



*International Food and Agribusiness Management Review*  
Volume 15, Issue 1, 2012

## **Comparative Economic and Gender, Labor Analysis of Conservation Agriculture Practices in Tribal Villages in India**

Cynthia Lai<sup>a</sup>, Catherine Chan<sup>a,b</sup>, Jacqueline Halbrendt<sup>c</sup>, Linsey Shariq<sup>d</sup>, Pravat Roul<sup>e</sup>,  
Travis Idol<sup>f</sup>, Chittanrajan Ray<sup>g</sup>, and Carl Evensen<sup>h</sup>

<sup>a, c, d</sup>*Graduate Students, Natural Resource and Environmental Management, 1910 East West Road, Sherman Lab 101, University of Hawaii, Honolulu, Hawaii, 96822, U.S.A*

<sup>b</sup>*Professor, Natural Resource and Environmental Management, 1910 East West Road, Sherman Lab 101, University of Hawaii, Honolulu, Hawaii, 96822, U.S.A*

<sup>e</sup>*Associate Professor, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India*

<sup>f</sup>*Associate Professor, Water Resources Research Center, 1910 East West Road, Sherman Lab 101, University of Hawaii, Honolulu, Hawaii, 96822, U.S.A*

<sup>g</sup>*Professor, Water Resources Research Center, 1910 East West Road, Sherman Lab 101, University of Hawaii, Honolulu, Hawaii, 96822, U.S.A*

<sup>h</sup>*Professor, Natural Resource and Environmental Management, POST 204H, University of Hawaii, Honolulu, Hawaii, 96822, U.S.A*

---

---

### **Abstract**

The tribal villages within the district of Kendujhar, Odisha State, India struggle with farming on marginal lands with an increasing detrimental effect on agricultural productivity. Research has been focused on the implementation of conservation agriculture (CA) practices, specifically: minimum tillage and intercropping in such villages. Results provide a comparative economic and gender labor analyses of selected CA practices, future implications, and insight for agribusinesses, farmers and policymakers.

**Keywords:** India, conservation agriculture, gender, labor, maize, cowpea

<sup>ⓐ</sup>Corresponding author: Tel: + 1 808.956.7530  
Email: [chanhalb@hawaii.edu](mailto:chanhalb@hawaii.edu)

## **Introduction**

Kendujhar is one of the poorest tribal districts in the state of Odisha, India. Located in the agro-climatic zone of Odisha's North Central Plateau (Figure 1), it is characterized by multiple small villages of 30-100 households. Each household is engaged in low-input subsistence agriculture, with farm sizes generally less than 2 hectares. More than 40% of farmers earn less than 100 Indian Rupees (INR) per month (2 USD/mo/capita).

Farmers grow a variety of crops, focusing mainly on staple crops such as rice and maize. Yields throughout Odisha are lower than the national average, with approximately 1.5 tons per hectare for rice and 2.2 ton per hectare for maize (Government of Odisha 2010). However, these yields generally apply to modern, high-yielding crop varieties, which dominate much of the commercial production in the state. In the tribal villages of Kendujhar, household income is mainly through the selling of agricultural outputs where farmers predominantly use traditional low-yielding varieties of maize and rice, irrigation is uncommon, and fertilization consists primarily of farmyard manure application with occasional supplements of inorganic N and P additions.

In developing countries, agriculture can play a significant role in regards to economic development; specifically, to tribal subsistence farmers who rely on their land for food and income. Given the propensity for low agricultural outputs and land degradation from such conventional farming systems, there exists much opportunity for the introduction of improved farm management and cultivation practices. While introducing standard agricultural "Green Revolution" technologies into these villages can increase crop yields (Dr. P.K. Roul (OUAT), personal communication, 2010), farmers with small landholdings, low income, poor access to credit, and limited technical capacity simply cannot take full advantage of interventions that are more suitable for large, mechanized farms. Moreover, output growth is not only determined by technological innovations but also by the efficiency with which available technologies are used. As such, more appropriate for these farmers are conservation agriculture (CA) practices, which aim to conserve natural resources while enhancing food and livelihood securities. For this study, CA practices refer to a general set of practices including the concepts of minimum tillage and intercropping (FAO 2000). Not only do these CA practices offer environmental benefits such as improved soil and water conservation, as highlighted in this study, there can also be significant savings of agricultural labor through reduced demands of tillage and weeding (Bishop-Sambrook 2003), which can then be directed towards agricultural diversification, farm improvements, or off-farm work to supplement agricultural income, and impacts to household income and yields depending on the CA practice selected.

To date, there has been little published on the potential benefits or tradeoffs of various integrated CA practices, particularly on resource-poor smallholders in tribal villages, such as those in Kendujhar. Nevertheless, evidence suggests that combining these practices (minimum tillage and intercropping) can have positive implications for input use, yield, income, and gender equity, while promoting long-term environmental sustainability.

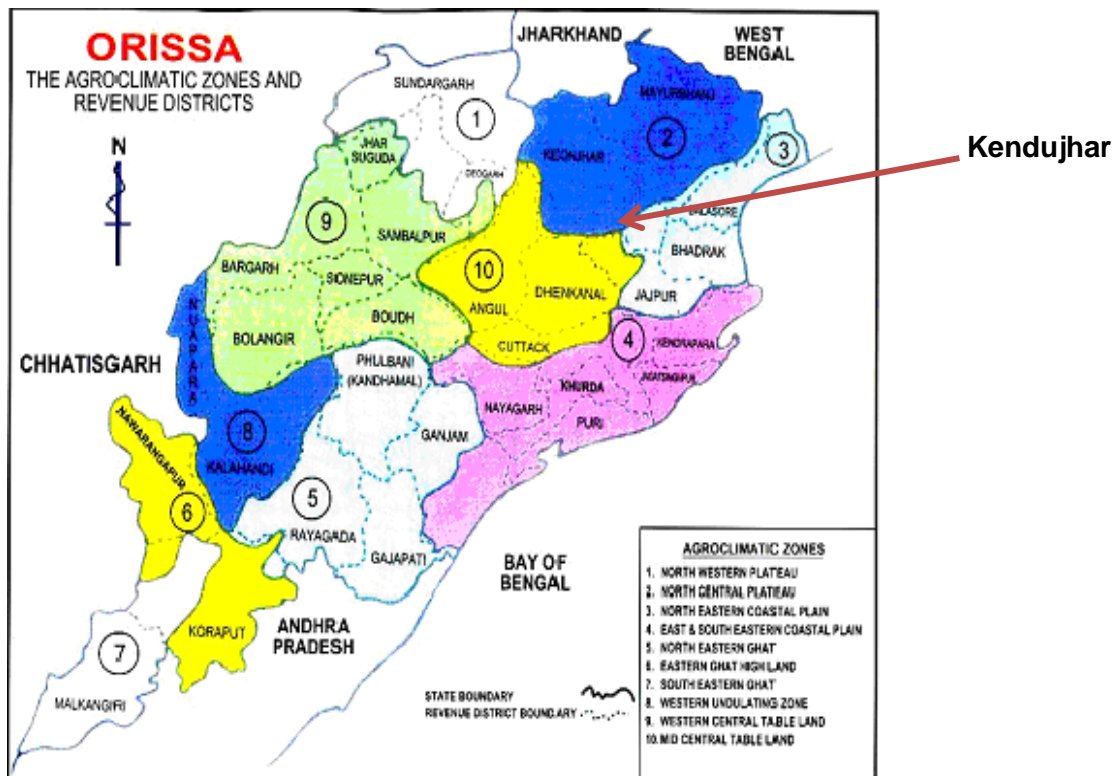
To ensure selection and implementation of appropriate CA practices in Kendujhar, current farming practices must first be understood within the context of their economic and social impacts. This study's location lies in the northern part of Odisha in Eastern India, which epitomizes the

challenges facing the sustainability of smallholder, rain-fed agriculture in southern Asia as well as the cumulative impacts of environmental conflicts within the food production system (Figure 1). Given that agriculture in Odisha represents approximately 30% of the state's economy, improvements to the local farming systems have the potential to improve the sustainability and security of numerous households within the state and across the nation of India (Pattanayak 2004).

## Objectives

The goal of this research is to evaluate the food security and economic livelihood of the tribal farm families in Kendujhar, in Odisha State through the introduction of sustainable conservation agriculture practices of minimum tillage and intercropping. The specific objectives of this study are to:

1. Estimate the yield, labor and profitability differences between the CA practices of minimum tillage and intercropping and the use of conventional tillage on representative maize-based farms.
2. Evaluate the gender implications of implementing selected CA practices as they relate to labor use.
3. Discuss the implications of introduced CA practices for policy-makers, local entrepreneurs and agribusinesses, and smallholder farmers.



**Figure 1.** Location map of Kendujhar district, Odisha State, India with agro-climatic zones.

## Literature Review

The following literature review provides comparative yield statistics of different CA practices, offering insight into the influence of changing yields on farm profitability and rural farm labor. Based on a review of past studies regarding maize-based production systems, CA practices including conservation tillage, residue retention and intercropping with legumes have all been shown to increase yields. The results of several studies analyzing the effectiveness of CA practices revealed that the highest yield increases resulted from intercropping with legumes, improving total yields by 15-40% over conventional practices. Adopting some form of conservation tillage without intercropping practices resulted in slightly lower yield improvement of 13% (Table 1).

**Table 1.** Yield Effects of CA Practices in Maize-Based Production Systems.

Region/Country	CA Practices	Yield effect in kg ha <sup>-1</sup> (% change)	Reference
Kisii / Kenya	Conventional tillage Residue retention Intercrop: Maize-Common beans	+550 (20%)	Nzabi et al. (2000)
North East India	Conservation tillage No residue Intercrop: Maize-Pea	+130 (15%)	Ghosh et al. (2010)
Ethiopia	Conservation tillage Residue retention Maize-alone	+170 (13%)	Rockström et al. (2009)
South Africa	Conventional tillage Residue retention Intercrop: Maize-cowpea and Relay Crop (RC)	+2450 (40%) RC: +1200 (20%)	Bloem et al. (2009)

As new farming practices become more prominent, a shift in farm labor time allocation can occur. For example, with the introduction of a new cotton variety in rural India, increased yields showed a direct increase in labor during harvest yet experienced decreased labor for pest management. This offset of labor can be considered as a net neutral outcome; however, since harvesting is a predominantly female activity, whereas pest management is a typically male activity, a shift in time commitment and distinction of labor division between genders is created (Subramanian 2009).

When labor time is reduced as opposed to shifted, the household income effect depends on how the newly available time can be used. This is often determined by the availability of opportunities for off-farm income. In India, several income generating off-farm activities are available for male farmers, including: construction, mining, small-scale manufacturing, retail trade, private and transportation services including driving tractors and auto-rickshaws (Subramanian 2009). Within the district of Kendujhar, mining represents the predominant off-farm employment. The

contrast in opportunities for off-farm employment is apparent in Tamil Nadu, India, where the decreased labor requirements of growing *Jatropha* has led to an increase in male participation in off-farm seasonal migration while women have fewer alternative employment opportunities and take on increased household responsibilities when the men migrate for work (Ariza-Montobbio 2010; Kochar 1999). Therefore, even when farm labor requirements decrease, the potential for females to earn supplemental income is limited.

## **Methodology**

Three villages in Kendujhar were selected for this study. These villages were chosen based on their agricultural and demographic characteristics; their proximity to the local extension office of Orissa University of Agriculture and Technology (OUAT); past and current working relationships between the villages and the university; and the presence of tribal populations practicing subsistence agriculture on small farms within the village.

The methodological framework of this study consists of seven steps:

1. Develop farm household surveys to collect baseline economic farm data
2. Collect data through face-to-face interviews of randomly selected farmers
3. Validate data through comparison with relevant literature
4. Construct baseline representative maize-only and maize/cowpea farm budgets from survey data
5. Calculate yield and production cost specifically for labor changes from selected CA practices on experimental farm plots
6. Estimate potential economic returns in terms of changes in farm profitability with or without labor opportunity costs using data collected from step five above
7. Report results and provide recommendations to farmers, agribusinesses and policymakers.

## **Survey Design and Data Administration**

Surveys were designed to collect both qualitative and quantitative data. The questionnaire consisted of 6 sections (family profile, assets, land and input use, labor use, agricultural output and grain transaction descriptions). Specifically, the following data pertaining to this study were collected: size of farm plots by crop, land use and cropping patterns, cost of production, input and output data, crop yields, market transactions and prices.

Data was collected from a random sample of 145 households from three villages (Tentuli, Saharpur, and Gopinathpur), located approximately 15-30 km from the town of Kendujhar. During the time period of June to December 2010, 35 households were interviewed, representing approximately 24% of the sample interviewed.

## **Descriptive Statistics of Farm Household**

Key socio-demographic characteristics of the villages are shown in Table 2.

**Table 2.** Selected socio-economic characteristics of three tribal villages in the study district of Kendujhar, India.

Village	Farm Annual Income (INR)	Household Size	Highest level of Education	Farm Size (ha)	Major Staple Crops	Maize Yield (ton/ha)
Tentuli (56)	18,130 (410 USD)	7	None	1.4	Rice, Maize	0.25
Saharpur (64)	19,140 (433 USD)	7	None	1.2	Rice, Maize	0.3
Gopinathpur (25)	47,588 (1,076 USD)	7	Primary	2.1	Rice, Maize	0.3

**Source.** Household survey data 2010. Values represented are averages and modes.

The majority of the study population in the three villages is tribal, largely dependent on traditional agriculture and forest resources for daily sustenance, and practice smallholder, subsistence, rain-fed agriculture.

The average household family size is seven members, with 2-3 generations per household. Average farm size is between 1.2 to 2.1 hectares. Major staple crops grown are rice and maize. Maize yield is relatively low, averaging 0.25 to 0.3 ton/ha. Average farm household annual incomes range from about 400 to 1000 USD per household. According to the survey data, farm incomes are higher for families with additional off-farm employment. As mining is the major industry present in the Kendujhar District, families with more than one son over the age of 18 typically earn additional income (9 USD/day). However, villages such as Tentuli, with low literacy rates and the majority of the population under age 10, must rely on the farm for income (Table 2).

The survey also revealed that each of the three villages were major producers of maize. 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 limited amount of crop available to be marketed indicates the population's vulnerability to food security in the region. Due to World Bank funded extension efforts meant to address these food security issues, some farms began to incorporate cowpea intercropping to improve soil nitrogen content and corresponding crop yields. According to market surveys, cowpea has a seasonal market price of USD\$.30 -.45/Kg, nearly double the price of maize, making it one of the more profitable crops for sale. For this study, cowpea was considered an introduced crop, as over 80% of the survey population did not previously produce cowpea.

## Research Design

### *Selected Conservation Agriculture Practices Scenarios*

For this study, a representative maize-based production system using conventional tillage was compared with three potential CA practices to be introduced to the tribal villages (Table 3).

The three conservation agriculture practices include one or more of the following:

1. Minimum tillage (MT): Land was tilled once prior to sowing vs. conventional tillage (CT) where land is tilled twice.
2. Intercropping (M-CP): Cowpea (*Vigna unguiculata*) was planted between rows of maize (*Zea mays*). The inter-row spacing for maize was standard for a maize monocrop treatment (M), with no reduction of maize plants in the intercropped treatment.

**Table 3.** Conservation Agriculture (CA) treatments implemented in Kendujhar, Odisha State, India, 2010.

Treatments	CA Practices (Abbreviations)
Farmer Practice: Maize Plow	CONTROL
Maize Minimum Tillage <sup>1</sup>	MT/M
Maize/Cowpea Intercrop Plow <sup>2</sup>	CT/M-CP
Maize/Cowpea Intercrop Minimum Tillage <sup>2</sup>	MT/M-CP

**Source.** Household Survey Data 2010

<sup>1</sup>For maize only plot size 0.005 ha

<sup>2</sup>For maize/cowpea intercrop plot size is 0.0025 ha for maize and 0.0025 ha for cowpea (original plot size, 0.005 ha, divided in half)

The above CA practice interventions and associated abbreviations will be referred to throughout the following tables and discussions.

The CA experimental trial was conducted at the Orissa University of Agriculture and Technology (OUAT) experiment station in Kendujhar to evaluate the benefits and costs of each intervention.

For this study, the effect of both minimum tillage and intercropping were assessed individually, in combination, and compared with conventional maize monocrop plow production systems. Experimental data were collected on the quantity and cost of seeds planted and fertilizer applied; amount and cost of agricultural labor by gender required to plant, maintain, and harvest crops; and the quantity and market value of maize and cowpea seed yields.

### The Representative Maize Only Production Budget

A representative maize-only production budget was constructed from the survey data to reflect the costs from that system for 2009. Using the budget, which included price and cost of production for maize and cowpea, the data was assessed to identify changes to input and output costs (Table 5). The data was further assessed to determine the differences of households with and without the opportunity for off-farm employment, where the experimental plot farm wage rate of USD\$.26/hr (Dr. P.K. Roul (OUAT), personal communication, 2010) was used as the opportunity cost. According to the farm household survey, there were no commercial agricultural input costs for the production of maize and cowpea. Seed used is typically retained seed from the pre-

vious year or government subsidized, while fertilizer is often farmyard manure. As such, the remaining cost is for labor. The on-farm labor is from household members. Gender impact was evaluated using current labor requirements for the representative farm to determine potential gender implications from the new labor requirements associated with adopting selected CA practices.

## Results and Discussion

Performance indicators focusing on farm profitability, labor use and gender impact were evaluated. Although non-market benefits would be desirable for inclusion in a more comprehensive assessment, emphasizing the immediate profitability impacts is essential for promoting the adoption of CA practices. The evaluation of gender equity in terms of labor changes has further implications to household well-being and thus is also important to evaluate.

### *CAPS Intervention Strategies: Comparing Returns from the CA Practices*

Data collected from the experimental plots in Kendujhar was compared based on a percent change between no CA (Control) and the selected CA practices in terms of maize yield and labor for the cropping practices. Subsequently, profitability accounting for opportunity costs is evaluated based on the collected data, as well as current market prices and labor wages.

### *Yield Impacts*

As previously mentioned, cowpea would be an introduced crop to these farming systems; therefore, all yields would result in a 100% increase. Yields for cowpea on the intercropped experimental plots averaged 998 Kg/ha with conventional tillage and 747 Kg/ha with minimum tillage. On the other hand, all CA practices resulted in a decrease in maize yield from the current farming practice of conventional tillage (Control). Conventional tillage (Control) produced a maize yield of 570.8 Kg/ha, while CA practices of MT/M produced a maize yield of 393.28 Kg/ha (a decrease of 31%), CT/M-CP produced a yield of 476.96 Kg/ha (a decrease of 16%) and MT/M-CP produced a yield of 405.89 Kg/ha (a decrease of 29%). The effect of yield differences for maize and cowpea is further discussed in the section titled "Profitability: Economic Analysis of Opportunity Costs", Table 5.

CT/M-CP represents the least reduction in yield of maize (-16.44%) of the three CA practices while benefiting the additional cowpea yield. This treatment may be the most beneficial and most easily adoptable technically for tribal villages, as they are familiar with intercropping and are currently practicing conventional tillage. As such, seed suppliers should work in collaboration with agricultural researchers to determine other beneficial crops (focus on enhanced economic income and environmental benefits) for intercropping in Kendujhar, such as cowpea with maize, and with policy makers to subsequently promote and provide subsidies for those crops' seeds.

If yield is the only factor to be considered, farmers should not consider implementing MT/M, as this practice produces a decrease in maize yield in the short term and has no supplemental cowpea yield to compensate for this loss.



### Labor Impacts

For the purposes of this study, labor was measured in hours. The percent change in labor for each CA practice compared to the control (No CA) is as follows:

**Table 4.** Labor hours for production activities, incorporating gender division and percent changes indicated in ( ) for each CA practice compared to the control.

Labor	Land											
	Preparation		Sowing Cowpea		Sowing Maize		Fertilization		Weeding		Harvest	
	M	F	M	F	M	F	M	F	M	F	M	F
Control	13.50	-			4.5	4.5	4.5	13.5	-	31.5	9	9
MT/M	9.64 (-28.6%)	-			4.5 (0%)	4.5 (0%)	4.5 (0%)	13.5 (0%)	-	31.5 (0%)	9 (0%)	9 (0%)
CT/M-CP	20.73 (+53.6%)	-	2.37 (+100%)	2.37 (+100%)	4.5 (0%)	4.5 (0%)	4.5 (0%)	13.5 (0%)	-	44.1 (+40%)	17.4 (93%)	17.4 (93%)
MT/M-CP	9.64 (-28.6%)	-	2.37 (+100%)	2.37 (+100%)	4.5 (0%)	4.5 (0%)	4.5 (0%)	13.5 (0%)	-	44.1 (+40%)	17.4 (93%)	17.4 (93%)

**Source.** Household survey data 2010. Percent changes indicated in parentheses ( ) were taken from KVK experimental plot data, 2010

**Note.** Shaded squares represent that no labor activity occurred as the practice solely includes maize; dashes represent that the gender does not participate in this labor activity.

Labor is a major determinant for adoption of new farming practices for these farmers, as the current subsistence farming provides little or no opportunity costs. Furthermore, gender represents a distinct division of labor for agricultural activities. Women are typically involved with activities such as weeding and fertilization, while men typically manage tasks such as plowing for land preparation. Thus, labor requirements must be considered for each of the CA practices and are outlined based on gender in Table 4 and further discussed in this section.

At present, farmers in the villages of the Kendujhar district practice conventional tillage through plowing. In theory, the transfer of minimum tillage from conventional tillage has the greatest impact on the land preparation activities of agricultural production. Both MT/M and MT/M-CP practices include minimum tillage; as such, these practices reduce the amount of labor required for land preparation activities. Minimum tillage reduces labor hours by 28.6%, as land preparation for the field is only plowed once as opposed to two times for conventional tillage. Therefore, the reduction in labor hours for land preparation of MT/M and MT/M-CP will influence the seasonal activities of male farmers as they will have more time for other activities (Table 4). On the other hand, it will have the opposite effect on labor hours for CT/M-CP, where there is an expected increase of 53.6%, due to an additional plowing for the intercrop field.

MT/M-CP and CT/M-CP introduce cowpea to the farmers' fields for the CA intercrop system. Intercropping has the greatest impact on weeding activities, with labor hours increasing by 40% due to the additional precision required for weeding as opposed to maize-only fields. For women, the increase in labor hours noted for weeding intercropped fields will take away from time available for non-farm activities (Table 4). As such, extension researchers should consider technologies and/or tools that may help to reduce weeding hours for women.

These intercrop CA practices (MT/M-CP and CT/M-CP) will both have an increase in sowing labor (100%) and increase in harvest labor (93.33%) due to the introduction of cowpea that results in an overall increase in yield. Increases in labor hours are equal for both genders as they contribute equally to these activities.

There is no increase in overall labor for fertilization as the farm plots are the same in size and use the same amount of inputs as the conventional plow system. However, there is a distinct contrast in labor hours contributed to fertilization between the genders, as females contribute three times more labor hours (+200%) than their male counterparts. Based on these results, future research should consider the variable off-farm opportunities that exist for farmers (male and female) as a result of either an increase or decrease in labor saving hours, the following section introduces this topic.

### Profitability: Economic Analysis of Opportunity Costs

Opportunity costs (OC) represent the potential income that farmers would forego by not engaging their labor elsewhere. An analysis of the opportunity costs reveals the profitability trade-offs incurred as a result of adopting various CA practices (Table 5).

**Table 5.** Percent change in profitability from CA implementation with and without opportunity costs

	Yield, Maize	Cowpea, Yield	Total Labor (Hrs)	Total Input Costs <sup>1</sup> (INR)	Profit <sup>2</sup> , INR (w/ OC)	Profit, INR (w/o OC)
CONTROL	50 kg		90	1,012.50	-592.5	420
MT/M	31.10%		-8.11%	-8.11%	3.41%	-31.11%
CT/M-CP	16.44%	100%	46.69%	49.69%	-46.98%	62.92%
MT/M-CP	28.89%	100%	26.37%	26.37%	-25.54%	30.39%

<sup>1</sup>Total Input Costs (Labor only, seeds are assumed to be saved from the previous season)

<sup>2</sup>Profit (Y) = TR – OC

Total Revenue (TR) = Yield (kg) x Price (INR/kg)

Price of maize: 8.4 INR/kg, Price of cowpea: 15 INR/kg (Household survey data, 2010)

Opportunity cost (OC) = Total labor hours x Wage Rate per hour (11.25 INR/hour)

This analysis shows the potential profitability of farming with off-farm opportunities (at 11.25 INR/hour) as negative. In general, if there are off-farm opportunities available, farmers would have greater earning potential working off-farm. Yet, if there are no outside opportunities for farmers, the farm profitability compared with the profitability from current conventional tillage farming would increase through the implementation of CA practices which include intercropping. By implementing intercropping alone (CT/M-CP), farmer profitability increases by 69.92%, while increasing by 30.39% when implementing minimal tillage plus intercropping (MT/M-CP) (Table 5). Since the availability of off-farm opportunities differs between genders, ages, and through seasons, women and older aged farmers often find it difficult to attain alternative employment, whereas young men do not. For this reason, women and older farmers would likely experience the no opportunity cost scenarios, gaining the greatest profitability through the

adoption of CA practices with intercropping. Men, however, are subject to seasonal fluctuations in employment opportunities and sometimes experience the lack of jobs that women and the elderly do. As mentioned previously, future research should consider these specific employment opportunities (i.e. for young men, seasonal employment opportunities, and other alternative employment options for farmers) and their effects on farmers' decision-making and practices.

The analysis also shows that minimum tillage with a single maize crop reduces labor hours, which in turn increases the time available to work at a second job. For this reason, farmers could increase their income when off-farm opportunities are available if they practice minimal tillage. When there is no available outside employment, the profitability of a minimal tillage practice decreases by 31.11% due to yield decreases and labor hours saved with no off-farm opportunities for income generation. As women have limited off-farm opportunities, this practice would not be as beneficial as it would be to men, who have greater opportunities to generate secondary income.

Based on the results, the short run economic incentives are what have caused farmers to continue their current and unsustainable practices. As the aim is to promote and enhance farmer households' food security and livelihood, policy makers should work in collaboration with extension research, agricultural managers, seed suppliers and farmers to promote CA practices with a focus on the long-term economic and environmental benefits. To be specific, policy makers should provide subsidies to young farmers so that they can focus on the farm rather than look for off-farm employment, extension researchers should not only focus on the innovative technologies themselves but also incorporate workshops and other learning opportunities in which they can explain the long term benefits of CA practices and subsequent food security. In addition, seed suppliers and agricultural managers can work together in determining other crops that may work well in these environmental conditions and that incorporate intercropping to further emphasize the significance of the long term benefits of CA practices.

## **Conclusion**

From the data presented in Table 5 and the overall analysis of this study, three optimal scenarios have been determined based on the comparison of the three conservation agriculture treatments to conventional farming practices:

1. When taking opportunity costs of labor into account, labor is more effectively used for off-farm employment. If one must farm, the best scenario is to incorporate minimum tillage with maize, as it requires the least on-farm labor and the saved labor can be used for off-farm employment.
2. When opportunity costs of labor are not considered, as in the cases where heads of household are either elder or female with limited options for off-farm employment, farmers would optimize earnings through the adoption of intercropping.
3. Although incorporating minimum tillage generates short-term decreases in maize yields, it should nevertheless be integrated into farming systems due to the potential for long-term gains. Evidence has shown that minimum tillage has the potential to contribute to higher yields over time. Continuous practice of minimum tillage has been estimated to increase maize yields by at least 12% and between 8-25% when intercropped with a leguminous crop (Jeranyama et al. 2000).

Part of the objective of this research was to provide solutions to enhance the food security and livelihoods of tribal farm families in Kendujhar, Odisha State. As such, this study focused on ways to increase farmers' yield through introducing the sustainable conservation agriculture practices of minimum tillage and intercropping cowpea with maize. At present, the district of Kendujhar produces only one-fifth of the average national maize yield, representing a significant obstacle for subsistence farmers attempting to earn a living. Yields are currently too low for Kendujhar farmers to sustain their families' livelihood and food security. Therefore, it is apparent that a major policy recommendation should be to increase yields through more advanced technologies, including the use of improved seed varieties, more effective fertilizers and modified farming practices. Seed companies and extension services can each play a role in enhancing the rural knowledge of improved agriculture technology and seed varieties.

The results show that the net profits of adopting some conservation agriculture practices are positive while adopting minimum tillage either has negative or lower returns due to decreased yields. Since CA practices have shown that benefits such as yield and soil improvement take a longer period to reflect positive results, policy-makers should provide farmers with immediate incentives for adopting CA practices. Currently, only a limited number of households (5%) surveyed produced cowpea. Given that cowpea represents one of the more profitable crops sold in the market, introducing cowpea for intercropping would be a profitable enterprise. The role of policy-makers in providing subsidized seeds, other inputs and technical advice would be crucial for promoting the successful adoption of cowpea by farmers without imposing any further input costs to current farming systems (Table 6).

**Table 6.** Role of stakeholders in enhancing the livelihood and food security of smallholder farmers in the District of Kendujhar, Odisha State, India.

Stakeholder	Roles
Policymakers/Government	<ul style="list-style-type: none"> <li>▪ Strengthen extension services to rural farming areas</li> <li>▪ Subsidize seeds, fertilizers and other inputs for the initial stages of implementing conservation agriculture (CA) practices</li> <li>▪ Provide low cost loans and insurance</li> </ul>
Seed suppliers	<ul style="list-style-type: none"> <li>▪ Provide training on benefits and use of commercial seed varieties</li> <li>▪ Work with agricultural managers and extension to focus on seeds that utilize intercropping</li> </ul>
Extension	<ul style="list-style-type: none"> <li>▪ Disseminate the benefits/costs of CA practices</li> <li>▪ Provide long-term demonstration plots comparing yield and soil effects for conventional and CA practices</li> </ul>

At present, the state of Odisha supports 30 KVKs (agriculture technology transfer stations) and 8 regional research stations across the state. Therefore, although this specific study is supported by a local agricultural university (OUAT) in collaboration with a KVK station, the numerous tech-

nology transfer and research stations reflect the potential for replication of CA practices in villages across the state. However, due to the prevalence of low yields and food insecurity amongst these smallholder populations, the lack of effectiveness in extension by these research stations for capacity building and information dissemination highlights a disconnect between extension workers and communities. With the pressing need for improved food security and livelihoods for these farmers, policy-makers should enhance the quality of extension services with regards to agriculture technology and knowledge transfer.

Without sustainable high returns from farming, the lure of off-farm employment will only serve to further threaten the food security of these tribal farm families. Additionally, there are potential implications for the distribution of labor within the household with the implementation of CA practices. Although results from this study showed changes in labor hours for minimum tillage in land preparation, a typically male activity, and weeding, a typically female activity, as well as increases in time spent sowing and harvesting, a shared activity, the resulting labor shift negatively impacted females only.

This study presents the short-term economic benefits and gender impacts of implementing specific conservation agriculture practices. The long-term benefits of sustained higher yields and environmental improvements are expected to result from future studies with similar villages.

## Acknowledgements

This study was funded by USAID/SANREM. Our host country partners at the Orissa University of Agriculture and Technology in Bhubaneswar, India, Drs. K.N. Mishra, S. Dash and D. Naik were instrumental in the successful completion of the research experiments and gathering farm survey data. Thanks also to Dr. Adel Youkhana for his assistance in the literature review of conservation agriculture.

## References

- Ariza-Montobbio P, and S. Lele 2010. Jatropha plantations for biodiesel in Tamil Nadu, India: viability, livelihood trade-offs, and latent conflict. *Ecological Economics* 70:189-195.
- Bishop-Sambrook C. 2003. Labour saving technologies and practices for farming and household activities. Rome: FAO.
- Bloem, J., G. Trytsman, & J. Smith. 2009. Biological nitrogen fixation in resource-poor agriculture in South Africa. *Symbiosis* 48:18-24.
- Food and Agricultural Organization (FAO). 2000. Soil management and conservation for small farms. FAO Soils Bulletin 77. Rome.
- Ghosh, P. K., A. Das, R. Saha, E. Kharkrang, A. K. Tripathi, and G. C. Munda. 2010. Conservation agriculture towards achieving food security in North East India. *Current Science* 99(7), 915-921.

- Government of Orissa. 2010. Orissa agriculture statistics 2008-09. Directorate of Agriculture & Food Production, Bhubaneswar, Orissa, India.
- Kamanga, B. C. G. and Z. Shamudzarira. 2001. On-Farm Legume Experimentation to Improve Soil Fertility in Zimuto Communal Area, Zimbabwe: Farmer Perceptions and Feedback. Seventh Eastern and Southern Africa Regional Maize Conference, 495-507.
- Kochar, Anjini. 1999. Smoothing consumption by smoothing income: Hours-of-work responses to idiosyncratic agricultural shocks in rural India. *The Review of Economics and Statistics* 81(1): 50–6.
- Monneveux, P., E. Quillerou, C. Sanchez, and J. Lopez-Cesati. 2006. Effect of Zero Tillage and Residues Conservation on Continuous Maize Cropping in a Subtropical Environment (Mexico). *Plant and Soil* 279 (1): 95-105.
- Pattanayak, Manoranjan. 2004. Performance of agriculture in the changing structure of the Orissa economy: Issues revisited. Paper presented at the *40th Annual Conference of Indian Econometrics Society*. February.
- Nzabi, A. W., F. Makini, M. Onyango, N. Kidula, C. K. Muyonga, M. Miruka. 2000. Effect of Intercropping Legume with Maize on Soil Fertility and Maize Yield. *Proceedings of the 2nd Scientific Conference of the Soil Management and Legume Research Network Projects* 193-197.
- Rockstrom, J., P. Kaumbutho, J. Mwalley, A. Nzabi, M. Temesgen, and L. Mawenya. 2009. Conservation Farming Strategies in East and Southern Africa: Yields and Rain Water Productivity from On-Farm Action Research. *Soil and Tillage Research* 103 (1) 23-32.
- Roul, P.K. Personal Communication. July 2010.
- Subramanian, Arjunan and Matin Qaim. 2009. Village-wide Effects of Agricultural Biotechnology: The Case of Bt Cotton in India. *World Development* 37(1): 256–267.