Economic analysis of conservation agriculture in maize-based farming system in Nepal

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Introduction

- Agriculture in maize-based mid-hills of Nepal characterized by 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)
- Short term benefits of conservation technologies varied (FAO, 2004) but beneficial in long run (Pimentel et al.; 1995)
- Short-term economic indicators important for adoption

Objectives

1. To identify the revenue maximizing cropping mix for a representative farm under different scenarios of soil loss
2. To estimate the change in national economic surplus by adoption of conservation ag. Production system (CAPS) in maize-based farming system

Materials & Methods

Data and sources:

- Baseline data – construct representative farm from survey of 37 HHs
- Field trial data – difference in yield and cost of production coefficients (25 farmers field trials of CAPS in 3 villages of Nepal)
- Secondary information- (MoAC, 2011, Reed et. al, 2012; Prasad et al, 2011)

Linear Programming model is used for maximization of total revenue was used to identify optimum crop-mix

Model Constraints:

- Total Area constraint (4673 m^2 per season);
- Available labor hours (4 x 7 x 26 = 728 human/hours/month)
- Cash flow (Outflow in month I - inflow in month i-1 >$0)
- Min. consumption requirements millet (30 kg)

Constraints for medium term prediction

- Area of Strip Tillage in year i < Area of ST in year i-1
- Yield of ST plots reduced by 5% up to 4 years and gradually increased to 15% in 8 year (≈FAO, 2004; Mazvimavi et al, 2012 etc.)

Different Soil loss targets used for building scenarios

- Estimation of change in economic surplus as a result of adoption of the optimum crop-mix identified by LP in % area of maize-based system
- Total change in economic surplus was estimated by using closed economic model equation for technology adoption (e.g. Alston et al. 1995; Nguema, 2012)
- Scenario was build for 1-5% of adoption of CA, and Net present value estimated for 12 years

Abstract

A linear programming technique was used to estimate the revenue maximizing allocation of land for a representative household using conservation agriculture production system (CAPS) and farmers' traditional practices. The model was optimized in five different scenarios. Scenario 1, 2, 3 and 4 were build by allowing annual soil loss to 1, 2, 3 and 4 t $ha^{-1}yr^{-1}$ respectively, whereas scenario 5 was build with unconstrained soil loss. Scenario suggested that unless soil loss is considered, conservation tillage does not appear in the profit maximizing allocation of land. Practice with strip tillage appeared in the profit-optimized model of all scenarios where soil loss was constrained. Scenario 1 and 2 had about 71 and 66 % of land allotted to maize followed by millet+cowpea intercrop with strip tillage practice. Result also suggested that the representative farm have to sacrifice about $88.6 for about 7 years and $ 50.1 $ha^{-1}yr^{-1}$ (-7.6% and -4.1% revenue) if they aim to reduce the soil loss to 1 and 2 t $ha^{-1}yr^{-1}$, respectively. An analysis of the total change in economic surplus associated with adopting the revenue maximizing crop mix was completed. The analysis suggests that conservation agriculture will eventually pay off because total change in economic surplus for 12 years is estimated to be $3,735 million (net present value) if only 1% of the total area adopts the revenue maximization crop mix with a 2 t $ha^{-1}yr^{-1}$ soil loss constraint.

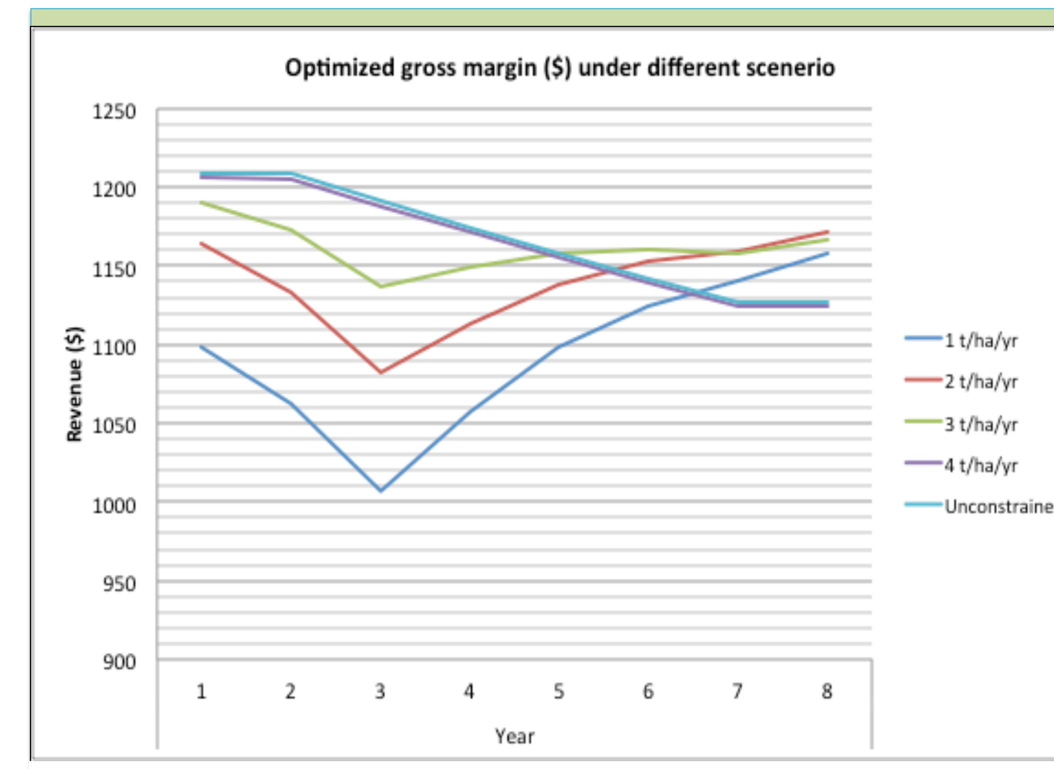
Results and Discussion

1. Revenue Maximizing cropping mix for representative farm

CA Practices	SC 1 (Soil loss ≤1t ha^{-1} yr^{-1})	SC 2 (soil loss ≤ 2 ha^{-1} yr^{-1})	SC 3 (Soil loss ≤ 3 ha^{-1} yr^{-1})	SC 4 (Soil loss ≤ 4 ha^{-1} yr^{-1})	SC 5 (soil loss unconstrained)
Maize→millet/CT	-	-	-	-	-
Maize→black gram/CT	14.4%	21.0%	20.4%	20.3%	20.2%
Maize→cowpea CT	-	16.5%	42.1%	63.3%	64.9%
Maize→cowpea +millet/CT	-	-	-	7.8%	14.9%
Maize→cowpea +millet/ST	70.5%	62.5%	37.5%	8.6%	-
Revenue ($)	1099	1164	1190	1206	1209

Note: → indicate 1st season crop followed by 2nd season crop, + indicate intercropping and CT and ST indicate the farming was done with conventional or strip tillage

- For all the scenarios, some land are planted with maize→legume with CT
- Under strict soil loss target (SC1), about 70% area under ST, resulting about 9% of revenue loss in first year, the loss reduced in subsequent years
- Relaxation of soil loss target increased area of maize→cowpea (CT)
- Optimum solution less sensitive change in constrains (except the soil loss)
- Shifting SC 5 (current potential maximum) to SC 1 and SC5 to SC2 results in loss of potential revenue of about $88.6 (7.6%) and $50.1 (4.1%) for 7 and 6 years, respectively. Cumulatively $620 and $308 sacrifice to meet soil loss targets of SC1 and SC2
- Clear financial gain for the small-holders to adopt legume in production system but no clear advantage for adopting the strip tillage



- Any labor saving technology for tillage was would not improve profit because of low/no opportunity cost of labor (except in August)
- Evaluation and inclusion of non-tangible benefits (to environmental, soil health and ecosystem) is essential for CA

2. Total estimated change in economic surplus

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

The change in total economic surplus if optimum crop mix is adopted. It is expected to be positive when evaluated for 12 years

Conclusions

- Strip tillage practice do not appear to maximize revenue for farmers unless with mandated reduction of soil loss
- Farmers have to sacrifice about 7 and 4 % of revenue from maize-based system for more than 5 years if they adopt conservation agriculture
- Inclusion of indirect benefits to soil, environment and ecosystem is essential for economic benefits of CA
- The initial investment in CA is expected to be returned in medium term.
- Need government incentives to adopt CA and education to sustain the practice

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