Maximizing revenue for conservation agriculture practice system in maize-based hill farming system of Nepal and estimating change in total economic surplus

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OUTLINE

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- RESEARCH OBJECTIVE
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- RESULT AND DISCUSSION
    - Result of farm revenue maximization
    - Projection of overall economic surplus
- CONCLUSION

CONTEXT

Agriculture in the central mid-hills of Nepal

- maize-based rain-fed cropping system
- cultivation of steep slopes
- Long open fallow and grazing (Khanal, 2004)
- low productivity and significant soil degradation (MoEST, 2006; Manandhar et al, 2009)
- Conservation agriculture (CA) useful for sustainable agro-ecosystem management (Kassam et al., 2009; Jat et al., 2010)
- Potential of CA in Nepal for sustainable soil management (Atreya et al., 2006)

RESEARCH PROBLEM

- Short term benefits of CA varied (FAO, 2004)
- CA beneficial in long run
- About 5:1 B/C ratio for conservation technologies in the US (Pimentel et al.; 1995)
- Economic factors and profitability play an important role in decision making about technology adoption (e.g. Cary and Wilkinson, 1997)
- Is CA economically viable in Nepal?

RESEARCH PROBLEM

- **Farm Level**

- How farmers can maximize their benefits adopting CAPS in maize-based hill farming system of Nepal ?

- **National level**

- What would be the projected impacts of adoption of CAPS in national economic surplus?

RESEARCH OBJECTIVE

- To identify the revenue maximizing cropping mix for a representative farm under different scenarios of soil loss
- To estimate the change in national economic surplus by adoption of CAPS in maize-based farming system of Nepal

METHODOLOGY

- Data and sources:
  - ❖ Baseline data – define representative household
  - ❖ Field trial data – difference in yield and cost of production coefficients
  - ❖ Secondary information- Ag Stat Nepal (MoAC, 2011), annual soil loss estimates, elasticity of demand and supply

LP model summery

Objective: Maximize total revenue

Constrains

- **Total Area constrain (4673 m^2 per season)**
- **Available labor hours (monthly)**
- **Available cash flow (Outflow in month i <= inflow in month i-1)**
- **Minimum consumption requirements of crops**
- **Soil loss constrains**
  - Scenario 1 = 1 ton/ha/year
  - Scenario 2 = 2 ton/ha/year
  - Scenario 3 = 3 ton/ha/year
  - Scenario 4 = 5 ton/ha/year
  - Scenario 5 = soil loss unconstrained

Constrain for medium term prediction

Area of ST in year i < Area of ST in year i-1

Major crops in system

Main season (March-June)

Maize 90%

Second season (July – October)

- Cowpea = 46%
- Black gram = 26%
- Millet = 8%

(source-unpublished baseline data)

Coefficients for model

1. Yield coefficients

	M Yield (kg/m2)	C Yield (kg/m2)	Mi Yield (kg/m2)	Bg yield (kg/m2)
Maize-millet/CT	0.125		0.088	
Maize-black gram/CT	0.125			0.062
Maize-cowpea CT	0.131	0.088		
Maize-cowpea +millet/CT	0.129	0.065	0.043	0.046
Maize-cowpea +millet/ST	0.122	0.060	0.036	0.042

For multi-year model,

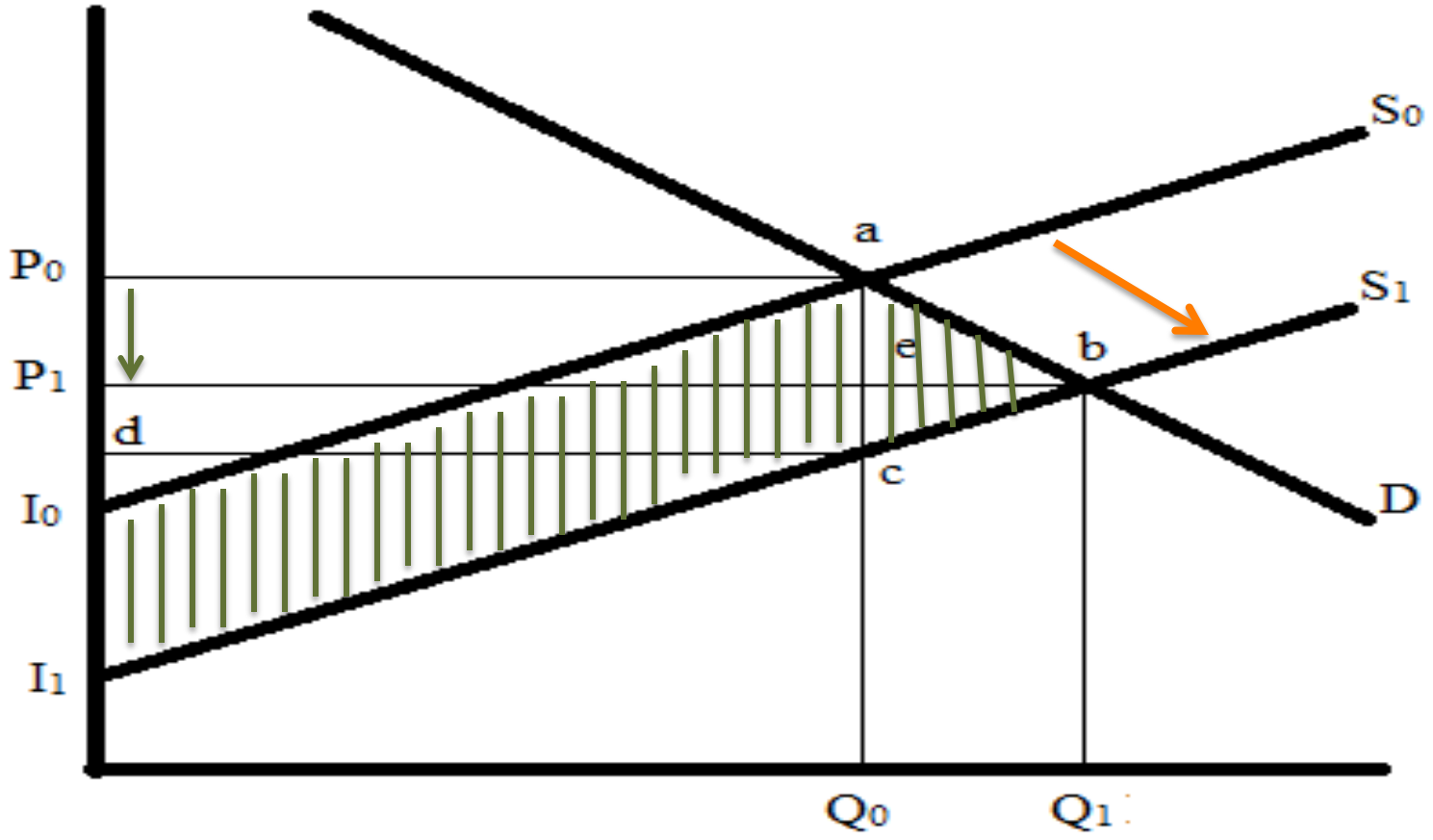
Yield of ST plots reduced by 5% to 4 years and gradually increased to 15% high in 8 year *(≈FAO, 2004; Matthews & Pilbeam; 2005;* Mazvimavi et al, 2012*)*

Representative household

Area constrain	
Available land of maize-based hill system (per season)	4673 m^2
Minimum consumption need constrain	
Millet	30 Kg
Maximum capital (money) requirement constrain	
Cash outflow in month i < cash inflow in i-1 month	$ 400
Labor constrain	
Monthly labor person, hours (4 x 7 x 26)	728 person hours

Change in total economic surplus

Assumption of closed economy……



Formula used: Alston et al. 1995 also used by Nguema, 2012

RESULTS AND DISCUSSION

% share of different cropping practices in base year for revenue maximization allocation

Practices	SC 1 (Soil loss ≤ 1 t ha-1 yr-1)	SC 2 (soil loss ≤ 2 t ha-1 yr-1)	SC 3 (Soil loss ≤ 3 t ha-1 yr-1)	SC 4 (Soil loss ≤ 4 t ha-1 yr-1)	SC 5 (soil loss unconstrained)
CT [M-Mi]	-	-	-	-	-
CT [M-Bg]	14.4%	21.0%	20.4%	20.3%	20.2%
CT [M]-C	-	16.5%	42.1%	63.3%	64.9%
CT [M-Mi +C]	-	-	-	7.8%	14.9%
ST [M-Mi +C]	70.5%	62.5%	37.5%	8.6%	-
Area (m2)	3,967 (84.9%)	4,673 (100%)	4,673 (100%)	4,673 (100%)	4,673 (100%)
Total revenue ($)	1099	1164	1190	1206	1209

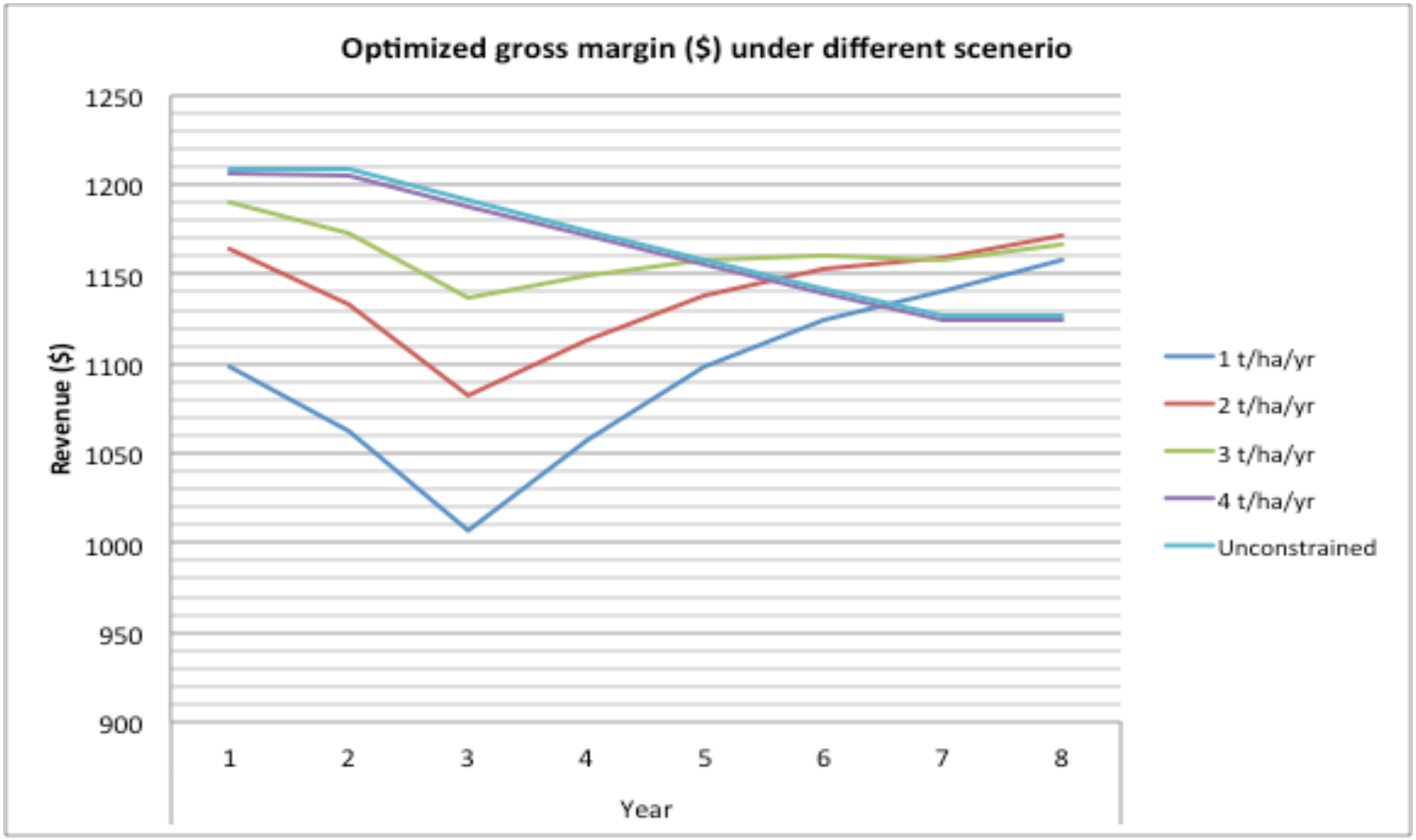
Sensitivity

- If we force CT (M-Mi), it would reduce the revenue by $ 0.1199 per m^2
- If we force CT (M-Mi+C), it would reduce the revenue by $ 0.025 per m^2

The model was not very sensitive to the constrains

- decrease in the labor availability in July & Sept and increase in Labor availability in August or October might change the results

Change in revenue over years under different soil loss scenario



Loss of gross margin due to adoption of conservation scenario

Comparison pairs of scenario	Total loss for representative farm ($)	% Loss in revenue	Revenue Loss ($/ ha/yr)	Year for breakeven
SC 5 & SC 1	**620.1**	**7.6%**	**88.60**	**7**
SC 5 & SC 2	**300.8**	**4.2%**	**50.15**	**6**
SC 5 & SC 3	135.6	2.3%	27.13	5
SC 3 & SC 1	542.6	5.8%	77.53	7
SC 3 & SC 2	183.6	2.6%	30.60	6
SC 2 & SC 1	**365.2**	**4.0%**	**52.19**	**7**

Parameters and assumptions for estimating change in total economic surplus

Parameter	Maize	Millet	Cowpea	Black gram
Production (tons)	2,067,722	302,691	5,660	22,530
Baseline area (ha)	623182	206340	16557	8000
Price per ton (US $)	376.5	317.6	855.3	1208.2
Percent yield gain	0.0004	-0.0606	0.0522	0.0306
Percent cost increase per ha.	-0.0767	0.1078	0.0194	0.0194
Years to first adoption		1		
Years of benefits		12		
Probability of success (%)		100		
Elasticity of supply	0.390	0.910	0.219	0.088
Elasticity of demand	-0.91	-0.77	-0.92	-0.92
Discount rate (%)				3

Assumed - Closed economic model

Sources: MoAC, 2011; Reed et. al, 2012; Prasad et al, 2011;

Total change in economic surplus under different rates of adoption

Maximum adoption rate (%)	Change in economic surplus (NPV million $) (12 years)
1	3753.2
2	6109.3
3	7067.0
4	6631.1
5	4797.3

CONCLUSION

- Strip tillage practice do not appear in revenue max. plan of farmers unless forced through objective of reducing soil loss.
- Farmers have to sacrifice about 7 and 4 % of revenue from maize-based system for more than 5 years to adopt conservation agriculture
- The initial investment in CA is expected to be returned in medium term

- THANK YOU !

References

- Kassam, Amir, Theodor Friedrich, Francis Shaxson, and Jules Pretty. "The spread of conservation agriculture: Justification, sustainability and uptake." *International Journal of Agricultural Sustainability* 7, no. 4 (2009): 292-320.
- Atreya, Kishor, Subodh Sharma, Roshan Man Bajracharya, and Neeranjan Prasad Rajbhandari. "Applications of reduced tillage in hills of central Nepal." *Soil and Tillage Research* 88, no. 1 (2006): 16-29.
- Manandhar, G. B., S. K. Adhikary, and G. Sah. "Sustainable agricultural practices and technologies in Nepal." (2009).
- Cary, John W., and Roger L. Wilkinson. "PERCEIVED PROFITABILITY AND FARMERS 'CONSERVATION BEHAVIOUR." *Journal of Agricultural Economics* 48, no. 1-3 (1997): 13-21.
- McConnell, Kenneth E. "An economic model of soil conservation." *American journal of agricultural economics* 65, no. 1 (1983): 83-89.
- MoEST. "Nepal: Third National Report on the Implementation of the UN Convention to Combat Desertification". Ministry of Environment, Science and Technology, Kathmandu, Nepal. (2006).
- Jat, M. L., Y. S. Saharawat, and Raj Gupta. "Conservation agriculture in cereal systems of south Asia: Nutrient management perspectives." *Karnataka Journal of Agricultural Sciences* 24, no. 1 (2011).
- FAO. 2004. Conservation of natural resources for sustainable agriculture: training modules. FAO Land and Water Digital Media Series CD-ROM 27. FAO, Rome. Original references are given in the CD-ROM.

References

- Quinton, J N & Catt, J.A. 2004. The effects of minimal tillage and contour cultivation on surface runoff, soil loss and crop yield in the long-term Woburn Erosion Reference Experiment on sandy soil at Woburn, England. Soil Use and Management (2004) 20, 343–349
- Matthews, R B & Pilbeam C. 2005. Modelling the long-term productivity and soil fertility of maize/millet cropping systems in the mid-hills of Nepal. Agriculture, Ecosystems and Environment 111 (2005) 119–139
- Mazvimavia, K., PaNdlovub, P.V., Anc H, and Murendo, C. 2012. Productivity and Efficiency Analysis of Maize under Conservation Agriculture in Zimbabwe. Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.
- Carlos A. Urrea (HMRP/CIMMYT-Nepal) 2005. Hill Maize Research Project in Nepal
- Prasad S K, Pullabhotla, H, Ganesh-Kumar, A. 2011. Supply and Demand for Cereals in Nepal, 2010–2030. IFPRI Discussion Paper 01120. Environment and Production Technology Division