Title: Comparative Economic Analysis of Conservation Agricultural Practices in Tribal Villages in India

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ABSTRACT:

The tribal villages within the district of Kendujhar, Odisha State, India, struggle with farming on marginal lands and are experiencing diminishing returns on agricultural productivity, which will not be sustainable over the long term. Research has been focused on the implementation of conservation agricultural production systems (CAPS), with a specific focus on minimum tillage and intercropping, in this area to reduce pressure on natural resources while increasing food security and livelihoods. Quantitative and qualitative survey results allowed for technical and comparative economic analyses of the specified CAPS systems, future implications, and insight for natural resource managers regarding extension research and a bottom-up approach.

Keywords: India, conservation agricultural practices, economics, minimum tillage, tribal village

EXECUTIVE SUMMARY

During this time of environmental change, the management of natural resources may be our wisest pursuit; specifically in regards to international agricultural development. The SANREM/SMARTS project has taken forth the task of initiating agricultural development in the tribal villages of Kendujhar, one of the poorest districts in the state of Odisha, India. With a population highly reliant on smallholder farming systems, and a physical environment consisting of poor soil fertility, poor moisture retention, limited irrigation, and susceptibility to erosion, these factors have increasingly affected agricultural productivity in this region. As such, this project's research focus is the implementation of conservation agricultural production systems (CAPS). Primary data collection of face-to-face interviews was completed to establish agricultural and socioeconomic household baselines within the district and representative maize-based production scenarios were developed based on survey data and literature review. The study results have shown that implementing both an intercrop of maize and cowpea with a minimum tillage system would have the most beneficial impact when we consider agricultural yield and revenue in addition to numerous environmental benefits. The implementation of CAPS in these villages may provide improvements to household economy and nutrition from the increase in maize and cowpea yields, agricultural inputs through the fixation of nitrogen, while also providing the long-term benefits of increased soil nutrients and biota, organic matter, and greater resilience against degradation. This study revealed and provided potential monetary and agricultural yield benefits of CAPS adoption from conventional practices in a comparative economic analysis structure. It also provided future implications and insight for natural resource managers regarding the significance of extension and research in science and economics in dealing with agricultural development challenges.

PROBLEM STATEMENT

Kendujhar, India is one of the poorest tribal districts in the state of Odisha situated in the North Central Plateau Agro-climatic zone of the state (Figure 1). It is characterized by multiple small villages of 30-100 households, each engaged in subsistence agriculture, with farm sizes generally less than 2 hectares with over 40% of marginal farmers making below 100 rupees (2 USD/mo/capita) (2010 Survey Data). Poor soil fertility, poor moisture retention, limited irrigation, and susceptibility to erosion have affected agricultural productivity in this region. In recent years, there has been demonstrated evidence of the merit of practicing conservation agricultural production systems (CAPS) in enhancing food and livelihood securities (Bloem *et al*. 2009; Ghosh *et al*. 2010; Kamanga and Shamudzarira 2001; Monneveux *et al*. 2006; Nzabi *et al*. 2000; Timsina *et al*. 2006). CAPS refer to a general set of practices that focus on three main concepts: minimum tillage; continuous soil cover; and optimal crop rotation (FAO 2000). Studies suggest that yields from CAPS may be as high, if not higher, than conventional or traditional agriculture practices for crops such as maize (Govaerts and Sayre 2006). There are also significant savings of agricultural labor through reduced demands of tillage and weeding (Bishop-Sambrook 2003). Thus, strategic measures to enhance technological capital investment, such as introducing CAPS, are needed to address the poor and declining livelihood performance indicators. In addition, there is need to support farmer's knowledge and participation in the development of improved CAPS for marginal farms in these poor and minimally educated areas of India. This study's location lies in northern Odisha in India, which epitomizes the challenges facing the sustainability of smallholder agriculture in southern Asia as well as the cumulative impacts of environmental conflicts within the food production system.

OBJECTIVES

The objective of this study is to enhance the food and livelihood security of the tribal farm families in Kendujhar in Odisha State through the introduction of sustainable and profitable conservation agricultural practices of minimal tillage and optimal crop rotation. The specific objectives are:

1. Collect baseline farm household data on:
    a. The current farming practices, crop production, and marketing patterns
    b. The socioeconomic status of farm households
2. Estimate the economic benefits of introducing CAPS to representative maize-based production systems using existing studies and in-country experimental results

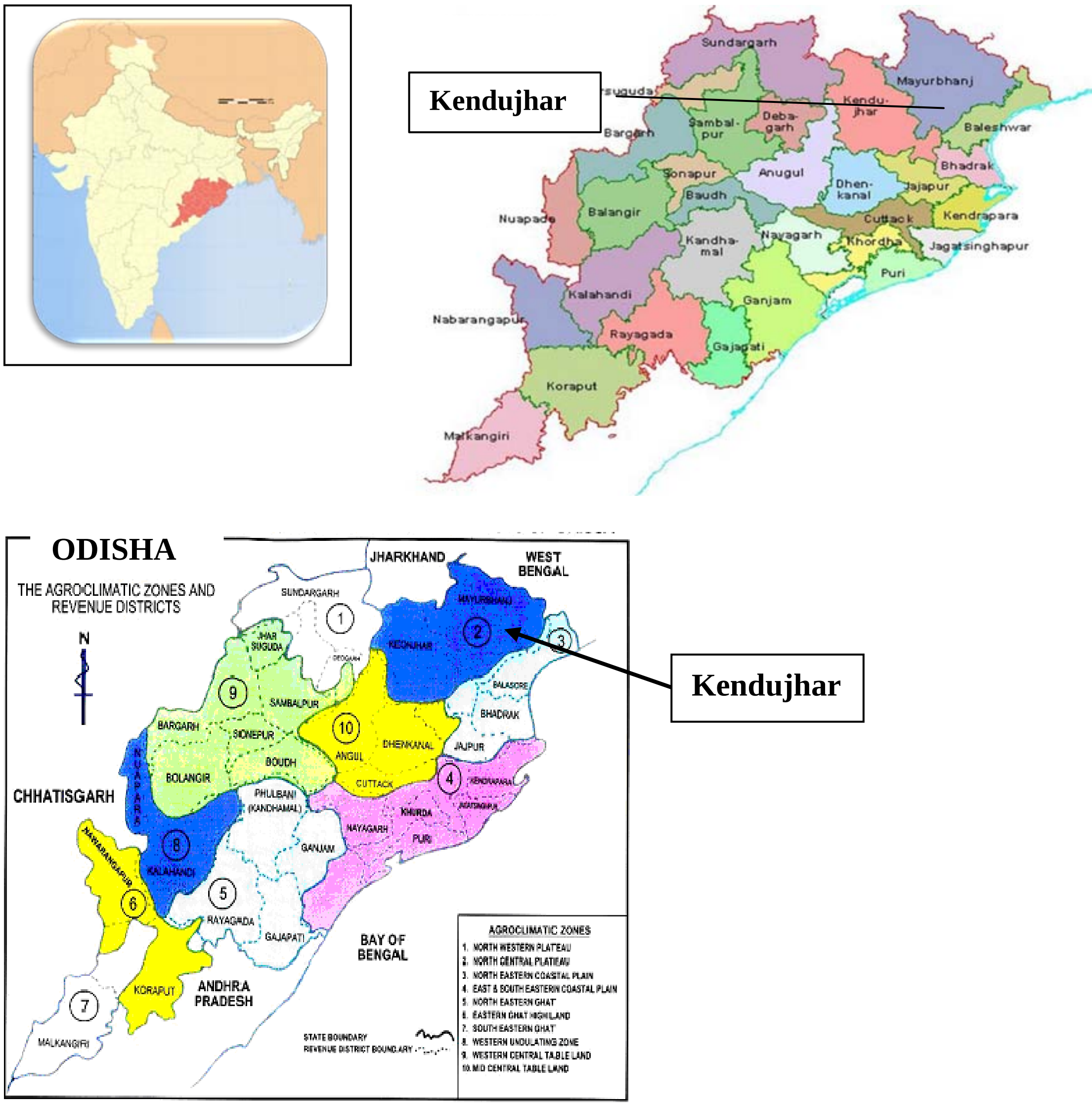

Figure 1. Location map of the Kendujhar district of Odisha, India, and a detailed map showing agroclimatic zones (SMARTS 2009)

PROCEDURE

Methodology

Three villages Saharpur, Tentuli and Gopinathpur of Banspal block, Kendujhar, have been selected for this study.

The methodological framework of this study consists of 6 steps.

1. Develop farm household surveys. The questionnaire consists of qualitative and quantitative questions
2. Collect data through face-to-face interviews
3. Validate data through comparison with relevant literature

4. Construct representative farms based on maize-based production systems
    a. Maize monocrop
    b. Maize/Mustard intercrop
    c. Maize/Cowpea intercrop
5. Devise productivity gains from practicing selected CAPS created through extensive literature review
6. Estimate potential economic returns from representative farms practicing CAPS

Data Collection and Estimation

In the Kendujhar District, data was collected from a random sample of 148 households from three villages (Tentuli, Saharpur, and Gopinathpur), each separated by varying distance to the market town center of Kendujhar and level of government extension intervention. Data collection methods were designed to collect both qualitative and quantitative data. The questionnaire consisted of six sections (family profile, assets, land and input use, labor use, agricultural output and market transactions). Primary data was collected through extensive surveys by conducting face-to-face interviews in either the village center or individual households by a rotation of one researcher (total of three) and an interpreter. Fourteen households were interviewed from May to June 2010. Representative maize-based production budgets were constructed to reflect the costs and total revenues from those systems. Scenarios of potential yield changes from conventional to minimal tillage were compiled to simulate the budget models for each of the maize production systems.

RESULTS/DISCUSSION

Background Household Farm Characteristics

The majority of the population in the three villages is tribal, largely dependent on traditional agriculture and forest resources for daily sustenance, and practices smallholder subsistence agriculture. Until recently, forest products and agricultural yields within these village areas provided sufficient energy and income to meet the needs of the tribal people and their livestock.

The average village household family size is seven members, with 2-3 generations per household. The age distribution for each village is shown in Figure 2. Livestock in these villages are domestic and consist mainly of cattle, oxen, goats, and chickens. In the district of Kendujhar, approximately 50% of households own a pair of oxen, mainly for the use of plowing for agricultural purposes, transportation and heavy tasks (Table 1).

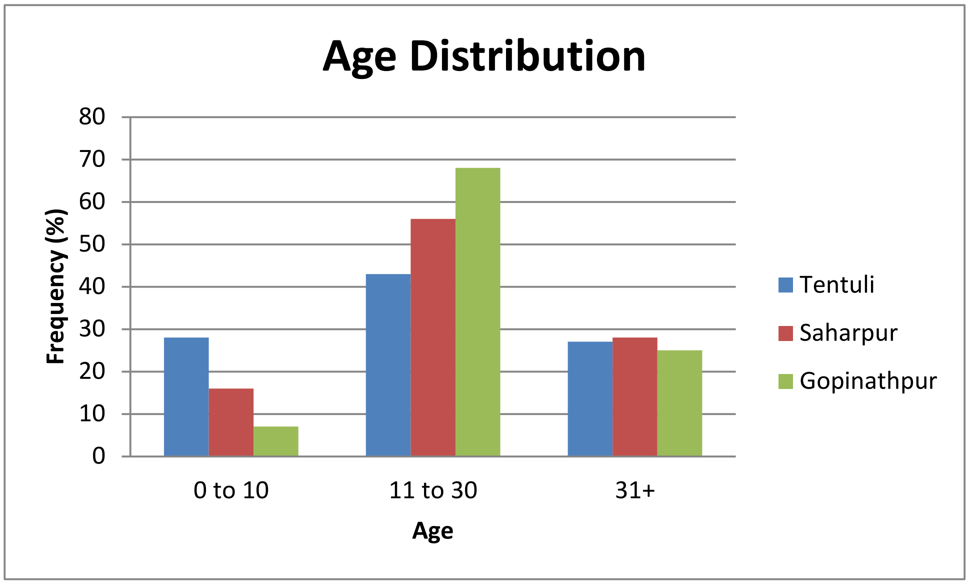

Figure 2: Farm household family age distribution of three villages (Tentuli, Saharpur, and Gopinathpur) in the Kendujhar disitrict, Odisha State, India, constructed from the 2010 extensive farm household survey data.

Table 1: Key farm household characteristics of three tribal villages (Tentuli, Saharpur, and Gopinathpur) in the study district of Kendujhar, India, constructed from the 2010 extensive farm household survey data.

Village	Avg Farm income 2008-2009 (INR)	Household size (Avg)	Highest level of education (mode)	Farm size (ha)	Major staple crops grown	No. of bulls (Avg)	Maize yield* (ton/ha)
Tentuli	18 130 (410 USD)	7	None	1.4	Rice, maize	2.8	0.25
Saharpur	19 140 (433 USD)	7	None	1.2	Rice, maize	2	0.3
Gopinathpur	47 588 (1 076 USD)	7	Primary	2.1	Rice, maize	1.5	0.3

*Maize yield in ton/ha is determined by taking average output production determined from surveys divided by average plot size (0.081 ha).

The majority of families in these villages attend local or town markets, specifically, the Kendujhar town market located 5-28 km from the villages (Saharpur representing the furthest village) or the local village market approximately 3-5 km outside of each village. The barter system still exists in these villages either through neighbor transactions or small vendors. Farm household incomes for the 2008-2009 period varies from zero (0 INR) to somewhat high (122,400 INR or 2,227 USD).

Families in this area are highly dependent on agriculture and some form of additional wages to sustain their livelihood. A combination of on- and off-farm income at the household level in these tribal villages provides the resilience these families need against adverse situations such as an unexpected drought or poor crop yield. In these tribal villages, women's tasks are often limited to cultivation, collection of firewood, and household chores. According to the 2010 survey, farm incomes are higher for families who have men capable of additional off-farm employment, as was seen in the village of Gopinathpur. In the district of Kendujhar, mining is a major industry and the predominant opportunity for wage earning; many families with greater education and more than one son over the age of 18 works for the mining companies to earn additional income for the family. Such off-farm employment for farmers is having an increasing influence on household income as wages from off-farm employment is more reliable, as compared with the uncertainties associated with farming. To be specific, working in the mining industry in the district of Kendujhar pays approximately 60,000 INR/person/yr (approximately 1,330 USD/person/yr). On the other hand, villages such as Tentuli that have very low literacy rates and the majority of their population under the age of 10, are more highly reliant on men to remain within the village and work on the farm, making them more vulnerable to adverse environmental and market conditions within the agricultural sector.

The surveys revealed that all three villages were major producers of maize and mustard (Table 1). In 2009, 47% of the surveyed population produced maize solely for household consumption and livestock feed, the other 53% of the population sold on average 55% of their maize output. The low proportion of households selling their yields and the corresponding marketed yield reflect the population's reliance on crop performance and indicate the population's vulnerability to food insecurity and the necessity for effective CAP systems.

Conservation agricultural production systems (CAPS) approach refers to innovative ways to increase agricultural productivity, technology transfer, and economic returns while maintaining and/or enhancing the natural environment. In this study, the focus is on the comparison of conventional tillage (Non-CAPS) to minimum tillage (CAPS). Due to extension efforts in the past, some farms had begun to incorporate cowpea intercropping to improve the soil nitrogen content. Therefore, based on the survey information, three representative maize-based production systems (maize, maize/mustard and maize/cowpea were used for analysis of the potential of CAPS in this study.

- Conventional tillage or plow (CT): Refers to the current tilling practice of these tribal villages to overturn soil using a wooden plow pulled across farm plots by two oxen.
- Minimum tillage or Dibble (MT): Weeding occurred prior to planting but the soil was not tilled. Instead, dibble sticks were used to make holes in the soil into which crop seeds were planted.

Inputs into Conventional On-Farm Activities

The major agricultural system practiced in this area is rainfed shifting cultivation. This farming system uses low to no external inputs and is subsistence-oriented. The soil in the area is shallow with low fertility. Fertility is generally enhanced by slashing and burning of natural vegetation, use of animal manure, with limited use of chemical fertilizers, resulting in low input costs. Input seeds for crop production are derived from retained seed and/or subsidized by the government. As the majority of families do not hire laborers outside of the family for crop production, there are no reported costs for input labor (Table 2). Therefore, human labor is the main energy input into the conventional agricultural systems of these tribal villages and should be taken into consideration when developing appropriate CAPS for these villages.

Table 2: Organized outline of costs of production for the three conventional maize-based production system scenarios of three villages in the District of Kendujhar, Odisha State, India, constructed from the 2010 extensive farm household survey.

	Maize	Maize/Mustard	Maize/Cowpea
Land Preparation			
Input Seeds (INR)	0 (retained seed + govt subsidy)	0 (retained seed + govt subsidy)	0 (retained seed + KVK** subsidy)
Labor	2 pd*, No reported cost	2 pd, No reported cost	2 pd, No reported cost
Sowing			
Labor	0.5 pd, No reported cost	2 pd, No reported cost	2 pd, No reported cost
Fertilizer			
Input (INR)	0 (On farm manure and compost)	0 (On farm manure and compost)	0 (On farm manure and compost)
Labor	5 pd, No reported cost	2 pd, No reported cost	2 pd, No reported cost
Pesticide			
Input (INR)	0 (No pesticide)	0 (No pesticide)	1,000 INR
Labor	0 pd, No reported cost	0 pd, No reported cost	1 pd, No reported cost
Weed Control			
Labor	5 pd, No reported cost	2 pd, No reported cost	2 pd, No reported cost
Harvesting			
Labor	2 pd, No reported cost	5 pd, No reported cost	1 pd, No reported cost
Total Costs (INR)	0	0	1,000

*pd refers to "person days"
** KVK refers to in-country government experimental farm science center

Conventional vs. Minimum tillage

Table 4 illustrates the net revenue changes due to yield increase for the CAPS scenario of minimum tillage as compared to traditional conventional tillage (Non-CAPS) for the three types of maize cropping systems. These results were based on the assumption that all produced yield was sold in the market. The plot size was determined from the survey data to be 0.2 acres (0.081 hectares). The following conversions were necessary (sourced by private communication with an expert at the University of Hawaii at Manoa seed lab) to account for maize yields reported in cobs: 1 cob = 500 kernels and 100 kernels = 15 grams (Table 4).

Minimum tillage output (MTO) production was calculated by incorporating a percent increase yield in selected cropping systems as determined by the literature: maize (11.1%); mustard (37%); cowpea (17%) (Table 4) (Ghuman and Sur 2001). Using the market prices and multiplying the increase in yield due to CAPS determined the total net revenue and percent increase in revenues (Table 4).

It is apparent that by incorporating minimum tillage into representative maize production systems (M, M/C, M/M), while keeping the other variables (price and input costs) constant, each type of farms had gains of varying levels from 11 to 13 %, with maize/cowpea intercropping having the highest return.

Table 4: Net Revenue comparison of conventional vs. minimum tillage by different maize-based production systems developed from 2010 farm household survey data and Ghuman and Sur (2010)

	Avg Plot Size (ha)	**Conventional Tillage Production Output (t/ha)**	***Price (INR/t)***	**Total Revenue (INR)**	**Total Input Cost (INR)**	**Net Revenue (INR)**	**Min.Till Production Output **(t/ha)**	**Total Revenue (INR)**	**Net Revenue (INR)**	**Change in Net Revenue (%)**
M	0.081	0.37	*29 900*	11063	0	11063	0.41	12259	12259	10.8
M/C	0.081	0.62 (Maize); 0.43 (pods)	*29 900 (Maize); 20 000 (pods)*	18538 (Maize); 8600 (pods)	1 000	26138	0.69 (Maize); 0.50 (pods)	20631 (Maize); 10000 (pods)	29631	13.3
M/M	0.081	0.46 (Maize); 0.04 (Mustard)	*29 900 (Maize); 24 000 (Mustard)*	13754 (Maize); 960 (Mustard)	0	14714	0.51 (Maize); 0.05 (Mustard)	15249 (Maize); 1200 (Mustard)	16449	11.8

*Legend: M = Maize; M/C = Maize/Cowpea; M/M = Maize/Mustard production systems
**Minimum tillage yield is determined using percent increase yields of: Maize (11%); Cowpea (17%); Mustard (37%). (Source: Ghuman and Sur, 2010, Survey Data)

The following equations were used to complete Table 4. All units were converted to tons and hectares for consistency amongst data:

Net Revenue Analysis of Conventional tillage vs. Minimum Tillage

1. *CTO = Yield (tons)/Plot Size (0.081 ha)*
   Where CTO is the conventional tillage output production
2. *Price: based on average of reported market prices (INR/ton)*
3. *TR = CTO production (tons) x Price (INR/ton)*
   Where TR represents the total revenue
4. *Total Input Cost (TIC), as determined by Table 2*
5. *NR = TR – TIC*
   Where NR represents the net revenue

With farm families in Kendujhar struggling to establish food security and relying on their crop production for subsistence, an increase in as much as 11% in yield may provide significant potential for improving the health and welfare of these families (Table 4). Currently 23% of the marginal farm households in Kendujhar have a daily calorie intake of < 800kcal. In terms of profit, transferring from a conventional plow system to a CAPS plow system that includes intercropping will increase revenue (Table 4).

CONCLUSION

The villages of Tentuli, Saharpur, and Gopinathpur of Odisha State depend on traditional agriculture for their daily sustenance. Traditional methods of cultivating crops, specifically conventional tillage practices and minimal inputs, have resulted in declining natural resource quality and crop productivity levels, resulting in livelihood and food insecurity for village families. This study has demonstrated that there is an explicit potential economic benefit to farmers with the adoption of minimum tillage practices when opportunity costs of labor are excluded.

Adoption of conservation agricultural practices such as minimum tillage provides numerous environmental benefits that will support and maintain the fertility of the land for the future. Increases in soil fertility, reduction in soil erosion, carbon sequestration due to residue recycling are just a few of the environmental benefits that farmers can profit from.

Smallholder farmers in the rural areas of India, specifically the state of Odisha, have minimal contact with the outside world. Family members and village neighbors are often the only form of information sharing and introduction to new practices that exists in these areas. Formal education has been found to support the process of information access and these areas have little to no education. Therefore, as off-farm employment is becoming more appealing to some tribal farmers and education in these tribal villages is limited to none, extension research focusing on a bottom-up approach may be the necessary catalyst to a sustainable future in these areas.

This study provides future policy implications regarding on- and off-farm employment and the significance of extension education for sustainability and livelihoods in terms of information sharing and family labor versus educational opportunities.

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