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PhD Thesis

Abstract

This thesis analyzes the process of the adoption of agricultural intensification in a mid-hill watershed in Nepal and the impacts of soil disturbances due to chemical fertilizer inputs into intensive agriculture and livestock grazing in the forest on greenhouse gas emissions. In order to avoid food insecurity and meet household expenses, mid-hill farmers have been shifting to intensified agriculture and commercial vegetable production. Agricultural intensification has been seen as an important option to overcome the food deficit, while chemical fertilizer is regarded as the engine of agricultural growth. However, the country's changing fertilizer subsidy schemes could better contribute to food production in the country.

The study was carried out in the Ansikhola watershed in the mid-hill region of central Nepal and the Biligiri Rangaswamy Temple wildlife sanctuary in India during 2009 and 2010. The objectives were to (i) assess the process of agricultural intensification, (ii) determine factors influencing the adoption of intensified farming practices, (iii) assess the effects of high nitrogen fertilizer inputs on soil acidification and the potential for N₂O emission, (iv) determine the effects of livestock grazing in forests on the fluxes of N₂O and CH₄, and (v) examine fertilizer policy development by focusing on fertilizer subsidy schemes, and farmers' actions and perceptions. In order to meet the objectives of the research, data collection was conducted using a questionnaire survey, group discussions, key informant interviews, participant observation, a workshop, informal discussions, laboratory and field experiments and analysis, and desk studies.

Each of the five objectives has been addressed in five separate papers. However, the synthesis of these studies reveals that the process of agricultural intensification in the midhills of Nepal has been described as a ladder approach where some steps of the ladder take longer time to climb than others and each step is characterized differently. With the intensification process, mid-hill farmers have increased the number of crops per year that resulted in a significant increase in the use of urea and diammonium

phosphate and a significant decrease in the use of farmyard manure and potassium fertilizers in the past 20 years. However, the adoption behaviour of farmers is determined by several socio-economic and institutional factors. The study revealed that irrigation, crop yield, landholding size and access to credit increased the likelihood of adoption behaviour significantly, whereas distance to the chemical fertilizer store has significant negative influence. The total amount of chemical fertilizer used by farmers and the net income accrued from selling cereals and vegetables due to the high market value of these crops imply that there will be a tendency towards increasing the area under crop intensification. However, the increased dependency on chemical fertilizers with intensive cultivation practices appears to lead to soil acidification. The results from standardized anoxic incubations of soils revealed that intensification increased the $\text{N}_2\text{O}/\text{N}_2\text{O}+\text{N}_2$ product ratio of denitrification. Whatever mechanisms are involved in soil acidification, it is clear that the widespread application of ammonia-based fertilizers that is taking place in South Asian countries has a potential to acidify the soil to the level for denitrification N_2O release.

Soil disturbance by grazing is often an important phenomenon in South Asia due to the increased human and livestock population. It significantly lowered the net CH_4 uptake in disturbed forest areas. However, the net N_2O emission was significantly higher for undisturbed forest areas contrary to expectations.

The development of the fertilizer policy and subsidy schemes in Nepal occurred in four phases: without subsidy (from 1952 to 1972); with subsidy (from 1973/74 to 1996/97); with deregulation of fertilizer trade (from 1997/98 to 2007/08); and with the current policy on fertilizer subsidies (from 2009 to the present). The majority of the farmers (88%) were not aware of recent change in fertilizer policy.

Based on the research conducted for this thesis, the need for balancing increased food production with reduced impacts on soil and atmosphere (climate gases emission) through sustainable agricultural intensification is recommended. Sustainable agricultural intensification can be achieved by improving the effectiveness of the country's extension services and their approaches, especially those related to fertilizer inputs and new technology.