Global Environmental Change 28 (2014) 50–62

Contents lists available at ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Differences in farmer and expert beliefs and the perceived impacts of conservation agriculture

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ARTICLE INFO

Article history:
Received 23 August 2013
Received in revised form 13 March 2014
Accepted 20 May 2014
Available online

Keywords:
Cognitive mapping
Conservation agriculture
Nepal
Subsistence farming
Agriculture development

ABSTRACT

Departing from the traditional agricultural model of input-heavy, intensive agriculture via the use of agrochemicals and irrigated water, many international development projects have started to promote conservation agriculture in developing countries. However, relying solely on technical expertise, largely generated outside the rural communities in which they are applied, often does not consider whether local ecological and culturally influenced beliefs are consistent with the technologies being promoted for adoption. We suggest these disconnects can be linked to differing 'mental models' of scientific experts and rural agricultural communities regarding the nature of farming dynamics and predicted impacts of introduced farming practices. Using an agricultural development project in Nepal as a case study, this research seeks to understand the relationship between trends in expert and rural farmer reasoning and predictions regarding the outcomes associated with development technology based on these beliefs. Further, we seek to compare these mental model-based differences with local environmental conditions (using soil measurements) and agricultural outcomes in terms of farm production (i.e. yield). While researchers' mental models predicted that minimum tillage would improve yield, mental models from two of the three villages predicted that yield would decrease. Local soil and yield measurements support the farmers' mental model predictions. Our results indicated that conservation agriculture techniques should not be applied universally, development practitioners should engage in a two-way learning with local communities to benefit from locally situated knowledge.

1. Introduction

With rising populations, increasing demands are placed on agricultural systems to produce greater yields through the more efficient use of natural resources. Worldwide, there are 500 million smallholder farms (<2 ha), in which 80 percent of the food that is produced is consumed within Asia and Africa (IFAD, 2011). As a result, considerable research and international development resources have focused on promoting the long-term productive capacity of smallholder farming communities and improve food security. These development approaches often focus on promoting "green revolution" technologies (Fitzgerald, 1986; Perkins, 1997) and other approaches designed for large-scale production, including conservation agriculture, without regard for adapting these technologies to meet the needs of rural farming communities. Conservation agriculture includes the practices of minimum tillage, improved crop varieties, intercropping, and the use of cover crops that help to mitigate soil nutrient depletion, land degradation, and increase yields (Hobbs et al., 2008). Extensive global promotion of these practices has resulted in 72 million hectares of conservation agriculture systems worldwide with an estimated average growth rate of and additional 7 million ha per year (Freidrich et al., 2012). Moreover, 105 million hectares of no-till agricultural land were recorded in 2008, though this has been primarily on large-scale farms (Derpsch and Friedrich, 2014). Conservation agriculture has been promoted because it requires simple changes in farming techniques, which can be a more

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http://dx.doi.org/10.1016/j.gloenvcha.2014.05.001
0959-3780/

economically viable approach for rural farms as compared with other soil and water conservation technologies. In the United States alone, it is estimated that the decreased erosion that has resulted from conservation tillage practices resulted in a savings between 90.3 and 288.8 million USD (FAO, 2014a).

This top-down approach of "modern" agricultural technologies for the global South, however, has recently been called into question and there is a lack of evidence to support long-term agricultural and environmental improvement (Giller et al., 2009). In fact, recent studies have indicated that conservation agriculture may not be the most appropriate way to increase farming capacity at the local and community scales due to problems associated with competing uses for crop residues, increased labor demand for weeding, and lack of access to, and use of external inputs (Giller et al., 2009).

In addition to issues associated with the hidden costs of conservation agriculture, many agricultural development programs make global recommendations with little regard for farmers' existing beliefs, or so called "mental models", of existing or new farming practices/technologies and their perceived impacts on productivity. Perhaps because of this disconnect between the way in which researcher and rural farming communities conceptualize new technologies and integrate them into existing decision-making processes, new practices introduced by government extension, Non-Governmental Organizations, or other research institutions are often abandoned for traditional practices after development projects have been completed (Bunch, 1999; Cochran, 2003; Yadav, 1987). More recently, a review of conservation agriculture studies revealed that there are few, if any, universal factors that determine the adoption of new technologies and the factors that influence local adoption are highly contextual and tend to vary due to differing local and ecological conditions (Knowler and Bradshaw, 2007). Thus, it is crucial to consider the bottom-up perspective when approaching the introduction of agricultural development programs, encouraging a community and stakeholder participatory approach in order to design project goals and objectives that serve the interests of multiple farm stakeholder groups (Chambers, 1994; Pretty, 1995). Studies have found that conservation approaches promoted in developing countries as universally applicable scientific methods may actually reflect the particular social and historical contexts of their genealogy, for instance, in the case of biodiversity protection (Goldman, 2011) and soil erosion prevention (Forsyth, 2011). Therefore, when promoting conservation agriculture in international development, it is necessary to critically scrutinize its assumptions and to ask whether the promotion of new technologies, including conservation agriculture practices, are locally appropriate and how different perspectives about agricultural beliefs and expected outcomes can be aligned to increase the success of international conservation development.

This research adopts an interdisciplinary and empirical approach to understand the relationship between trends in expert and rural farmer reasoning and predictions regarding the outcomes associated with development technology based on these beliefs. Further, we seek to compare these differences in understanding with local environmental conditions and measured development outcomes in terms of farm production (i.e. yield). At the center of our study is an interest in comparing differences between expert and locally based environmental knowledge regarding the dynamics of farming systems. These two knowledge systems increasingly interact in the agricultural development sector, including conservation agriculture projects, across the globe. Knowledge systems are typically categorized based on local knowledge (e.g. lay or traditional) or scientific knowledge. Local knowledge is typically drawn systematically from personal experiences or generational knowledge, while scientific knowledge is gained from structured ways of knowing, based on principles that place high importance on reliability, validity, and repeatability of knowledge claims and generalizable implications (Gray et al., 2012). The literature shows that local ecological knowledge is expected to vary given changes in local, social, and environmental conditions (Berkes et al., 2000; Folke et al., 2005). Furthermore, knowledge of ecosystem dynamics gained from historical experience become culturally embedded and are an important part of developing adaptive management strategies (Berkes et al., 2000). The identification of the environmental and/or social and cultural conditions that act as pre-cursors to affect farmer decision-making will be invaluable in developing a greater understanding of the mechanisms in how rural farmers understand various agricultural practices and their views of introduced practices that are promoted by researchers and extension personnel. Recognizing these key factors will also expose hidden assumptions and blind spots in "scientific" approaches that may be overlooked with the conventional top-down development approach. The specific objectives of this research are: (i) to understand how environmental conditions and social contexts may influence agricultural beliefs or perceptions, (ii) to estimate how these different beliefs may influence the predicted outcomes of introduced conservation agriculture practices, (iii) to assess the accuracy of the predicted outcomes of conservation agriculture practices via empirical farm-based measurements.

Although criticisms of top-down approaches and over-reliance on expert knowledge have been around for some time (Arnstein, 1969), methods that measure the differences between local and scientific knowledge remain under-developed. Further, many models suggest that the promotion of social-learning between development personnel and local communities are qualitative and explain only the general processes that should occur with less attention paid to generating empirical data to validate or reject these suggested models. However, by specifically identifying the differences in perception resulting from local ecological knowledge as compared with scientific knowledge, we can better understand where these differences originate and develop improved methods for creating shared knowledge and improved collaboration. In this study, we seek to understand the differences in perception of the agricultural system by combining aspects of 'mental modeling' (Gray et al., 2014). As a case study, we will use farmers and scientists engaged in an agriculture development project and utilize soil and crop science to better understand how knowledge of agricultural dynamics are initially developed, how these beliefs may influence expected outcomes of introduced technologies, and how these expectations compare to measured agricultural outcomes.

1.1. Mental models

First introduced by Craik (1943), today the notion of mental models and their use for understanding individual and group decision-making is a widely accepted construct in the social science literature (Jones et al., 2011; Gray et al., 2014). Mental models are the internal constructs that provide interpretation and structure of an external environment and are therefore an important component of how individuals make decisions. These internal representations are often constructed as individuals navigate time and space, modifying their understanding of the world around them, filtered by culture and influenced by environmental conditions and new experiences. The ways in which different representations of the world are organized, socially influenced, and made useful for understanding the management of natural resources has seen increasing attention in recent years (Kellert et al., 2000; Gadgil et al., 2000; Armitage, 2003; Brown,