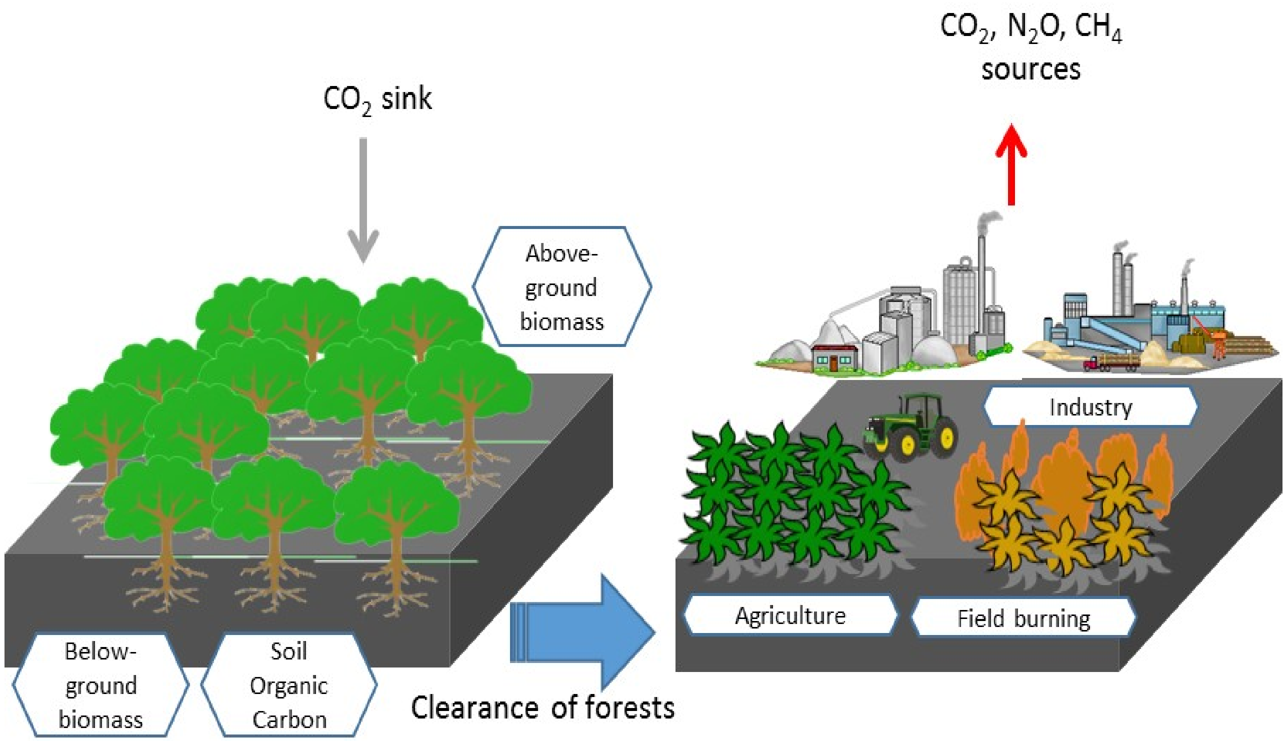
To examine the net present value and carbon stocks of main type of land use, and opportunity cost of land use changes for intensive monocrop agriculture

This study is a part of IGES research project, entitle "*Biodiversity and ecosystem values of, and indigenous and local knowledge in, Karen rotational farming systems in northern Thailand*"

I. Impacts of Land Use and Land Use Change on Greenhouse Gases Emissions

- Land use and land-use change directly affect the exchange of greenhouse gases between terrestrial ecosystems and the atmosphere (IPCC, 2007)

- Clearing of forests for use as cropland accounted for the largest fraction of CO2 emissions from net land-use change; emissions from conversion to pastures and shifting cultivation were lower (Houghton et al., 1999)



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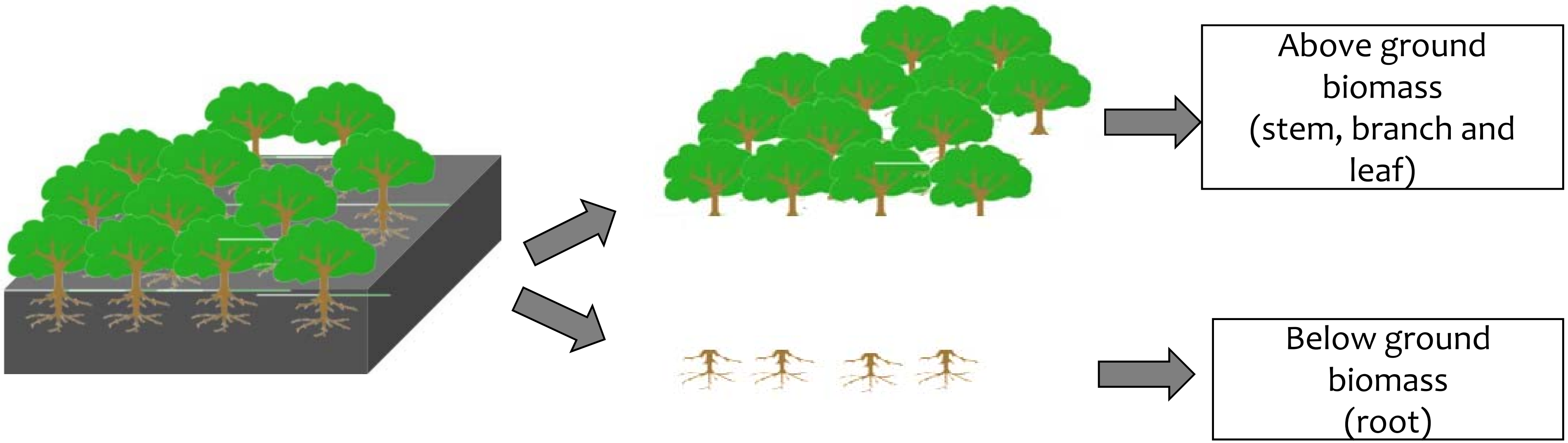
Carbon Stock Calculation of Forest Land



Total biomass of tree (ton/ha) = Above ground biomass + Below ground biomass

Total carbon stocks of tree (ton/ha) = Total biomass of tree x 0.5

Equations for Biomass Calculation of Conservation Forest

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Biomass of stem (W_S) = $0.0509*(D^2 H)^{0.919}$
Biomass of branch (W_B) = $0.00893*(D^2 H)^{0.977}$
Biomass of leaf (W_L) = $0.0140*(D^2 H)^{0.669}$
Root biomass (W_R) = 24% of Aboveground biomass of tree

Total carbon content of tree (ton/ha) = $(B_S+B_B+B_L+B_R) \times 0.5$

Biomass of the groundcover plants (G_C) => Dried weight of groundcover plants and litters

Total groundcover carbon content (ton/ha) = $(G_C) \times 0.5$

Carbon content of top soil horizon (S_T)= Soil mass x 58% OM

Carbon stocks= $C_i x A_i$; CO_2 stock = Carbon stocks x 3.67

Sources: Tsutsumi et al. (1983); Cairns et al. (1997); Jobbagy and Jackson (2000)

Carbon Stock Calculation of Rotational Farming

- In Thailand, the fallow periods of Karen's traditional rotational farming is 8-12 year fallow cycle

- The above-ground carbon stock on land under RF was estimated at 152 ton/ha at Hin Lad Nai community, which employs a 10-year rotational cycle (NDF and Hin Lad Nai community, 2011; Trakansuphakon, 2015), 46 ton/ha for the 8-year cycle at Mae Lan Kham community (Mae Lan Kham Community-IKAP-RECOFTC, 2014), and 97 ton/ha for the 6-year cycle at Tee Cha community (Takeuchi et al., 2014).

II. Estimating of Net Present Value (NPV)

Net present value of land use is future net cash flows generated by each land use

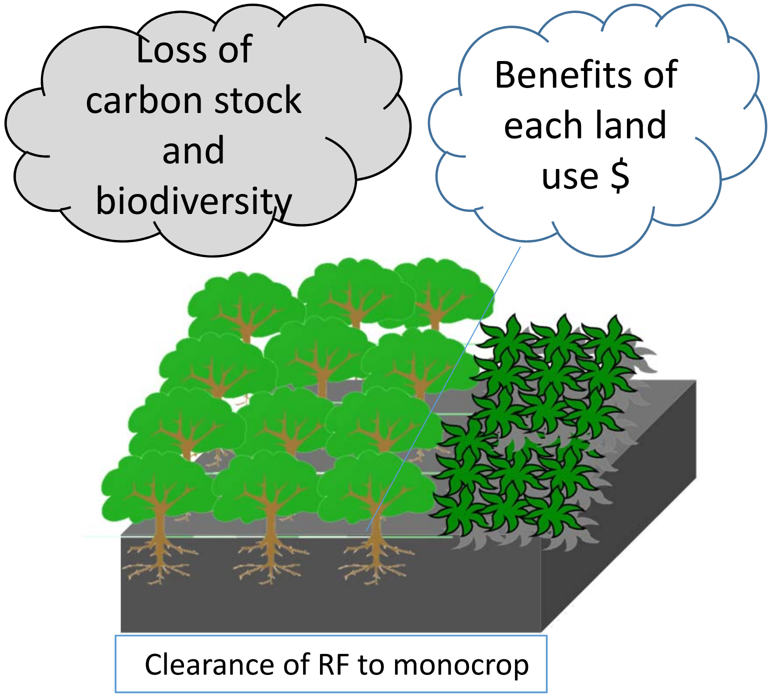
Equation for estimating of **NPV**$_i$ = $\sum_{t=0}^{n} \frac{(Revenue-Cost)_t}{(1+r)^t}$

r = A discount rate of 5%

t = a 20 year timeframe

Revenue$_i$ = Revenues of land use i categories (US$/ha/year)

Cost$_i$ = Cost of land use i categories (US$/ha/year



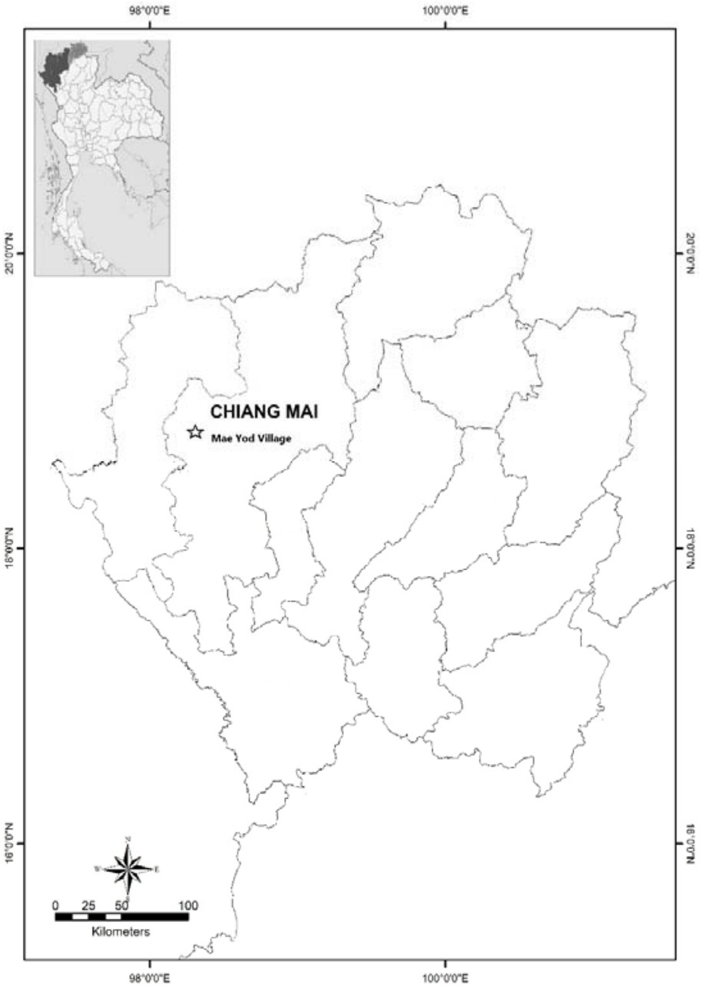
Total revenue = Price (US per ton) x Yield (ton per ha)

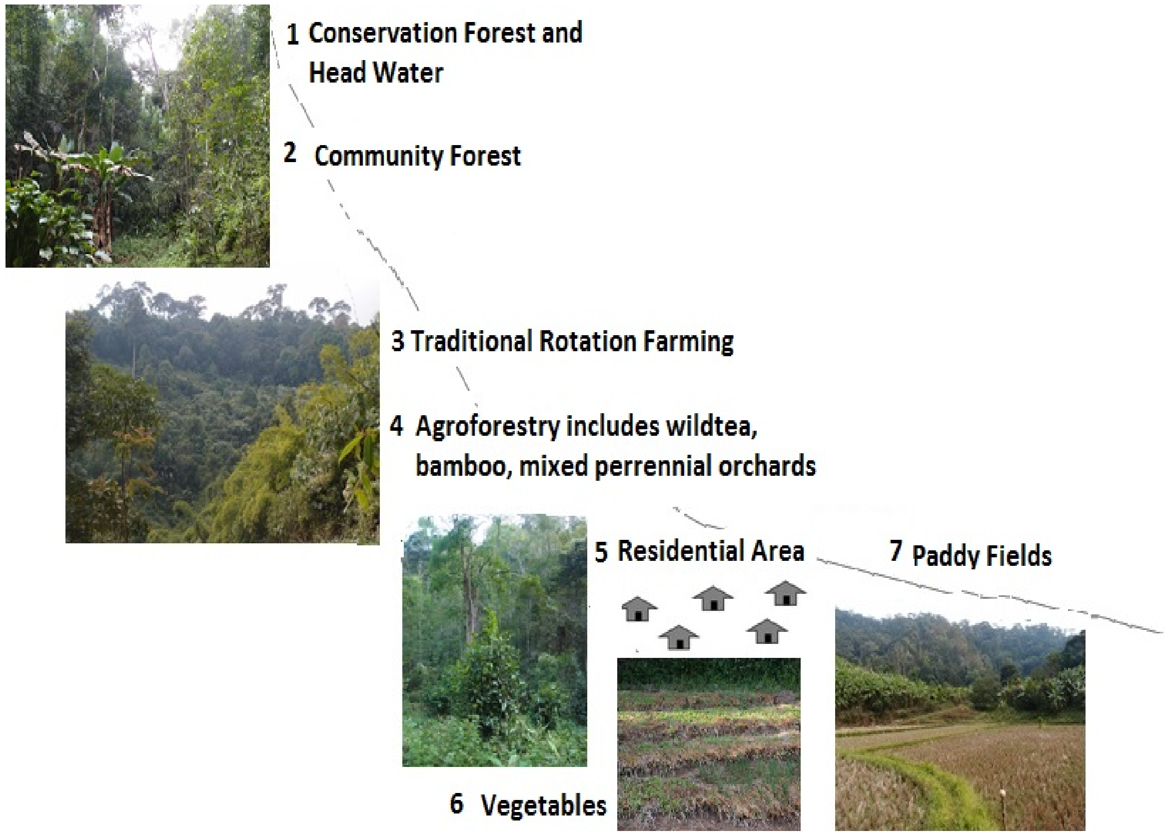
Total cost = Seeding + Fertilizers + Pesticides+ Labour

Opportunity cost (OC) of land use change (World Bank, 2011) is calculated from the difference in net present value (NPV) and carbon emission caused by land use change

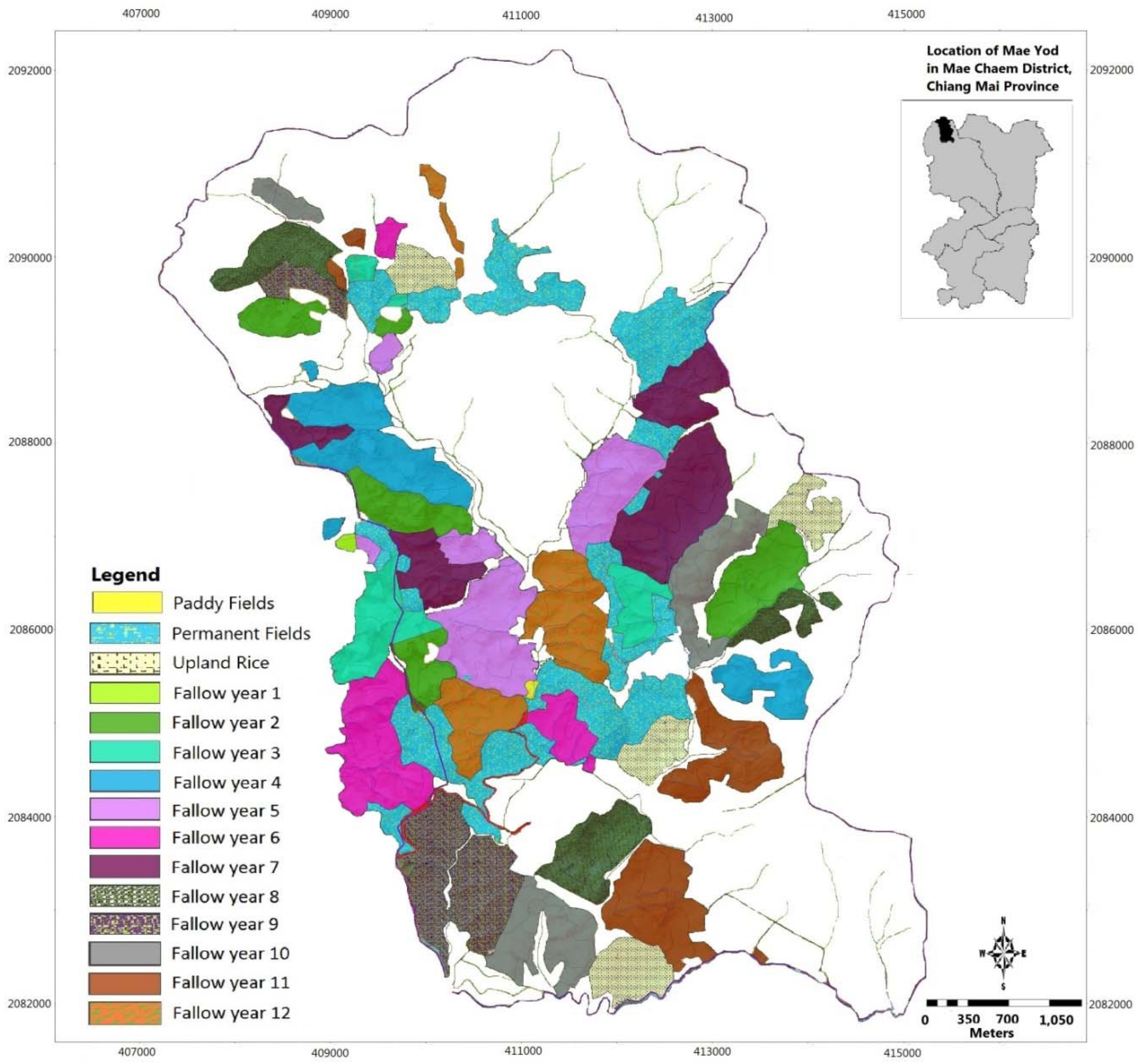
Equation for estimating OC = $\frac{\text{NPV}_{after} - \text{NPV}_{before}}{\text{CO2}_{stock\_before} - \text{CO2}_{stock\_after}}$

III. Case Study in Mae Yod Village, Chiang Mai Province





Traditional land use in Mae Yod Village



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Type of land use	Area	
	Ha	%
Forest land	2,503.10	49.64
• Conservation forest and head water	1,638.27	32.49
• Utility forest	864.83	17.15
Agricultural land	2,487.31	49.32
• Rotation farming	1,853.64	36.76
Fallow year 1	3.28	0.07
Fallow year 2	184.51	3.66
Fallow year 3	108.83	2.16
Fallow year 4	170.61	3.38
Fallow year 5	203.09	4.03
Fallow year 6	145.48	2.88
Fallow year 7	235.63	4.67
Fallow year 8	144.23	2.86
Fallow year 9	163.56	3.24
Fallow year 10-12	494.43	9.80
• Paddy field	2.04	0.04
• Permanent field (Adzuki bean and maize)	631.63	12.53
Residential areas	52.53	1.04
Total	5,042.94	100.00

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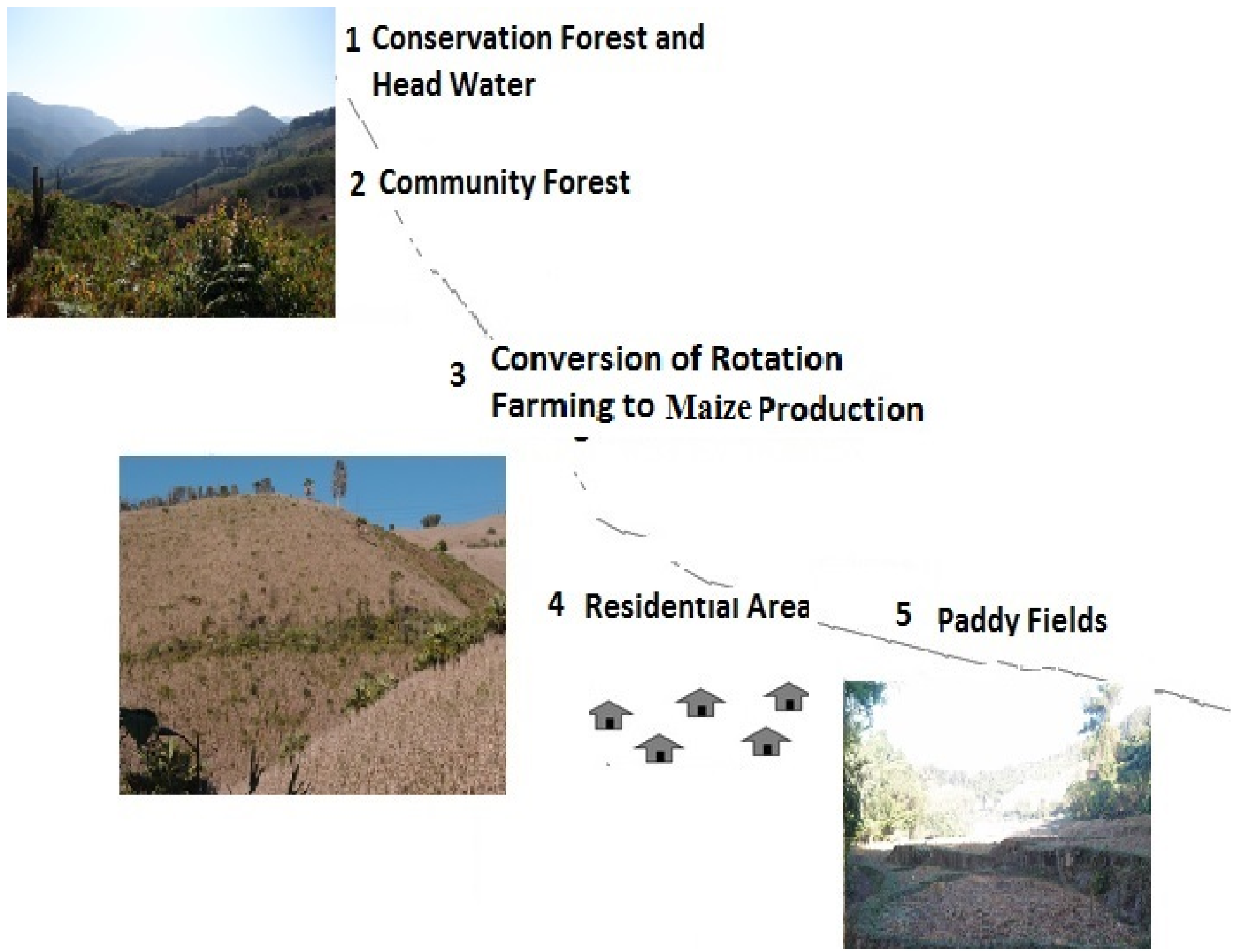
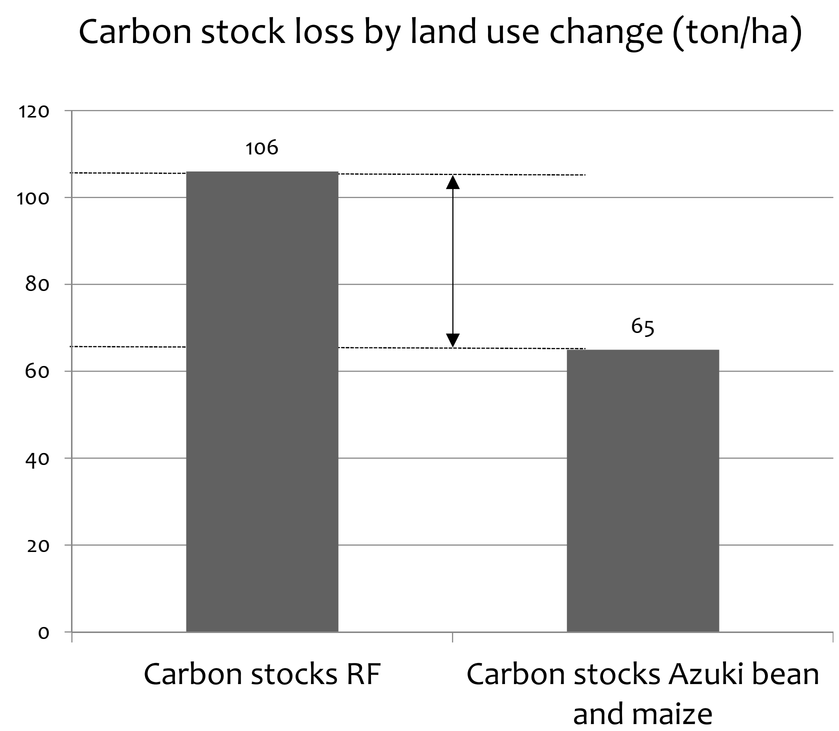
Conversion of traditional rotational farming to modern monocrop farming in other neighbour villages of Mae Yod Village

Over the past 20 years, the rotational farming decreased in the study site, while the conservation forest and head water substantially increased. Some rotational farming fields were abandoned due to limited farm labours.



Carbon Stocks across Land Use Change in Mae Yod Village

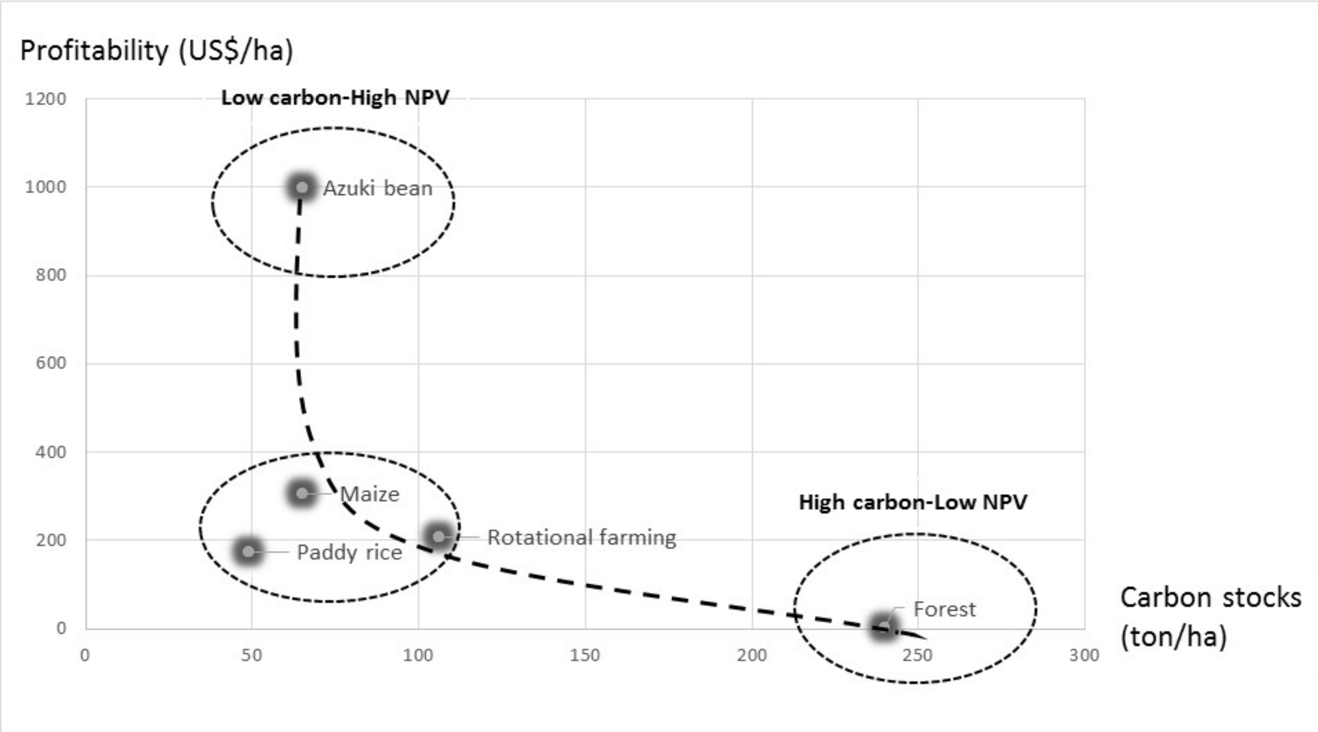
Type of land use	Carbon stocks (ton/ha)	Area (ha)	Total carbon stocks (ton)
Forest land		2,503.10	527,233.99
• Conservation forest and head water	240	1,638.27	393,185.28
• Utility forest	155	864.83	134,048.71
Agricultural land		2,487.31	261,246.39
• Rotation farming		1,853.64	220,090.17
Fallow year 1	96	3.28	314.88
Fallow year 2	95	184.51	17,528.03
Fallow year 3	104	108.83	11,318.36
Fallow year 4	105	170.61	17,913.67
Fallow year 5	96	203.09	19,497.06
Fallow year 6	93	145.48	13,529.34
Fallow year 7	106	235.63	24,976.31
Fallow year 8	121	144.23	17,452.27
Fallow year 9	137	163.56	22,407.06
Fallow year 10-12	152	494.43	75,153.18
• Paddy field	49	2.04	100.04
• Permanent field	65	631.63	41,056.18



Profitability of Each Land Use in Mae Yod Village

Items	$RF_{upland\ rice}$		Paddy rice		Azuki bean		Maize		Forests
1. Total costs (US$ per ha)	1,127.6	%	474.86	%	742.74	%	758.73	%	none
1.1 Seeds	55.10	5	70.76	15	120.94	16	8.51	1	
1.2 Fertilizers and pesticides	none		22.29	5	115.58	16	265.45	35	
1.3 Labours	1,072.5	95	381.81	80	506.22	68	484.77	64	
2. Total revenues (US$ per ha)	3,933.13		751.68		2,344.0		1,250.08		1.7
2.1 Selling price (US$ per kg)	0.29		0.16		1		0.16		
2.2 Yields (ton per ha)	13.563		4.698		2.344		7.813		
3. Profits (1-2)	2,805.53		276.82		1,601.26		491.35		1.7

Cluster of land use by net present value (NPV) and carbon stocks in Mae Yod Village



Type of land use	Total NPV (US$)	NPV (US$/ha/year)	Carbon stocks (ton/ha)	CO_2 stocks (ton/ha)
RF upland rice	4,159.77	208	106	389.02
Paddy rice	3,449.79	173	49	179.83
Azuki bean	19,955.24	998	65	238.55
Maize	6,123.31	306	65	238.55
Forest	20.55	1.03	240	880.80

Estimation of Opportunity Cost of Land Use Change in Mae Yod Village

The opportunity cost assessment of land use change covered four scenarios: 1) rotational farming to Azuki bean (RF-B), 2) rotational farming to maize (RF-M), 3) rotational farming to paddy rice (RF-R), and 4) forest to rotational farming (F-RF)

$$OC_{RF\text{-}B} = \frac{998-208}{398.02-238.55} = \frac{790}{150.47} = 5.25 \text{ US\$ per ton} CO_2$$

$$OC_{RF\text{-}M} = \frac{306-208}{398.02-238.55} = \frac{98}{150.47} = 0.65 \text{ US\$ per ton} CO_2$$

$$OC_{RF\text{-}R} = \frac{173-208}{398.02-179.83} = \frac{-35}{209.19} = -0.17 \text{ US\$ per ton} CO_2$$

$$OC_{F\text{-}RF} = \frac{208-1.03}{880.80-398.02} = \frac{206.97}{491.78} = 0.42 \text{ US\$ per ton} CO_2$$

Initial/Final	Rotational farming	Paddy fields	Azuki bean	Maize	Forest
Rotational farming		**-0.17**	**5.25**	**0.65**	**0.42**
Paddy fields	-0.17		-14.05	-2.26	0.25
Azuki bean	5.25	-14.05			1.55
Maize	0.65	-2.26			0.47
Forest	0.42	0.25	1.55	0.47	

Conclusions

Conversion of forest land to monocrop land increased CO_2 emissions from loss of exiting tree biomass (880.80-238.55= 642.25 tonCO_2 per ha) and also environmental impacts from increased use of chemical inputs for improvement of its yield and production efficiency.

Traditional rotational farming (RF) maintained high land productivity of upland rice (13.56 ton/ha), and contribute to conservation of biodiversity and ecosystem services through applying organic pest control methods and gently piercing the soil surface for planting and weeding.

Recommendation

- Government need to be more aware longer-term environmental costs and values of biodiversity loss from conversion of land into monocrop agriculture.
- Traditional rotational farming continues to be practiced in agricultural land without deforestation, and contribute to conservation of biodiversity and ecosystem service.
- Government should explore strategies to increase the role of Karen communities in forest management and maintain of biodiversity

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Thank you very much for your attention