Economic feasibility of conservation agriculture production system (CAPS) for smallholder tribal farmers in Nepal

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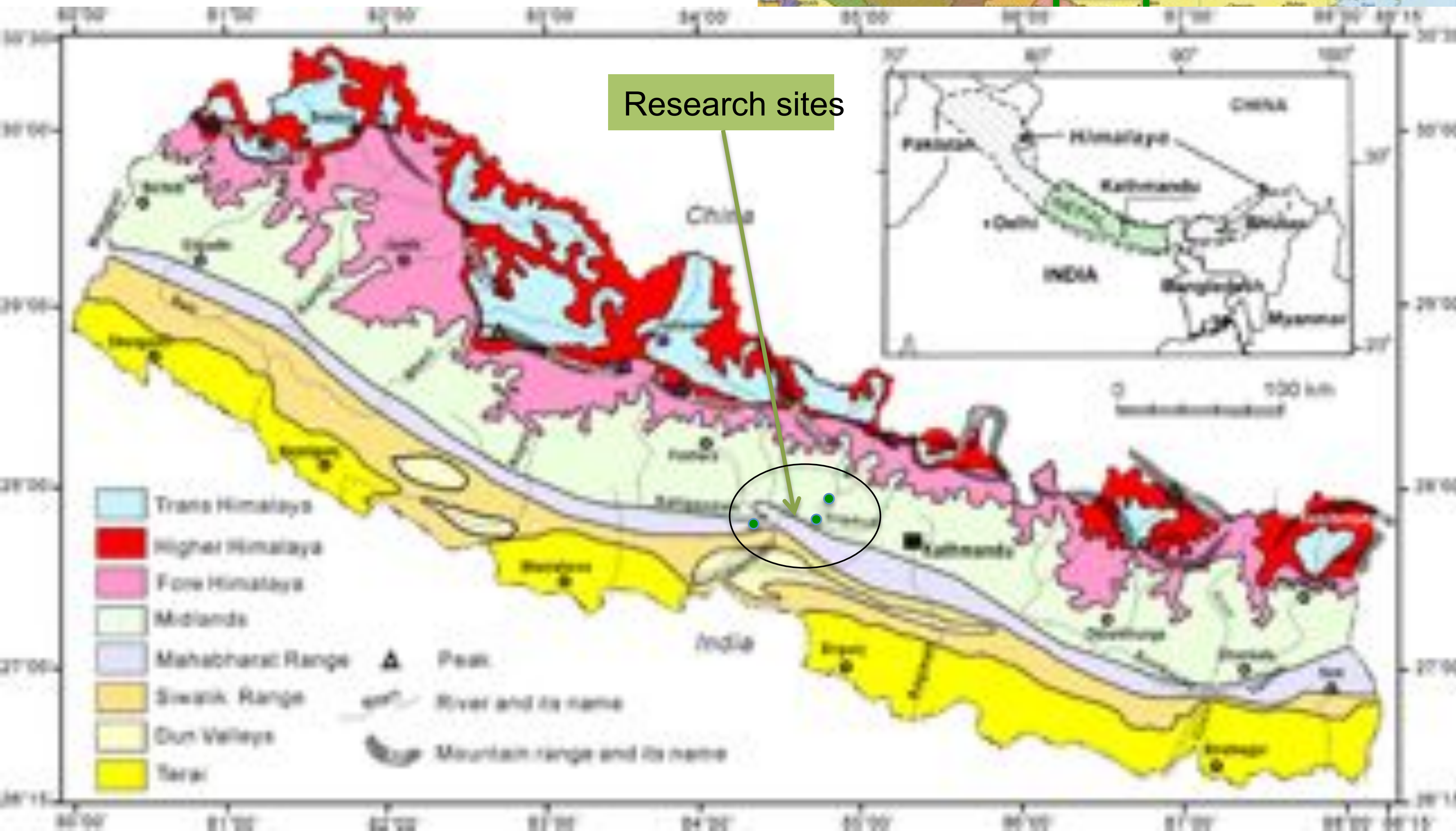
Nepal: mid-hill



CONTEXT

Agriculture in mid-hills of Nepal

- maize-based rain-fed cropping system

Maize crop (cover about 80%) of land in 1st season;

Followed by,

- Millet = 37.9%
- Cowpea → 1.3%;
- Black gram → 2.6%
- Other legume (soybean, horse gram, green gram, pea, rice bean etc.) → 6.2%

Problems: agriculture in mid-hills of Nepal

- Cultivation at steep slope
- Long open fallow after winter plowing (Khanal, 2004)
- Low productivity
- Serious problem of soil degradation (MoEST, 2006; Manandhar et al, 2009)
- Annual soil loss of 3-20 t/ha (Gardner et al. 2000), up to 105 t/ha (Chalise and Khanal, 1997)
- Downward poverty spiral (Upadhaya, 2010)

Conservation Agriculture Production system (CAPS)

- CA combine profitable agricultural production with environmental concerns and sustainability (FAO, 2013, Kassam et al., 2009; Jat et al., 2010)
- High potential of CA to develop sustainable agro-ecological system in Nepal (Atreya et al., 2008; Acharya, et al., 2007)
- CA needs to be evaluated and customized for local condition (Knowler and Bradshaw; 2007)

RESEARCH QUESTIONS

- **IS** Conservation Agriculture Production System (CAPS) economically feasible in short and long run for smallholder farmers in Nepal?
- **WHAT** would be the best cropping strategy to transform the current conventional agriculture to CAPS for smallholder farmers in Nepal?

METHODOLOGY

Data and sources:

PRIMARY

- Baseline data – to specify input constraints of representative household (37 HHs from 3 villages)
- On-farm trial data –crop yield variation, cost of production variation, monthly labor distribution among CAP systems

SECONDARY:

- Long-term crop yield of CAPS generated using the results of Thierfelder et al. (2013) (verified by Liu et al. (2013) & Paul et al. (2013))

ANALYSIS: Net present value (NPV) estimation

$$NPV = \sum_{t=0}^{n} \frac{(\text{Benefits} - \text{Costs})_t}{(1 + r)^t}$$

where:
r = discount rate
t = year
n = analytic horizon (in years)

- Discount rate was taken as 3%

<u>Two levels of NPVs were estimated</u>

- ❑ NPV_{BLC} = NPV was not adjusted for labor cost
- ❑ NPV_{ALC} = NPV was adjusted for opportunity cost of labor

FRAMEWORK of LP NPV maximization model

INPUTS

- ❑ Crop yield (kg/m2)
- ❑ Cost of production ($/m2)
- ❑ Monthly labor requirement (hours)
- ❑ Price ($/kg)

- ❑ Projection of crop yield change under CAPS for 10 years

- ❑ Soil loss (kg/ha)

MODELS

MODEL OBJECTIVES

1.Max NPV

◆ NPV_{BLC} (before labor)

◆ NPV_{ALC} (after labor)

DECISION VARIABLE

Allocation of land area (m^2)

MODEL CONSTRAINTS

Household production constraints

Linking constraints

OUTPUTS

Optimum allocation of land area

- ❑ **NPV_{BLC} / NPV_{ALC} ($)**

- ❑ Soil loss (tons)
- ❑ Maize prod

Household production constraints

Model household profile:

- Land for maize-based CA system = 4,670 m2
- Labor available per month:
  - 504 hours/month (3 person x 24 days/month x 7 hours/day)
  - Sensitivity analysis (+1 person for a month)
- Cash flow: $ 400.00 for a season
- Consumption needs: produces millet at least 30 Kg for cultural needs

Linking constraints

Cropping system and rotation constraints

- Cropping sequence within a year
- Yearly crop rotation

Conservation agriculture constraints

- No CAPS area in year 1
- Continuous strip tillage

CA Enforced model constraints

- All the area in year 10 under CAPS

CAPS TREATMENTS

Systems	Crops		FARMING Practice	Tillage	Remark
	1st (Mar-Jul)	2nd (Jul-Oct)			
FT Maize-->Millet	Maize	Millet	Sole crop	Conventional	
FT Maize-->Blackgram	Maize	Blackgram	Sole crop	Conventional	
FT Maize-->Cowpea	Maize	Cowpea	Sole crop	Conventional	
FT Maize-->Mi+BG	Maize	Blackgram	Intercrop	Conventional	
FT Maize-->Mi+Cp	Maize	Cowpea	Intercrop	Conventional	
ST Maize-->Mi+BG	Maize	Blackgram	Intercrop	Strip tillage	FULLCAPS
ST Maize-->Mi+Cp	Maize	cowpea	Intercrop	Strip tillage	FULLCAPS

NOTE: FT = full tillage, ST = Strip tillage; Mi+BG = millet and blackgram intercrop; Mi+Cp = millet and cowpea intercrop

--> sign indicate preceding crop was followed by the succeeding crop in second season

Coefficients for model

Yield & Soil Loss Coefficients for the Model (source: on-farm trial data $ baseline data)

Systems	Maize (t/ha)	Millet (t/ha)	Cowpea (t/ha)	Black gram (t/ha)	Estimated soil loss (t/ha/year)
FT Maize-->Millet	2.171	0.709			26.10
FT Maize-->Blackgram	2.448			0.764	23.30
FT Maize-->Cowpea	2.352		1.001		23.30
FT Maize-->Mi+BG	2.253	0.551		0.372	18.20
FT Maize-->Mi+Cp	2.319	0.347	0.745		18.20
ST Maize-->Mi+BG	2.293	0.523		0.368	3.40
ST Maize-->Mi+Cp	2.293	0.289	0.680		3.40

NOTE: FT = full tillage, ST = Strip tillage; Mi+BG = millet and blackgram intercrop; Mi+Cp = millet and cowpea intercrop

--> sign indicate preceding crop was followed by the succeeding crop in second season

Enterprise budgeting coefficients

Cost of production (CoP), labor requirement and revenue

Systems	COP_{BLC}($)/ha	Labor (person. days/ha)	Labor cost ($/hr)	Revenue ($)	$Profit_{BLC}$ ($)	$Profit_{ALC}$ labor $
FT Maize-->Millet	203	516	1146	1314	1111	-35
FT Maize-->BG	209	514	1143	2248	2039	897
FT Maize-->Cp	203	461	1025	2190	1987	962
FT Maize-->Mi+BG	210	633	1406	1821	1611	206
FT Maize-->Mi+Cp	207	686	1524	2040	1833	309
ST Maize-->Mi+BG	210	608	1351	1822	1612	261
ST Maize-->Mi+Cp	207	633	1408	1934	1727	319

NOTE: BLC = before labor cost, ALC = after labor cost, FT = full tillage, ST = Strip tillage; Mi +BG = millet and blackgram intercrop; Mi+Cp = millet and cowpea intercrop
--> sign indicate preceding crop was followed by the succeeding crop in second season

RESULTS

Structure of result

1. Maximize NPV WITHOUT LABOR OPPORTUNITY cost (NPV_{BLC})

2. Maximizing NPV WITH LABOR OPPORTUNITY cost (NPV_{ALC})

3. Comparison of model results for situations when:

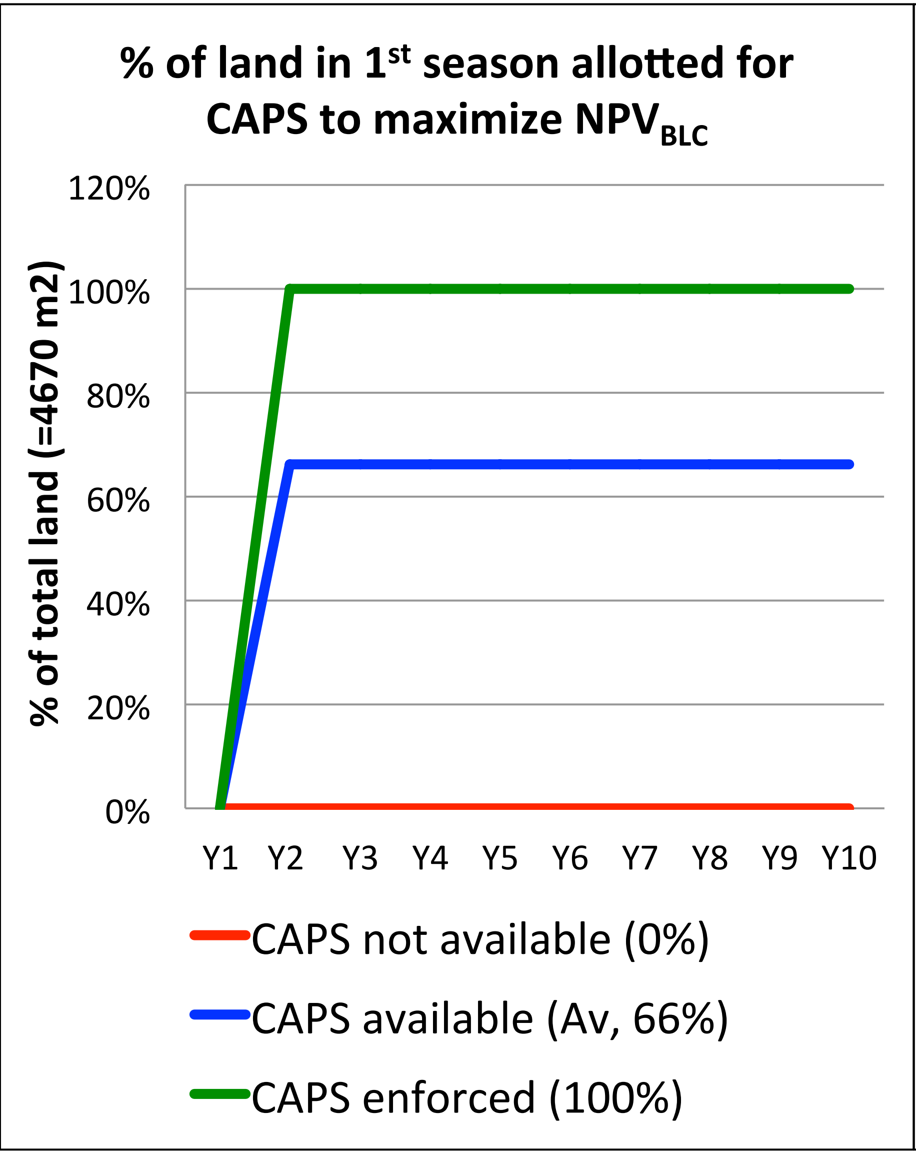
- ✓ CAPS not available,
- ✓ CAPS available to choose,
- ✓ CAPS enforced to 100% area

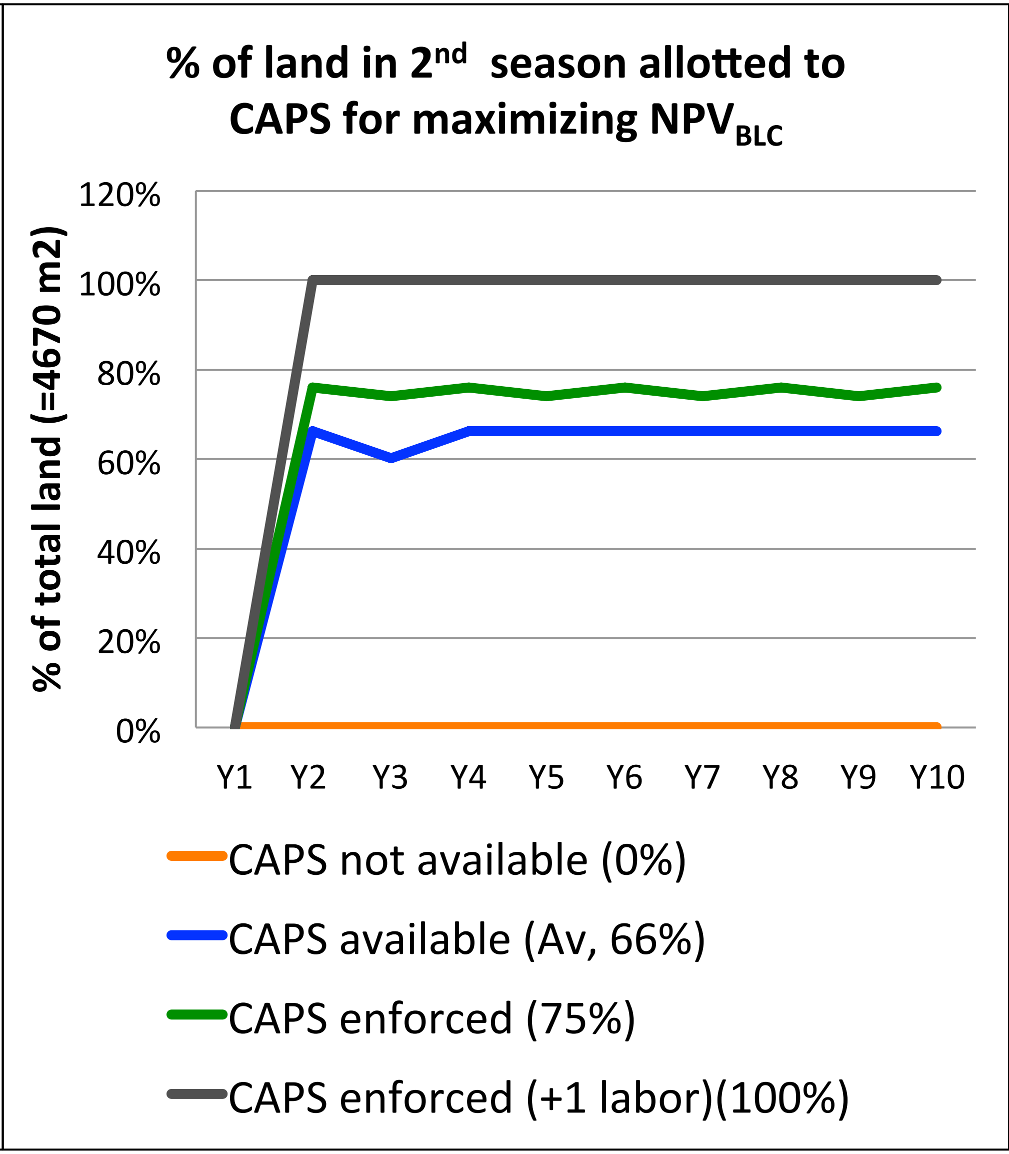
❖ **Sensitivity ANALYSIS (CA enforced model)**

- ✓ Addition of +1 labor person/day in during peak cropping period
- ✓ Change in yield projections

1. Maximize NPV <u>WITHOUT OPPORTUNITY LABOR</u> cost (NPV_{BLC})

% of land area allocation to CAPS : Maximizing NPV_{BLC}





Best cropping strategy for transition to CAPS enforced in 10 years (by maximizing NPV_{BLC})

System	Area (m²) in different Years									
	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
FT Maize	1843									
FT Black gram (BG)	1453									
FT Cowpea (Cp)										
FT Maize	2827									
FT Millet + BG										
FT Mi + Cp	2827									
ST Maize		4670	4670	4670	4670	4670	4670	4670	4670	4670
ST (Mi + BG)		3555		3555		3555		3555		3555
ST (Mi + Cp)			3461		3461		3461		3461	

<u>Sensitivity to labor availability :</u>

If we add +1 labor for Aug & Sep, all the lands in 2nd season was under strip tillage (Mi+BG or Mi+Cp)

Land allocation by model Maximizing NPV_{BLC}

- About two third (66%) of land put under CAPS while maximizing NPV_{BLC}
- If the CAPS area was enforced to 100% in 10 years, all the lands in 1st season can be put under CAPS, but about 9% of land in 2nd season can not be covered with CAPS under current labor availability
- Addition of 1 labor person during Aug & Sep (the peak crop season) put all the lands under crops in 2nd season

- **Maximizing NPV after opportunity cost of labor cost (NPV_{ALC})**

Best cropping strategy for transition to CAPS in 10 years to maximize NPV_{ALC}

System	Area (m^2) in different Years									
	1	2	3	4	5	6	7	8	9	10
FT Maize	423									
FT Millet (Mi)	423									
FT Maize	4247									
FT Black gram (BG)	2914									
FT Cowpea (Cp)										
ST Maize		4670	4670	4670	4670	4670	4670	4670	4670	4670
ST (Mi + BG)		715		521		452		439		439
ST (Mi + Cp)			1072		864		3461		3461	

<u>Sensitivity to labor availability :</u>

If we add +1 labor for Aug & Sep, small increase in the areas of ST (Mi +BG or ST (Mi+Cp), not as sensitive as Max NPV_{BLC} model

Land allocation for CAPS by Max NPV_{ALC} models

- Only about 9% of land was allocated to CAPS in both 1st and 2nd season of year
- Increased availability of HH labor was also not effective to increase the area under CAPS if the opportunity cost is considered

Labor opportunity cost in study villages

<u>**No labor opportunity cost scenario is realistic**</u>

- ➢ The research sites are central mid-hill villages in Nepal, where there is very less alternative opportunities of the off-farm jobs
- ➢ Minimizing total labor is not essential, until all labor required for cultivation is supplied from household

- ❖ Because of increased migration of the labor from villages in recent years, labor scarcity for agriculture works inside the village is expected in near future

- **Comparison of model results for situations when:**
  - ✓ CAPS not available,
  - ✓ CAPS available to choose,
  - ✓ CAPS enforced to 100% area

Profits, food production and soil conservation by adoption of CAPS

Comparison of the outputs under maximizing NPV_{BLC} model					
	CAPS not available	CAPS available to choose		CAPS enforced in 100% area	
NPV_{BLC} ($)	**7713**	**7917**	**2.6%**	**7167**	**-7.1%**
NPV_{ALC} ($)	2553	2426	-4.9%	2139	-16.2%
Maize production	11.0	11.9	8.9%	12.4	12.8%
Soil loss (tons)	103.2	53.4	-48.2%	27.9	-73.0%

- Compare 1st and 2nd situations for advantage of having CAPS
- Compare 1st and 3rd situation for advantages of adopting CAPS in all available lands

Profits, food production and soil conservation by adoption of CAPS

- Net Present Value (NPV) of the adopting CAPS was positive after 10 year period
- Farmers can increase their NPV_{BLC} and NPV_{ALC} by adopting combination of CAPS and non-CA agriculture systems
- If CAPS are made available for farmers, farmers can increase about 2% of NPV_{BLC} (--by adopting CAPS in about 66% of land)
- There was about 7% loss in NPV_{BLC} by enforced adoption of CAPS, BUT that reduced soil loss by about 73% and increase food production by about 12%

Sensitivity

Sensitive to accounting of labor cost in NPV:

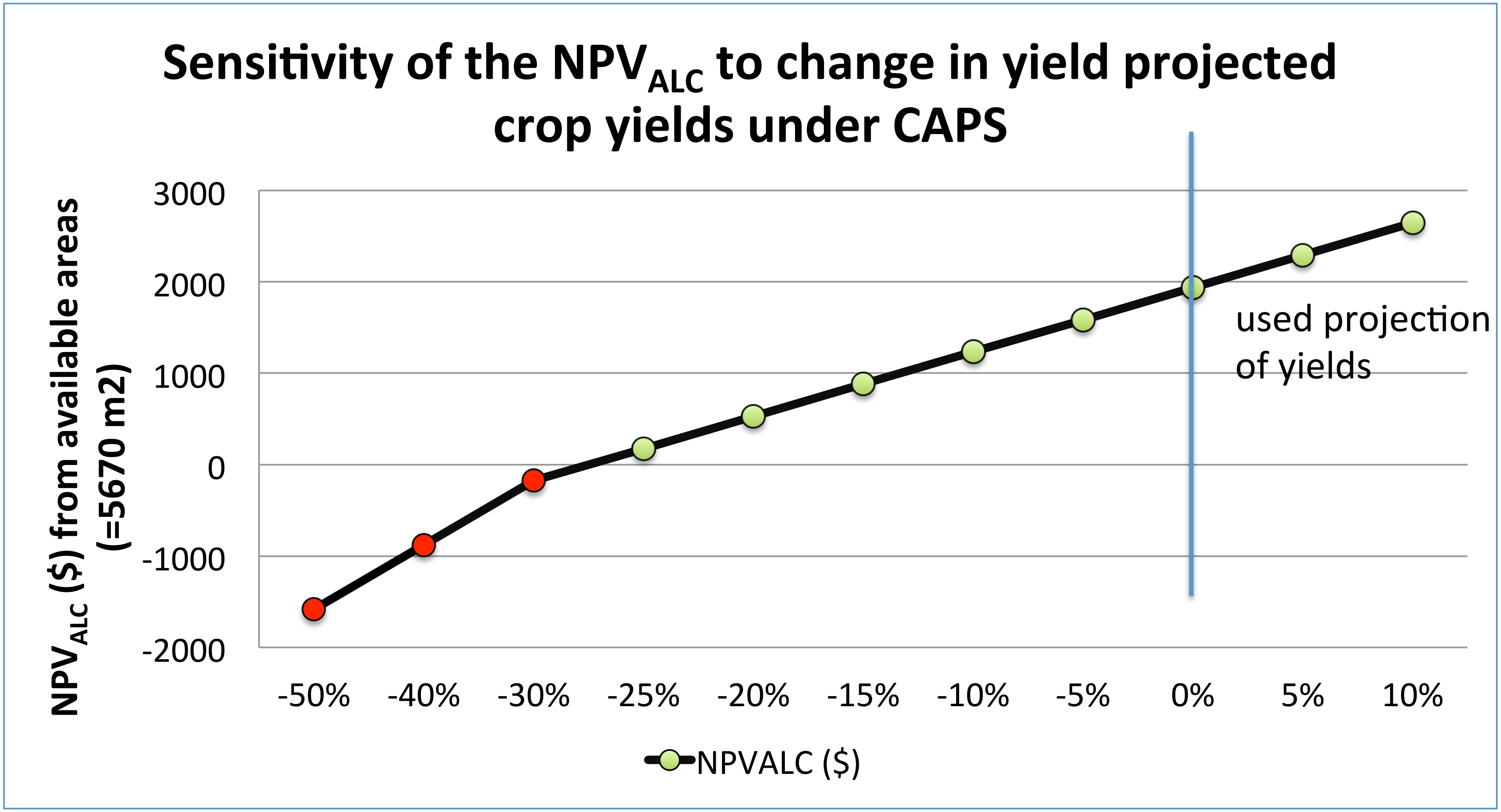
Replacing NPV_{BLC} (profit before labor cost) by NPV_{ALC} (profit after labor cost) reduced the allocation of land to CAPS

Sensitive to labor availability:

labor availability in Aug and Sep is crucial, +1 labor available in these two months had huge boost on NPV_{BLC} and highly affected allocation of CAPS area

Sensitivity to yield projection of CAPS

- NPV_{ALC} was +VE up to 25% reduction in the coefficients of projected crop yields



CONCLUSION

- Adoption of CAPS generated positive NPV over 10 years in wide ranges of modeling scenarios (e.g. considering labor opportunity cost, reducing yield projections up to 25%) in smallholder farmers condition in Nepal
- NPV of adoption of CAPS maximized when it was adopted as early as possible
- CAPS was more suitable in places where abundant household labor exist with no opportunity cost
- Diverse cropping options with different labor requirement & labor saving technologies would improve the benefits/adoption of CAPS

Future study

<u>Status & cost of Knowledge and information</u>

- How the economics change?

<u>Perception of Economic Risk</u>

- How CAPS affect the economic risk of farmers?

<u>Indirect economic value</u>

- Value of advantage on soil health, ecosystem services and environment

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