How Smallholder Farmers in Uttarakhand Reworked the System of Rice Intensification:
Innovations from Sociotechnical Interactions in Fields and Villages

Debashish Sen

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INVITATION

You are cordially invited to attend the public defence of my PhD thesis, entitled

How Smallholder Farmers in Uttarakhand Reworked the System of Rice Intensification:

Innovations from Sociotechnical Interactions in Fields and Villages

On Friday 20 November 2015
at 11 AM in the Aula of
Wageningen University
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You are kindly invited to join the reception after the defence

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Debashish Sen

Thesis

submitted in fulfillment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus
Prof. Dr A.P.J. Mol,
in the presence of the
Thesis Committee appointed by the Academic Board
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To the women farmers of Phalenda, Thayeli and Dakhwangaon

Abstract

How Smallholder Farmers in Uttarakhand Reworked the System of Rice Intensification: Innovations from Sociotechnical Interactions in Fields and Villages

The System of Rice Intensification (SRI) is presented in Asia and other parts of the world as an alternative ‘agro-ecological’ and ‘farm-based’ innovation in rice production. SRI calls for modifications in crop-management practices without relying on external inputs, which makes it different from innovations based on new rice varieties, which became dominant since the Green Revolution. SRI practices are therefore said to be appropriate for resource-poor smallholder farmers.

Previous studies on SRI have focused mainly on the yield effects in comparison with other crop management practices, overall costs and benefits of SRI or deviations from recommended practices. These studies have largely neglected farmers’ underlying strategies. This thesis provides an understanding of whether and how SRI can be called a ‘farm-based’ innovation. Rather than returning to earlier debates about SRI's adoption and disadoption, the study looks as how farm households and communities in Western Himalayan region of India responded to the introduction of SRI.

The main objective of this research was to understand how farmers respond to an intervention like SRI and what this tells us about SRI as a socio-technical system. The main research question addressed by this thesis is how SRI, conceived as a set of practices introduced from outside the communities, was incorporated into the local rice farming system. Specifically, the thesis examines how existing work groups were adjusted to accommodate the new method, how the SRI practices were interpreted and adjusted to fit with the local social and agro-ecological arrangements, and how the new method influenced existing rice farming practices in the locality.

The research was carried out in three contrasting villages of Uttarakhand, located in the Bhilangana sub-basin of the Western Himalayan region of India. SRI was introduced in this area in 2008. Fieldwork in the three villages was conducted throughout two rice seasons.

The theoretical resources drawn upon for this research include the concept of “socio-technical system”, “agriculture as performance”, and the culture of “task groups”. Together these concepts help to understand rice farming as a collective and mutually shaping social and technical performance rather than the activity of an individual farmer. The thesis shows how existing and new rice farming practices and task groups are reconfigured through socio-technical innovations within a given agro-ecological setting. SRI acted as a catalyst, initiating a process of readjustments in the socio-technical configurations of rice farming, varying according to the local context. Farm households, while incorporating SRI into the existing farming system, try to seek complementarity and synergy between various rice farming methods. This allows fluidity among task groups and leads to the extension and diversification of the repertoire of methods used, taking into account the dynamics of the larger socio-economic conditions. The thesis highlights farmers' adaptive capacities to reconfigure practices, reorganize social formations, and reschedule routines in response to farming interventions, in order to maximize the exploitation of agro-ecological niches, minimize uncertainty in farm production and rationalize the employment of the available work force.

The study indicates a potential for task groups as units for effectively promoting new agricultural interventions. The groups performing farm operations are crucial in developing and adjusting farmers' managerial skills to cater to the needs of the rice crop in light of the social and economic conditions of the community. For instance, elements of the set of SRI practices, like the use of younger seedlings, fewer seedlings per hill and wider spacing of hills were shown to have influenced practices in nominally 'non-SRI' plots. Changes in customary ritual like *Din Bar* announcing the date of rice transplanting, elevation in the status of Village Level Resource Persons (VLRPs), emergence of different forms of raised bed nurseries (RBNs), and inclusion of young women in transplanting groups reflect how introduction of SRI brought about changes in the social structure and institutions. This thesis thus highlights the role and importance of the human management component in farming activities and agricultural development. This provided insights into the integration of social and technical dimensions of crop cultivation, particularly the dynamics of rice farming using SRI but also for agronomy as a whole.

Keywords: Rice, smallholder farmers, System of Rice Intensification (SRI), socio-technical interactions, farm based innovations, task groups, technical practices, labour organization, mountain farms, Uttarakhand in India.

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Abbreviations and acronyms

ANGRAU	Acharya N.G. Ranga Agricultural University
ANT	Actor–Network Theory
ATMA	Agricultural Technology Management Agency
AWD	Alternate Wetting and Drying
DAS	Days after Seeding
FYM	Farm Yard Manure
GR	Green Revolution
HYVs	High Yielding Varieties
IAMWARM	Irrigated Agriculture Modernization and Water-Bodies Restoration and Management
MTs	Master Trainers
MVDA	Mount Valley Development Agency
NGOs	Non-Governmental Organisations
PSI	People's Science Institute
RBNs	Raised Bed Nurseries
SHGs	Self-Help Groups
SRI	System of Rice Intensification
TNAU	Tamil Nadu Agricultural University
VLRPs	Village Level Resource Persons
WWF	*World Wilde Fund for Nature*

Chapter 1

General Introduction

In the last two decades in Indiathe System of Rice Intensification (SRI) has emerged as a new way of growing rice. It is claimed that SRI is a coherent, integrated system comprised of several interacting and synergetic elements, yet the available literature and many anecdotal observations from India and other countries indicate that SRI has been taken up as a whole system in only a minority of cases. There is a distance between 'ideal' SRI as portrayed on paper and 'actual' SRI as seen in farmers' fields. This diversity of practice has been portrayed by critics as evidence that SRI does not exist, or that it doesn't work, or that it has been rejected by farmers. This has led to a debate about what counts or does not count as SRI. However, the same phenomenon is interpreted by supporters as a positive feature of SRI itself, an intrinsic characteristic of the system whereby it enables and encourages farmers to adapt and modify SRI practices to suit local conditions. How are we to understand SRI if it is said to be both an integrated system that activates synergetic interactions, and a decomposable system where the individual components can be adopted independently yet still somehow expressing SRI as a whole? In this thesis, rice cultivation is seen as an interaction between people and material elements in particular socio-economic, spatial and temporal situations. Moving away from the debate of what is and what is not SRI, this research investigated the mechanisms leading to variations in rice cultivation practice in different settings, in response to the introduction of SRI.

1.1 SRI - An Unconventional Approach to Rice Farming and Intensification

Rice in India: A Smallholders' Lifeline

India is the second major producer of rice after China, having a gross coverage of 45 M ha and contributing about 100 M T to global production (DRR, 2011; FAO, 2014a). These statistics represent an average yield level of about 2.2 T/ha, which is low by international standards and probably indicates that there is not much emphasis by cultivators on achieving high yields. Much rice farming in the country is done by smallholders (having farms of fewer than 2 hectares), who own 78 per cent of the landholdings. Smallholders' account for about half of India's total rice production but contribute to only 20 per cent of the marketable surplus of rice (FAO, 2002). The fact that only 10 M T of the total production is exported further illustrates rice's importance as one of India's major subsistence crops.

Rice, the staple food of more than 65 per cent of India's population, symbolizes luck, wealth and fertility for most of its inhabitants, and especially so for the smallholders putting in their labour and skills to grow it for their own food security and livelihoods. Rice therefore has an important socio-cultural significance for smallholders in India. This is well reflected by the rituals followed by rice growers during the stages of cultivation, and the crop’s essential use in the rites performed at different stages of human life. Smallholders grow rice mostly with family and exchange labour, and to a lesser extent hired labour. Rice cultivation by smallholders therefore deserves a socio-technical lens encompassing activities and organizational arrangements beyond agronomic practices alone.

The diverse landscapes and agro-ecological zones of India create a variety of rice-based agro-ecosystems. The major rice systems are irrigated (50 per cent), rainfed lowland (32 per cent), rainfed upland (14 per cent) and flood-prone (four per cent) (DRR, 2011). Smallholders dominate all of these rice-ecosystems. Among these ecosystems, the rainfed upland smallholders grow a wide range of crops besides rice in order to meet much of the farm households’ own food requirements and cope with climatic vagaries, leading to a diversified and complex rice farming system. Since the 1960s, much of the scientific effort to enhance rice production has focussed on the irrigated and rainfed lowlands, large tracts of which have been dramatically transformed during the Green Revolution (GR). By comparison, the rainfed uplands have generally been neglected.

The Green Revolution in India: Side-effects and the need for alternatives

The GR package of technologies emphasized the use of improved, High Yielding Varieties (HYVs), application of chemical fertilizers and assured irrigation. Mechanization and pesticides (insecticides, fungicides and herbicides) were later additions to this package. Incentivesand input subsidies were provided through government policies. Recommendations for suitable varieties and standardized doses of external inputs were primarily based on experiments done in research stations, neglecting the diversity of farms as well as farm households’ other needs besides increased yields. The use of the relatively standardized technological package was pushed through a top-down approach, discounting farmers’ knowledge and experience (Harwood, 2012).

Though the GR is said to have contributed significantly to the increased rice productivity levels, especially during the 1960s to 1980s, it is often criticized for increasing the socio-economic inequality within and between regions of the country (Bajpai and Sachs, 1996; Pritchard et al., 2013). The GR technologies were more appropriate and became more widespread in irrigated and favourable rainfed lowlands (such as in Punjab, Haryana, Western Uttar Pradesh and parts of Tamil Nadu and West Bengal), and also benefitted the more affluent farmers. The uptake of the GR technology package and its performance were much lower in the marginal lands and among resource poor smallholders (e.g. in the North Western and North Eastern mountain states, Bihar, and Odisha) (Byerlee and Morris, 1993; Conway and Wilson, 2012; Pingali, 2012).

The same discrepancy is clearly reflected in the state of Uttarakhand, a northern state of India that includes both irrigated lowland plains and rainfed upland farming in mountainous regions. Uttarakhand is the home of India’s first agricultural university, G B Pant University of Agriculture and Technology established at Pantnagar in 1960, which was actively involved in promoting the technologies and programmes of the GR. However, the mountain regions of the state, lacking critical resources such as irrigation, credit, extension services, and transport systems, were largely ignored and rice productivity in these areas remains far behind that in the plains (Mani, 2011).

Indian policy makers are worried that the rapid production increases of the GR are declining. The growth rate in rice productivities (along with use of fertilizers and HYVs) have declined or stagnated in many parts of India during the last two decades, even in the prominent GR areas of the country (Grassini et al., 2013). Rice production in India as elsewhere in Asia is facing diverse challenges including a decrease in the number of farmers and increased scarcity of labour, land and water as an effect of urbanisation and industrialization, increasing input costs, declining profitability, and intensive cultivation, as well as diversification out of rice (Papademetriou, 2000; Singh 2000). Adding to the problems are increasing environmental impacts such as reduced groundwater levels, soil degradation including salinity, enhanced pollution, diminishing fossil fuels, greenhouse gas emissions, and human health hazards (FAO, 2003). In the context of 21st century's agricultural production and food requirements, the threats of unsustainability and climate change are increasingly being realized even in the Asian rice bowls (Pingali et al., 1997; Redfern et al., 2012). Smallholders, having limited access to resources and support, seem to be more at risk (UNEP and IFAD, 2013).

Recognizing the overarching problems associated with the GR and realizing that conventional science-based innovations and approaches alone could not provide solutions (Feldman and Biggs, 2012), there has been a search for new approaches, especially for the marginal regions and smallholders. Approaches are sought that can address the negative side-effects of GR-type practices while continuing to assure food security in the future. New approaches under the banner of 'sustainable intensification' have been suggested ever since the 1980s (Harwood, 2012). These focus on improved location-specific crop-management practices while conserving natural resources, reducing or reversing undesirable environmental effects and also withstanding weather aberrations. They emphasize the integration of farmers' experience or indigenous knowledge with scientists' technical knowledge. Examples of such practices include farming systems research, participatory plant breeding, integrated pest management, integrated soil fertility management, integrated water management, agroecology, agroforestry, minimum tillage systems, and conservation agriculture (Ringler et al., 2014).

SRI: An alternative approach and its spread in India

The general discontent with GR has been with the neglect of smallholders, adverse environmental effectsand top-down extension methods. SRI has been presented as an alternative way of growing rice (Uphoff, 2003; Mishra et al., 2007). Unlike the GR, the new system emerged from an unlikely source at the fringes of international science – an upland region of Madagascar during the 1980s, developed through field-level trial-and-error type experiments (Laulanié, 1993). According to Glover (2011a), these experiments also drew upon various scientific sources and some existing practices. Some have labeled SRI as a 'farm-based' innovation while others refer to it as a low-external input approach, recognizing its reduced emphasis on rice varietal improvements and other external inputs, as explained below.

SRI is a "methodology for increasing the productivity of rice cultivation by changing the management of plants, soil, water and nutrients" (Stoop et al., 2009). The commonly recommended set of six interdependent agronomic practices under the system include transplanting of (i) young (ii) single seedlings per hill at (iii) wide spacing; (iv) a water-management regime based on alternate wetting and drying (AWD) and/or shallow irrigation; (v) inter-cultivation with a mechanical rotary weeder; and (vi) use of organic fertilizers to the extent possible (Stoop et al., 2002; Uphoff et al., 2002). These have been projected as a set of flexible guidelines or 'suite of principles' rather than a standardized technological package (Uphoff, 2001; SRI-Rice, 2014), but in practice, as the cases introduced in thesis confirm, SRI is often introduced to farmers as a rather standardized package of practices.

Since its emergence in Madagascar, SRI has now been spread to about 50 countries, including India, with reported coverage of 10 million farmers and 4 million hectares (Uphoff et al., 2015). SRI was introduced to India around 2000 through at least three channels, namely the Acharya N.G. Ranga Agricultural University (ANGRAU) in Andhra Pradesh, the Tamil Nadu Agricultural University (TNAU) in Tamil Nadu, and the internationalist experimental commune Auroville (Prasad, 2006; Glover, 2011 b; Thiyagarajan & Gujja, 2013). What followed in the next decade was an impressive coming together of a coalition of NGOs, CSOs, farmers and farmers' groups, and individual policy makers and researchers, along with the support of agricultural extension agencies including the Agricultural Technology Management Agency (ATMA), national and international research and funding organizations (e.g. the Sir Dorabji Tata Trust, The World Bank, and WWF–ICRISAT[1]). Over one million farmers have reportedly put SRI into practice on up to three million hectares across more than 50 per cent of the rice growing districts in India (Prasad et al., 2013; WWF-ICRISAT, 2010). Interestingly, SRI principles have also been adapted and applied to other crops in India and elsewhere, such as wheat and sugar cane (SRI-Rice, 2014; LEISA, 2013). A more recent estimate indicates that more than 3.5 million Indian farmers have applied SRI principles (Prasad and Sen, 2014).

Though there have been attempts to promote SRI in a rather classic top-down manner (such as under IAMWARM[2] project by TNAU), much of the above spread is

[1] World Wilde Fund for Nature (WWF) and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) jointly undertook the project 'Improving the water productivity of the agriculture' researching approaches (including SRI) wherein the resource inputs are low and yields are high.

[2] Irrigated Agriculture Modernization and Water-Bodies Restoration and Management (IAMWARM) is a multidisciplinary project funded by World Bank and implemented by the Water Resources Organization (WRO), PWD and Government of Tamil Nadu as the nodal agencies.

largely credited to a bottom-up mode of technology transfer, including institutional collaborations in which civil society organizations and even the practitioners have taken the lead (Prasad, 2006; Prasad, 2008; and Thiyagarajan and Gujja, 2013). This is in stark contrast to the dominant role of public research and extension systems that led the GR in the country. There is a good conceptual argument saying that SRI methods ought to be particularly appropriate and accessible for resource-poor small-scale farmers, because it can be implemented without new seeds or costly chemicals. In contrast with the GR, there also seems to be a higher uptake of the system among smallholders rather than larger farmers, especially in states such as Tripura, Bihar, Odisha and Uttarakhand in India (WWF-ICRISAT, 2010) as in other countries (Uphoff, 2012; Uphoff et al., 2015). If this is correct, it is worth investigating whether and why smallholders are better positioned to respond to the system.

SRI is reported to have spread to all the rice-growing states of India. The recommended SRI practices diverge considerably from rice farmers' so-called traditional and conventional practices with respect to nursery raising, transplanting, weeding, water and nutrient management. SRI therefore presents challenges to farmers' learning and knowledge systems. Wide variations in the way SRI is adopted and practiced by farmers have already been reported across Indian states (Palaniswami et al., 2013; and Thiyagarajan and Gujja, 2013) and in other countries, but in-depth analysis of the mechanisms responsible for these variations and modifications remains to be done. Most of the studies conducted on SRI in India have focused on the more prominent GR areas such as Tamil Nadu and Andhra Pradesh, leaving SRI's impacts in marginal regions of the country still unexplored. Considering SRI as a compilation of recommended practices, schedules, inputs and techniques, it will be interesting to see how similarly or differently farmers, especially smallholders in rainfed upland ecosystems, respond to it.

This research studied farmers' and communities' responses to SRI in one of the more marginal and least studied regions in the country, namely the mountain farms of Uttarakhand in the Western Himalayan region of India. The choice of this region enables study of (a) farms comparatively less impacted by the GR package of technologies, (b) poor and marginal smallholders' responses to SRI, and (c) diverse farm conditions with and without irrigation and different soil conditions that exist within short distances.

1.2 The Problem: Unravelling Risks and Opportunities in SRI Farming

Most of the earlier studies on SRI investigated its yield potential, production costs, and risks (Stoop et al., 2002; Uphoff et al., 2002; Barrett et al., 2004; Sheehy et al., 2004, Latif et al., 2005; and Moser et al., 2006). Much of the early research sparked intensive debates about SRI's profitability, adoptability, and sustainability as compared with the conventional best management practices. There were major rifts between supporters and critics of SRI (Stoop et al., 2005; Uphoff et al., 2008) and the opponents (Dobermann, 2004; Sinclair et al., 2004; Sheehy et al., 2005; Mc Donald et al., 2006; and Mc Donald et al., 2008).

Subsequent research on SRI continued in two main directions. One set of studies focussed on exploring the claimed synergies between the recommended practices of SRI, trying to understand the new set of G (Genotype) × E (Environment) interactions related to crop physiology, root morphology and soil ecology under the system (Randriamiharisoa et al., 2006; Latif et al., 2009; Mishra and Salokhe, 2010; and Thakur et al., 2010). Others tried out different combinations of the new crop-management principles in order to analyze crop physiology, root morphology and yield characteristics, using diverse varieties, through on-farm trials as well as on-station experiments (Makarim et al., 2002; Zheng et al., 2004; Yang et al., 2008; Karki, 2009; Thakur et al. 2009; Veeramani, 2010; and Dhananchezhiyan et al., 2013). The effort was to try to find the best fit in a particular agro-ecological system.

The reasons and mechanisms leading to diverse implementations of SRI still require explanation. Previous research has not given much attention to the manner of SRI's adoption, farmers' various adaptations, and the mechanisms behind these processes (Prasad 2007; Glover 2011c; and Berkhout and Glover, 2011). Three basic issues emerge from earlier studies, warranting further investigations that may help to resolve these un-investigated problems.

Unexplained adjustments and exchanges

Studies in India and elsewhere have indicated that in practice the full suite of six basic components of SRI is rarely adopted by farmers (Xiaoyun et al., 2005; Mc Donald et al., 2006; and Palaniswami et al., 2013). These studies assumed that farmers respond to a new technological proposition or intervention by 'adopting' it or not, or perhaps adopting and then disadopting it. Consequently, deviations from the set of six commonly recommended SRI practices were often reported as 'dis-adoption' without probing into the changes in practices that had actually occurred. Reported 'non-adoption' and 'dis-adoption' in SRI has largely been attributed to higher labour demand and the absence of proper extension support (Moser and Barrett, 2003; and Namara et al. 2003). These types of analysis have generally conformed to an analytical frame that perceives technical change as a simple process of adoption or rejection by farmers, disregarding the complex social processes that take place concurrently (Ringler et al., 2014). Previous efforts to explain flexibilities and variations in SRI mostly followed a reductionist and economically rational model of adoption, with adoption as the dependent variable and various household characteristics as independent variables (Moser and Barrett, 2003; and Moser and Barrett, 2006) and/or plot level (Palaniswami et al., 2010; Lya et al., 2012; Martin et al., 2012; Doi and Mizoguchi, 2013; and Palaniswami et al., 2013). As a result, these studies offered a limited insight discounting the possible and intricate interactions even between the independent variables and the complexities and uncertainties of everyday farming practices. Very few studies mentioned SRI's influence on the existing rice-production systems in particular agro-ecological contexts (Kabir and Uphoff, 2007; and Sinha and Talati, 2007). These studies have therefore failed to explain farmers' motivations, compulsions, and processes behind the adjustments in SRI and its exchanges with existing practices.

Labour and Work Organization

A number of studies have highlighted labour as a constraint in SRI's adoption (Moser and Barrett, 2003; Namara et al. 2003; Barrett et al., 2004; Latif et al., 2005; Senthilkumar et al., 2008; Latif et al., 2009; and Lya et al. 2012). Others have identified a labour-saving potential in SRI (Anthofer, 2004; Li et al., 2004; Sinha and Talati, 2007; and Sato et al., 2007) compared to recommended best management or conventional practices. These studies tend to be limited to the assessment of labour usage and costs, overlooking organization and management-related issues. The requirement of timely labour interventions and new set of skills is implicit in the recommended practices of SRI (Glover, 2011a) and likely to create additional demands in labour and skill management. Farmers' decisions relating to labour use and work organization, and adjustments in these arrangements, cannot just be treated as individualistic at farm-level – which has often been the case. Group-level and community-level interactions need to be accounted for because farming practices involve more than one person – work groups, extension agencies and even the village community as a whole. This research investigates the set of social and institutional innovations for labour and work organization that were instituted to facilitate the reception of SRI in three mountain villages of Uttarakhand.

Unexplored Role of Farm and Cultural Diversity

Concepts and practices of SRI have been tried and adapted by farming communities in different rice ecosystems as well as other crop production systems, world-wide as well as in India (SRI-Rice, 2014). Even in the Western Himalayan region of India, a lot of spatial and temporal variability in practices has been observed among farmers exposed to SRI, in both rice and other crop production systems (Sen et al., 2010). The variability and diversity in rice ecosystems and related socio-cultural contexts between and within different crop production zones are likely to put multiple stresses on farmers and influence adaptations in SRI. To explain why and how different patterns emerge in different sites, whether villages that are geographically close together or even fields belonging to the same farm household, one would need to account for agro-ecological and socio-cultural factors and their interactions. Though "adaptation of SRI and its components to the needs and opportunities of diverse rice production systems, including adjustments for socio-economic acceptability and suitability" had earlier been identified as a critical aspect for research (Stoop et al., 2002, p.267), few studies have really explored this research area. Farmers' intentions, goals and strategies while incorporating SRI methods into their farm production system remain largely unexamined.

Literature and discussions around SRI have tended to focus on yield and productivity rather than other reasons farmers might have to value or reject the system. Is SRI decomposable, having a coherence and unity on one hand yet individual elements when adopted independently or in different combinations are somehow still expressing the essence of the whole? What can this tell us about farmers' skills and creativity? Is it that the farmers are taking SRI and making it their own or is SRI doing something to the farmers that make them more skilful and creative? These are problems and issues important to the debates that have gone on about SRI, which this thesis will elaborate on.

Instead of defining and measuring levels of adoption, non-adoption and dis-adoption or assessing water, labour use and yields, this study took a different approach by examining farmers' practices and decision-making, and how these are enmeshed with community, place and time. It offers an in-depth analysis of the mechanisms responsible for the deviations from recommended SRI practices and/or modifications in the current practices leading to a much clearer understanding of the ways in which SRI has been integrated within existing farming systems. It provides insights into how smallholders go about their farming, i.e. the notion of decision-making under various constraints, in the face of uncertainty, characterised by opportunism on one hand and hedging/risk spreading on the other.

1.3 Research Objectives and Questions

The main objective of the research was to understand how farmers respond to an intervention like SRI and what this tells us about SRI as a socio-technical system. This will help us to understand how to promote effective management practices for rice and other crops. The study investigated the integration of SRI practices into existing rice farming practices – in other words, the nature, extent and processes of socio-technical adaptation in response to a technical intervention from outside the community. The main research question that the thesis addresses is how SRI as a set of practices was incorporated into the local rice farming system. Specifically it was assessed how existing work groups were adjusted to accommodate the new method and, at the same time, how the SRI practices were interpreted and adjusted to fit with the local social and agro-ecological arrangements.

Three specific sets of sub-questions were developed, as outlined below.

(1) What is the socio-technical configuration of existing rice farming practices? What are the existing forms of work groups (or task groups) and how are their structures, workings and functions interrelated? What are the existing rules and routines for work groups and how do they vary across communities, farm households and seasons?

(2) How do the proposed new SRI practices disrupt existing rice farming practices and interact with the local social and agro-ecological context? What are the socio-technical (labour, skill, material) implications of the new practices with

respect to existing practices? What social and technical obstacles do work groups and their associations face in order to incorporate SRI practices into the existing rice farming system?

(3) How are rice farming operations and tasks adapted and adjusted in conjunction with the introduction of SRI methods? How are existing and new systems of knowledge, skill and practice integrated and recreated? How changes are brought about in labour organization and co-ordination and how are new relationships, rules and routines formulated? How does the agro-ecological setting influence these adaptive processes and how is the local agro-ecology changed in turn, due to SRI? And how do the patterns of adaptation and reconfiguration vary across locations and seasons?

To unravel these intricate processes, an analytical framework was required which could explain the formation and functioning of farmers' collectives (as work groups) in the form of complex socio-technical configurations while undertaking specific operations in rice farming, and could further address changes/adjustments brought about in such configurations with the introduction of SRI within diverse agro-ecological settings.

1.4 Conceptual Framework and Methodology

The analytical framework required concepts that could help probe and explain (a) farmers' strategies for organizing and coordinating labour and skills while they get into different socio-technical configurations in order to perform various tasks and achieve their goals (addressing the first set of research questions in understanding how socio-technical configurations come into being and operate in rice farming systems); (b) their attitudes and approaches when exposed to the new SRI practices addressing complexities and uncertainties under diverse conditions (addressing the second set of research questions pertaining to the nature of challenges posed by SRI to existing socio-technical systems and institutions operating in rice systems); and (c) farmers' ways of realigning tasks and labour/skills in coordination with each other and the wider environment while changing rice farming practices and work groups with the introduction of SRI (addressing the third set of research questions explaining changes brought about in the socio-technical systems and institutions in response to SRI's introduction).

The linearity of technology transfer and innovation diffusion models has long been questioned by many scholars (Biggs and Edward, 1981; Feder and Umali, 1993; Lyytinen and Damsgaard, 2001) using the notions of system, institutions and network. Decisions and activities related to farming are interrelated, linked and influenced by the wider environment of farming moving beyond the individual inputs/objects and farm boundaries, comprising an interactive array of bio-physical and socio-cultural elements. Understanding the behaviour of SRI (an intervention having a greater thrust on management practices rather than on material inputs) and of farming communities dealing with it therefore required a much broader analytical framework which could address interactions between recommended practices, material objects, forms of organizations and management, and interpret underlying farmers'/societal choices. This required moving beyond the application of simpler and singular notions of labour, actors and institutions.

Though socio-technical interactions have been studied in other areas of technology, there has not been enough work on exploring this in the context of agriculture and rice farming (Pinch and Bijker, 1984). The concept of 'socio-technical system' allows probing into the wide range of elements constituting socio-material configurations and their complex interactions around rice farming activities including SRI, a socio-technical intervention in itself. The concept of 'agriculture as performance' explicates and helps in interpreting why and how farmers shape socio-material configurations while incorporating an innovation like SRI. The notion of 'task groups' strengthens the analytical framework by giving the scope of undertaking institutional analysis of how farmers team up for specific operations in conjunction with material elements and formulate rules regulating the functioning of such groups. Work groups, technical practices and operational rules are realigned with changing environment, especially with introductions of SRI. How the three concepts i.e. socio-technical system, agriculture as a performance and task groups together helped probing and explaining farmers' way of interpreting and adapting SRI are discussed below.

Socio-Technical System: Understanding Social-Material Configurations

Sociotechnical systems are considered to be assemblages of both human (social structures) and non-human components (materials and artifacts) that act together and contribute directly or through other components to a common system goal (Hughes, 1989). Scholars using an STS (Science, Technology and Society) perspective on socio-technical change refer to sociotechnical systems to highlight the entangled nature of the social and the technical that are recognized as integral parts of a single system (Bijker and Law, 1992). Rice farming involves similar assemblages/networks of heterogeneous actors and materials which coexist and interact, generating complex socio-material configurations engaged in producing rice. Farmers, their collectives and even actors outside village communities interact with an endless list of material objects like soil, canal, water, seeds/seedlings, plough etc. Smallholders besides growing rice, for their food and livelihoods, often rely on supplementary on-farm activities (such as growing other crops, raising animals, and forestry) and off-farm ventures. Rice farming is thus embedded in a wider socio-material context, and subjected to complex uncertainties. This necessitates looking into rice farmers' and their work groups' activities from a socio-technical system's perspective rather than an individualistic one.

Socio-technical systems operate through human actors, organizations and social groups; whose perceptions, actions and interactions are guided by rules which are conditioned and embedded not only in actors but also material conditions (Hughes, 1989; Bijker et al., 1989). According to Hughes, socio-technical systems are 'socially constructed' as well as 'society shaping' (shaping social structures), again reinforced by Bijker (1997), and Oudshoorn and Pinch (2003). Such interactions and relationships between human and nonhuman actors are also further described in the Actor–Network Theory, ANT (Law, 1992; Law and Hasard, 1999), which highlights the role of non-human actants.In the context of rice farming, we show how these non-human 'actants' (including soils, rice plants, water, draft animals, and tools) are an important and integral part of socio-technical systems and interact in intricate and complex ways with human actors (including farmers and their work groups).

The notion of socio-technical system encourages the investigation and understanding of the complexities and dynamics of socio-material configurations around each task of rice farming and their fine-tuning in relation to the surroundings or the wider environment. Each element of SRI could have different implications and be understood or conceptualised differently by individual farmers and their social groups, which scholars have termed 'interpretive flexibility' (Pinch and Bijker, 1987). The introduction of SRI is thus likely to disrupt existing interactions and associations, calling for changes in the configuration of work groups and their relationships with the wider agro-ecological environment. This leads to newer rules and routines resulting in multiple and diverse outcomes depending upon the context. The context or the background conditions of group interactions, such as their relations to each other, the rules ordering their interactions, and factors contributing to differences in their power therefore become more important.

Individuals and groups are often constrained in what they can do by materiality – for example the characteristics and limits of the resources they have available, or properties of the natural environment and landscape (Sorensen, 2007). This helps to explain why it is sometimes extremely difficult to change an existing socio-technical system, even when change may be highly desirable. Technological artifacts, such as tools or machines, can be understood to represent the 'solidification' of social relations – drawing attention to the way in which the obduracy of artifacts and wider technical systems may constrain (and in fact are often designed to constrain) human freedoms, thus defining and limiting social relations (Murdoch, 1998). This argument helps to understand changes in relationships between work groups in response to introduction of young seedlings, marker, etc. along with SRI.

To analyze technological transitions within socio-technical systems, the notions of 'feedback mechanism' (Hughes, 1989) and 'translations' (Callon, 1987) become important. The feedback mechanism allows a socio-technical system to seek alternative configurations and processes to achieve the system goal. The notion of translation helps to explain how relationships among social and material components change during such alterations. These notions thus provide a basis for looking into the different interfaces at which farmers and other actors interact to experiment, observe, interpret, negotiate, compromise and reconfigure the existing socio-material assemblages under the influence of SRI, leading to what Latour terms as the 're-assembling of the network' (Latour, 2005) – in other words, the process of integrating

SRI into the rice farming system, accounting for the bio-physical setting as well as the socio-cultural context of the wider environment.

Agriculture as Performance: Understanding Individual Performance

Farmers routinely experiment and are often compelled (under situations of stress or with introduction of new agricultural interventions) to innovate. This often results in an increase in diversity and variation even within well-established agricultural practices and routines (Richards, 1989a; Morrison, 1996). Paul Richards' metaphor of 'agriculture as performance' recognizes this innovative and adaptive capacity, viewing farming as a product of 'human improvisational capacities' (Richards, 2010) and actions that are 'situated' in time and space (Suchman, 1987), conditioned by uncertainty or forced by unforeseen circumstances. The metaphor visualizes the farmer as something like a musician who responds to different situations by drawing upon a stock or repertoire of practised skills, routines, procedures and rules of thumb, generating not a random noise even while improvising and experimenting, but a skilful composition of well-rehearsed and familiar themes and rules rather like musical scales and rhythms.

The performance metaphor recognizes knowledge, skills and 'common-sense procedures' as critical elements shaping farmers' performances under varying 'material' (such as soil, water, seed, draft power, climate) and 'social' (such as labour, and human affiliations) circumstances. It sees farming as a temporally, spatially, institutionally and socio-economically situated performance, thus providing an alternative and appropriate framework for understanding farmers' responses to agricultural interventions. This contrasts with the notion of the rational, profit-maximising, economic actor. It conceptualises the outcomes of a farming performance as the products of a sequence of steps (i.e. decisions and actions) that made sense at the moment they were made during the unfolding process of farming.

Adjustments and interactions between SRI and existing practices therefore need to be explored in terms of farmers' performances that are based on knowledge, embodied skills, common sense and instincts (Richards, 1989c; Richards, 1993), in the service of their intentions, in the context of various constraints and opportunities. The 'performance' notion moves much beyond classical notions of labour and work (which tend to emphasize individual capacities) and draws in the wider socio-material setting (notably agro-ecology in a farming context). This allows space to investigate the processes that contribute to the modification of farming practices over time, and specifically the adaptations made in response to the introduction of SRI, where farmers continually compare the performance with the system goal, striving to reduce the gaps. The concept of farming as a contingent performance situated in time and space served as a useful analytical lens for studying how SRI and its constituent practices were interpreted and adapted by communities of farmers having diverse human capacities, as it was introduced to different farms and across different seasons.

Task Group Culture: Understanding Social/Collective Performance

Rice cultivation in Asia is labour-intensive and requires high levels of managerial skill to organize, direct and synchronize labour to accomplish farming operations in a timely manner, right from land preparation to harvesting (Bray, 1986). These managerial skills are performance skills possessed by farmers in addition to the technical skills required for the specific tasks that have to be performed at different stages of cultivation. These tasks are mostly undertaken, especially by smallholders, in collectives (work groups) comprising members of the same farm household or several households (exchanged, hired or contracted), and sometimes village communities as a whole (especially for water management at the landscape level, and agricultural rituals associated with rice cultivation).

Members of farm households frequently engage with others to form work groups for the cultivation of rice and other crops. Work groups may be formed by groups that share resources (such as water, manure, labour, tools and draft power) or to undertake common tasks that require significant labour inputs (such as rice transplanting or weeding rice and other crops). These work groups require coordination among social actors and also engage with the wider environment through complex interactions. They are coordinated principally through informal rules and routines. The use of discrete analytical categories, such as individual farmers, households or gender groups, may be insufficient for a proper understanding of these collective, interactive labour and work dynamics within rice farming, or the changes that occur in them following the introduction of a new agricultural intervention such as SRI.

The work groups performing various tasks in rice cultivation resemble the 'task groups' identified by McFeat (1974) and defined by Jansen and Vellema (2011, p.173) as "specialized, non-localized [or localized] organizational forms united by some kind of craft and skill-based specialism". Such task groups emerging from communities can align themselves differently creating diverse paths of production for achieving the same goal (Sigaut, 1994). According to Sigaut (1994), the culture of a particular task group is reflected by its 'structure' (composition), 'function' (purposes) and 'workings' (operations/procedures), which are inter-related and shape each other. Such groups provide places within socio-technical systems for 'social control' and 'social change', and where 'culture is created' and 'status order' is made (Harrington and Fine, 2000). These processes are referred to as 'controlling, contesting, organizing, representing, and allocating' features of task groups (Harrington and Fine, 2000). Thus the concept of task group and its features therefore can help in undertaking an institutional analysis of socio-technical systems and transformations taking place within them.

According to McFeat (1974), task groups are fluid with respect to organization, that is, they possess the ability to reorganize and adapt to the environment. The study of task group culture therefore helps us to understand how different work groups in rice emerge, how they function within farming communities, and how they respond to newly introduced methods such as SRI, which imposes new demands of labour and skill. With the introduction of SRI come changes in recommended tasks and a reconfiguration of task groups along with their rules and routines. These ‘task instructions’ and ‘social instructions’ (Sigaut, 1994) are generated and transmitted within and between work groups. These changes are processed and mediated at the level of work groups (task groups) rather than individual farmers. Key processes such as work distribution, role adjustments, co-operation and co-ordination, collective learning and joint interpretation, negotiation and conflict resolution (similar to the features of groups identified by Harrington and Fine) contribute to a collective rather than individual performance. Task group culture therefore serves as a suitable analytical lens for exploring the institutional dynamics of work groups and understanding the processes involved in the evolution and transformation of such groups under the influence of SRI. It was therefore used to characterize and explain both technical changes (adjustments in tasks) and institutional adaptations (reconfiguration of work groups) among farming communities exposed to SRI.

The concept of socio-technical systems thus provides a useful analytical framework for exploring interactions between human actors and material components in the context of rice farming and with introduction of SRI as a socio-technical intervention. It emphasises that the actors in a situation, trying to accomplish something (producing rice and incorporating SRI in our case), have to configure not only other people but also non-humans (material resources, living organisms and artefacts) such as seeds, soils, water, and bullocks in this case. It helps us to understand how the same set of human and non-human components configure and reconfigure themselves to undertake different operations across the rice growing season, while trying out SRI. By placing the endeavours of individual extension agents and farmers within the framework of a wider socio-technical system one can avoid placing too much weight on the agency or autonomy of individuals who aspire to fix a new technology (such as SRI) into that system, constrained and enabled as they are by their surrounding networks comprised of other social actors and resources within wider agro-ecological settings.

The concept of ‘agriculture as performance’ adds to the richness of the socio-technical system analysis, especially highlighting its situatedness within a wider socio-material environment. The ‘farming as performance’ metaphor emphasises the contingency and temporal situatedness of action – that is, dynamics and uncertainty, which are relatively neglected within the other two concepts. Task group cultures, coming from a different tradition than socio-technical systems, emphasises the interactions within and among groups of human actors. Some of those involved might be more influential or powerful than others, but still they cannot have things entirely their own way; they must accommodate themselves to a wider set of interests, capacities and constraints, including constraints from economics or the natural environment. Task group culture helps to explain how diverse and complex socio-technical configurations are coordinated, while the performance metaphor helps to understand how the work of individuals and task groups is regulated by a wider socio-material context and contingent on temporal context.

Adding ‘agriculture as performance’ and ‘task group culture’ to ‘socio-technical system’ thus helps to conceptualise farming as a collective, situated and contingent socio-technical performance involving interactions between individuals, society and technology, with diverse actors and work groups carrying out complex and coordinated tasks of material transformation (Richards 2010). These three concepts thus together create a conceptual framework to address the research questions and help explain the outcomes observed in the rice fields with the introduction of SRI, which are co-determined by various simultaneous socio-technical processes. The combination of these concepts helps to understand rice farming as a socio-technical performance rather than an individual farmer’s performance, and further explains the modifications of the farming performance that results from the integration of SRI into the whole farm production system.

Technography as a Methodological Approach

Technography offers an integrated methodology that encompasses material and technical aspects as well as social conditions and processes (Richards, 2001; Glover, 2011a). It is inspired by ethnographic methods and emphasises on careful, direct observation of practices. “The integrative nature of technographic research involves examining material transformations, technology use and performance as a configuration of material and social elements” (Jansen and Vellema, 2011, p. 176). This is what was required in order to analyse the knowledge, skills, and processes involved in the “making” (Vellema, 2002) of rice, and to understand the socio-technical transformations that took place with the advent of SRI. The technographic approach was used to explore the interconnections and interactions between “materialities”, “task groups” and their “rules and routines” (Jansen and Vellema, 2011) which contributed to the shaping of rice farming practices following the introduction of SRI. The technographic approach, using both qualitative and quantitative methods for data collection, provided detailed explanations and interpretations of various socio-technical interactions, under varying farm conditions and farmers’ circumstances.

Specific Methodological Tools

A multiple case-study design (Burawoy, 1998; Yin, 2003) was adopted. Three villages that had been exposed to SRI were chosen, in order to accommodate diversity in terms of agro-ecological locations and physical infrastructure, especially with regard to the irrigation system. The villages were purposively selected in consultation with the local SRI-promoting organization and reconnaissance surveys.

Fieldwork was undertaken in three rice seasons (2011–2013) in order to explore variations in practices, if any, across the seasons, with the aim of observing the learning process under way following the introduction of SRI to the area. The fieldwork relied largely on participant observations of farming activities combined with rapid rural appraisal exercises, focus group discussions, and semi-structured interviews with key informants. The primary unit of analysis was task-specific work groups under different rice cultivation methods. Individual rice plots and farm households were also taken as units of analysis for some purposes. Within the chosen villages, task-specific work groups, rice plots and farm households were randomly selected. Comparisons were made between villages, work groups, rice plots and farm households.

Various rice-farming practices were studied, namely plant nursery management, land preparation, transplanting, and water management in the wet rice systems (irrigated and rainfed lowlands ecosystems), taking into consideration other activities taking place simultaneously in dry rice systems and other crops. The peak of competing farming activities occurs during the rice crop establishment phase, which is considered to be the most critical phase, especially with regard to the timing of various activities. It is precisely the moment during the start of the *kharif* season when there is most intense competition for labour with all the other on-farm activities.

A stakeholder analysis was undertaken in all the villages to identify the different actors and work groups involved in farming, especially rice cultivation. Village transects, seasonal calendars, village resource maps, institutional network diagrams and historical timeline exercises were carried out to gain an initial understanding of the existing situations and changes taking place in the three villages.

In 2011, direct field observations were recorded of randomly selected plots under different rice cultivation methods. These observations focused on the tasks of nursery preparation, land preparation, transplanting and water management. Informal discussions were held with the concerned work groups and farmers to identify and comprehend the existing socio-technical variations in farming practice. Emerging patterns of practice under the influence of SRI, in terms of nursery use, land preparation and transplanting, were mapped on village revenue maps for the two rice seasons of 2011 and 2012.

In 2012, 30 farm households were selected randomly (10 from each village). Participant observations of all the rice plots belonging to the selected farmers, from land preparation through to the crop vegetative growth phase, helped in understanding the structure, function and workings of the work groups and their inter-relationships. These sampled farm households were also subjected to retrospective cross-sectional studies to trace, record and understand the modifications in practices, if any, across their rice plots and over the years since SRI's introduction. Comparisons were made between villages to understand the effects of agro-ecological, physical, and socio-cultural contexts.

These methods were used to trace the relationships between farm household circumstances, bio-physical conditions and socio-institutional dynamics, and to probe for mechanisms responsible for farm-based adaptations at different levels of the farming system. They were also employed to understand the strategies and decision-making processes of different work groups, negotiations amongst them, and their rules and routines relating to specific tasks.

These methods of direct observation were supplemented with semi-structured and informal interviews conducted with key informants and other actors, development organizations and government officials, which were used to triangulate information obtained from different sources (Miles and Huberman, 1994; Bernard 2002; and Mason 2002). Secondary data was obtained from literature reviews, census information and land revenue records, SRI training manuals and films, and reports and records produced by the concerned organizations. More detailed accounts of research methods, in terms of specific measurements and mapping exercises used for specific tasks and analysis, are provided in the methodology section of each chapter.

1.5 The Research Area: The Western Himalayan Region of India

The research was carried out in the Tehri Garhwal district of Uttarakhand state, located in the Western Himalayan region of India (Figure1.1), a region where the GR has not had any significant impact (Singh, 1996).

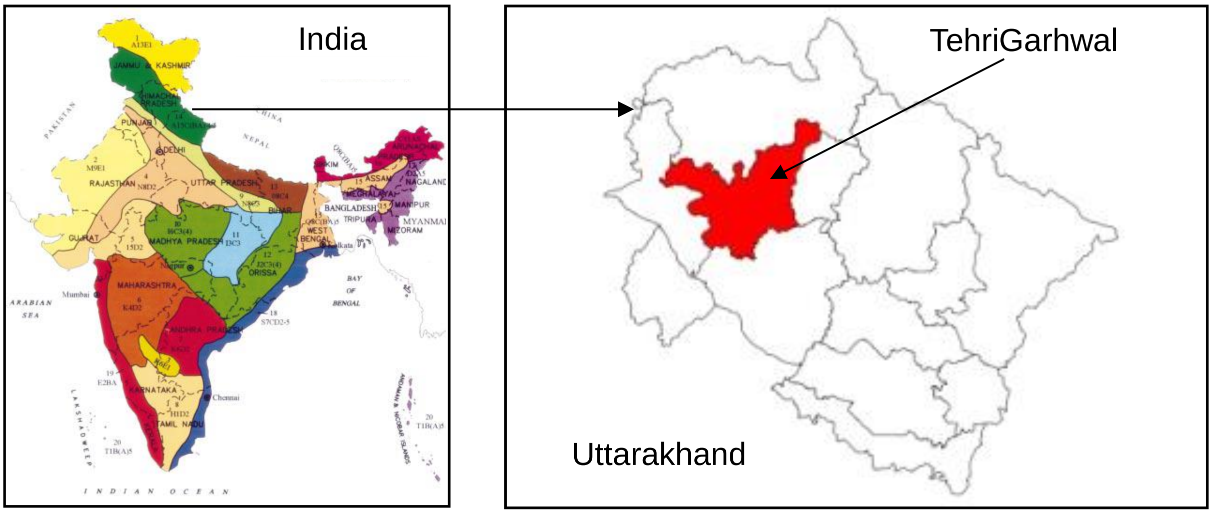


Figure 1.1: Location of Western Himalayan Region and Tehri Garhwal district in Uttarakhand

Agro-ecological and Socio-economic Characteristics

The region is well-known for its constraining features such as ‘inaccessibility’, ‘marginality’, and ‘fragility’, as well as enabling features such as ‘diversity’, ‘niche’ and ‘human adaptive capacity’ (Jodha et al., 1992; World Bank, 2010). With respect to farming, inaccessibility is reflected in the scattered layout of the fragmented landholdings, and remote institutional support systems; marginality in terms of the low resource productivities and lack of social capital; while fragility is revealed in the diminished capacities of farms and farmers to withstand climate vagaries, and low grain production. To deal with these constraints, farming communities in the region have developed coping abilities and strategies, incorporating ‘diversity’ and ‘niche’ in cropping practices growing different crops and varieties for their multiple needs through different methods, and combining farming with other on-farm and off-farm activities (Jodha, 2009).

The farming communities of the region have developed diverse farming systems according to the varying edapho-climatic conditions which may occur within short distances in a village because of variations in elevation. The elevation of the region ranges from 200 m to more than 5000 m above mean sea level and slope varies from eight to more than 45 degrees (Venkateswarlu et al, 1996; Gajbhiye and Mandal, 2000). The climate of the region varies from sub-tropical to dry temperate, as one move to higher altitudes. Mean annual rainfall varies from 900–2400 mm, three-fourths of which is received during the monsoon (June to September). Most of the region has soils that are shallow to deep, gravelly to sandy loam, forest and podzolic brown with medium to high organic matter, and neutral to highly acidic in nature (Gajbhiye and Mandal, 2000). The soils are prone to erosion, which is more severe on the degraded steep slopes.

Nearly 15 per cent of the geographical area is available for cultivation, of which only about 12 per cent is irrigated (Gajbhiye and Mandal, 2000). Agriculture (barring horticulture) has not been a priority development area for the state administration. With vastly sub-optimal farming conditions, and predominance of smallholders having limited access to irrigation, roads, markets, credit, and extension services, the region has less significantly been impacted by the GR (Singh, 1996). Farming is mostly done by women members of farm households, except for ploughing, which is done by men. Farming operations are often done collectively through sharing of labour and performed manually using simple hand implements. Organic sources of fertilizer are applied (mainly in the form of farm yard manure), except in the valleys where farmers also use chemical fertilizers, especially with HYVs of rice and wheat (Alam, 2004). Most of the past developmental efforts in the state have been focused on the plains while the rural mountain farming communities were largely ignored (Singh and Rao, 2002).

The two main cropping seasons are: (i) *kharif* (rainy season crop: from May/June to September/October); and (ii) *rabi* (winter crop: from November/December to April/May. Sowing and harvesting time varies according to the elevation. About 84 per cent of farmers have very small landholdings (on average < 0.68 ha), which are fragmented and consist primarily of irregularly shaped, terraced plots (Alam, 2004). The principal livelihood activity of rural communities continues to be highland mixed farming including a heterogeneous mix of crops, animal husbandry and forestry. Agriculture is heavily dependent on forestry and animal husbandry as sources for fertiliser, agricultural implements, and draft power. In irrigated as well as un-irrigated farms, rice and wheat are primarily mono-cropped (Singh and Rao 2002). In un-irrigated farms, as many as two to five crops per plot (mostly millets and pulses) are still cultivated as mixed crops in rotation with rice, in order to minimize risk and promote sustainability. There has been a decrease in native crops and varieties (Farooquee and Maikhuri, 2009).

Within the predominant rice-wheat cycle, rice is the main *kharif* season crop grown both for grain and straw. Rice thus provides both food and fodder. Multiple varieties of rice are grown by most farm households on irrigated as well as un-irrigated plots. Rice crop establishment is done by transplanting as well as broadcasting/dry seeding methods, creating a diversity of rice cultivation methods in the region.

The complex and diverse farming system of the region is currently going through a phase of unsustainability. The decline in forest cover of the region has directly or indirectly affected the availability of important resources such as fertile soil, water, fodder (for draft animals), and manure, which are crucial for smallholder subsistence farmers. The average productivity of both rice and wheat, which are the staple food of the region, is presently less than 2 tons per hectare (higher in the valleys and still lower in the upper reaches). Low and decreasing crop yields and absence of local off-farm activities are resulting in a male exodus, which increases the workload for women farmers as well as the proportion of fallow lands (Sharma et al., 1991; Dev, 1994; Gajbhiye and Mandal, 2000). Subsistence-oriented farm production therefore has to be supported by money coming in from the migrant members of farm households.

Since 2006, to address issues of household-level food and livelihood security of the mountain smallholders and the unsustainability of farming, the People's Science Institute (PSI, a civil society organization based in Dehradun, Uttarakhand) has been promoting SRI in the region. PSI has worked with other non-governmental organizations, termed Partner Organizations, POs. According to PSI, up to 2010 about 15,000 farmers of the Western Himalayan Region have tried out SRI (PSI, 2010). The interactions of the mountain fields and farmers with SRI have so far not caught much attention of either social or natural science researchers.

The Study Villages

The Tehri Garhwal district of Uttarakhand state, located in the Bhilangana sub-basin of the Western Himalayan Region has the highest concentration of farmers who have tried out SRI. The research therefore focused on the Tehri Garhwal district to select three contrasting villages i.e. Phalenda, Thayeli and Dakhwangaon (Figure 1.2) accommodating diversity in terms of agro-ecological and socio-institutional settings. These villages which have been exposed to SRI have been termed as SRI villages in this study. MVDA, a partner organization of PSI has introduced SRI in these villages in 2008.

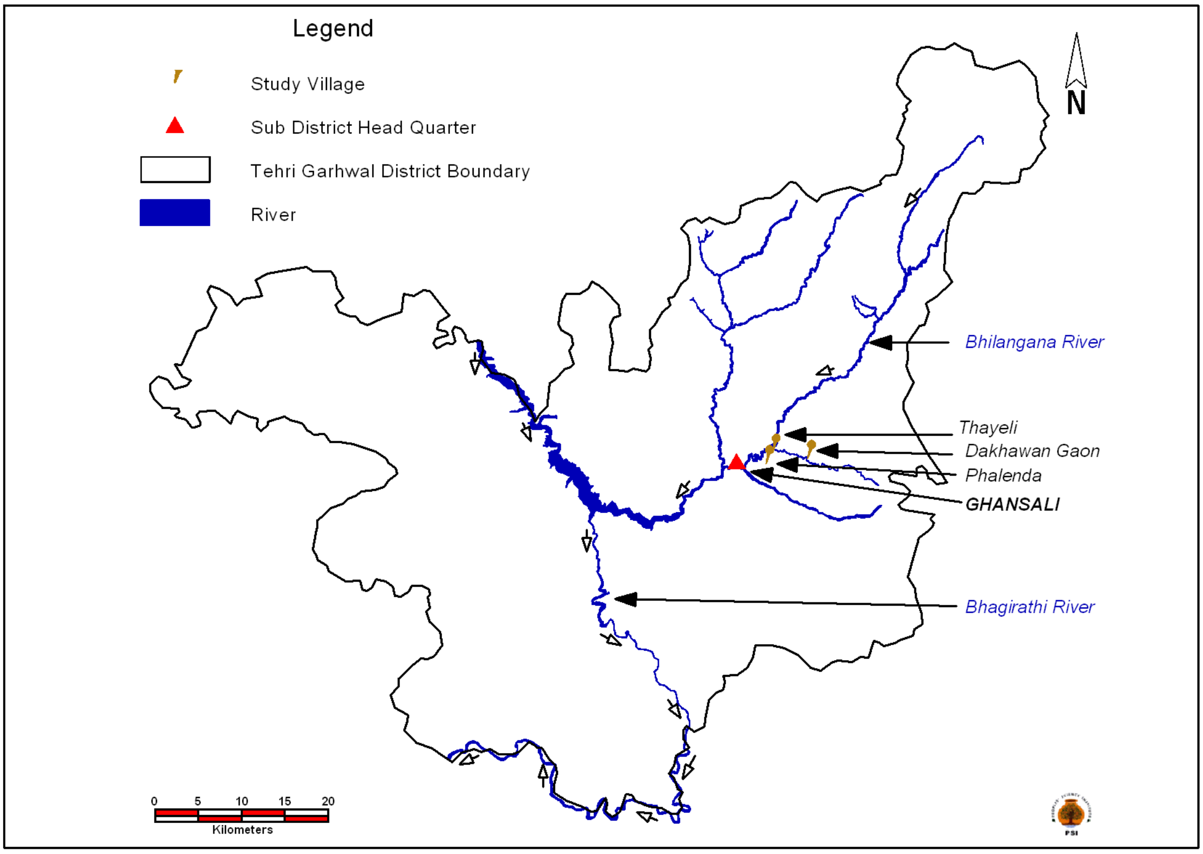
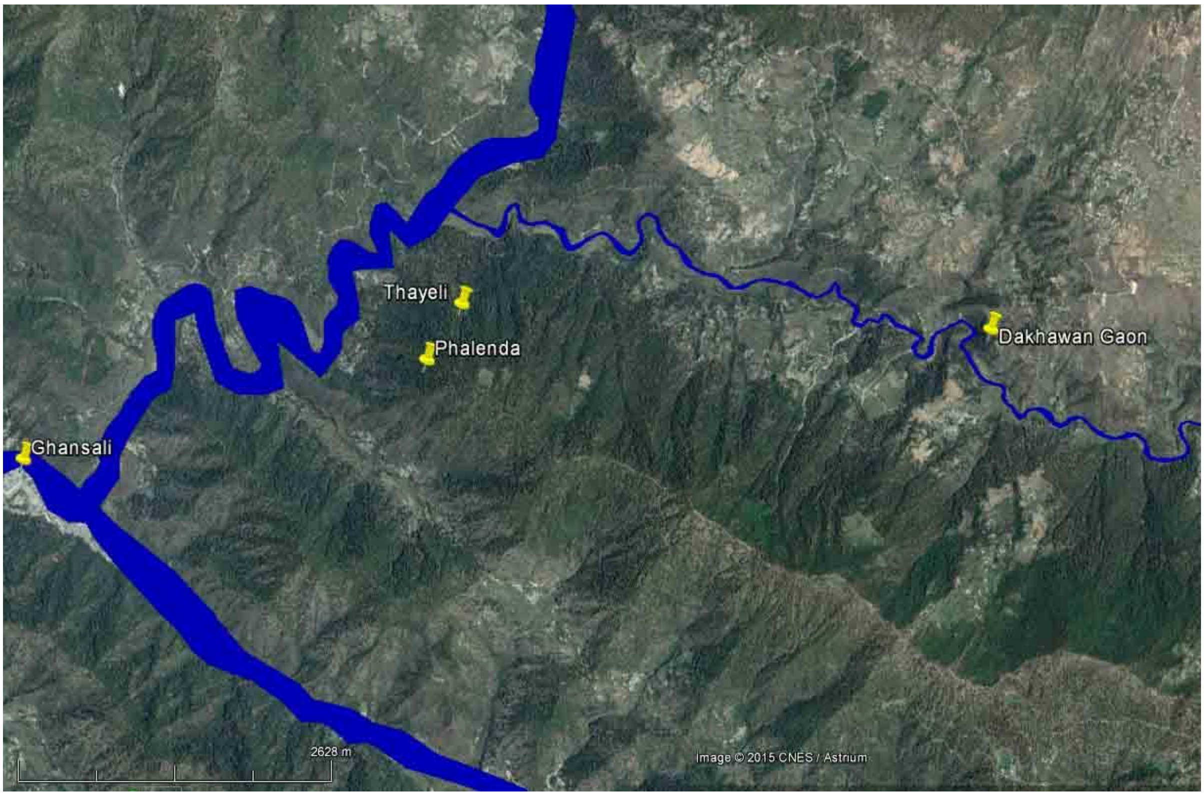


Figure 1.2: Location of Study Villages in the Bhilangana Sub-basin of Uttrakhand, India



The three selected SRI villages differ in elevation, market access, population, agricultural work force, draft power availability, soil conditions, irrigation infrastructure, cropping pattern, livelihood options, and presence of community-based institutions such as women's self-help groups (SHGs) (See Table 1.1).

The topography, climatic conditions and irrigation infrastructure play critical roles in influencing the cropping pattern of the three villages. The available labour is organized according to the cropping pattern. The agro-ecological and socio-economic differences in the villages were expected to create variations in responses to introduction of SRI, which were investigated and are discussed in this thesis.

Table 1.1: Main Features of Study Villages

Features \ Village	Phalenda	Thayeli	Dakhwangaon
Elevation (m above msl)	900-1200	950-1100	1300-2000
Geographical Area (ha)	133	24	79
Distance from nearest Market	7 km	10 km	17 km
Resident Households	113	18	60
Resident Population	471	89	279
% Cultivated Area	60	79	60
Irrigated as % of Cultivated	58	73	33
Bullocks (households per pair)	64 (4 hhs/p)	6 (6 hhs/p)	48 (3 hhs/p)
Average Agricultural Land/HH	0.71 ha	1.06 ha	0.78 ha
Agri. Work Force/HH	~ 2	~ 3	~ 4
Households Selling Rice	8 (7%)	8 (44%)	0 (0%)
Other Cash Crops	Potato, Onion	None	Pulses
Source: GPS; Village Revenue Records, 2011; RRA			

Approach to SRI Promotion

MVDA appointed Master Trainers (MTs) to undertake training and capacity-building of farmers for the adoption of SRI practices in the region. The MTs were allocated four or five villages each for overall supervision and monitoring. At the village level, interested farmers were identified and employed on a contractual basis by POs as Village Level Resource Persons (VLRPs). The VLRPs' role was to mobilize farmers to adopt SRI and to extend field support to their fellow farmers to implement the various components of the recommended SRI package.

1.6 Thesis Outline and Overview of Arguments

Each chapter of this thesis focuses on one rice-farming practice as an entry point for examining a particular interface of interactions (Figure 1.3). Chapter 1 (Introduction) is followed by the four empirical chapters (2–5). Each chapter examines different interfaces of socio-technical interactions explaining how transformations were brought about in the sub-groups of the rice-farming system. The chapters are organised in a sequence so that the thesis zooms in from interactions at the broader level (chapter 2 on water management) to those occurring between work groups performing different tasks (chapter 3 on field preparation and transplanting), down to different typologies of work groups performing the same task (chapter 4 on nursery management), and finally, within a work group, focusing on the performance of a particular task (chapter 5 on the transplanting operation). Chapter 6 summarizes and reflects on the findings from chapters 2 to 5.

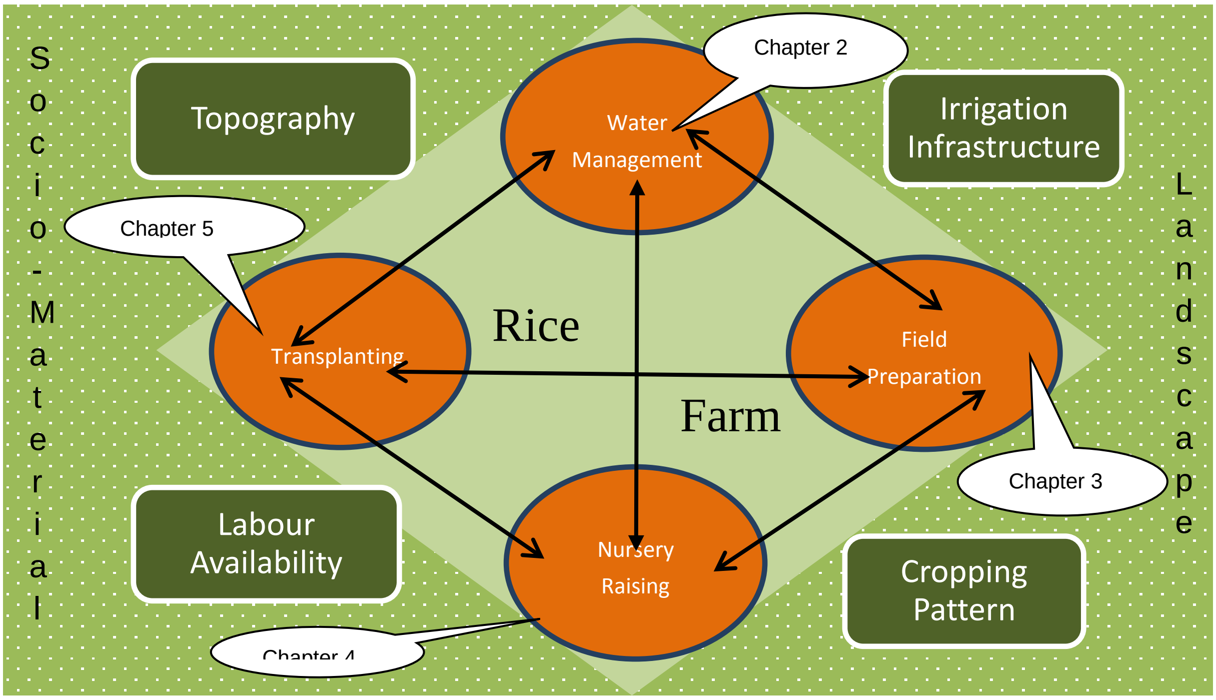


Figure 1.3: A simplified illustration of farming system showing selected interconnected tasks and work groups of a rice farm and their linkages with the key elements of the wider socio-material landscape

Chapter 2 explores how irrigation infrastructure and its management systems are a structuring element in the distribution and coordination of irrigation water and related tasks at the community level. The chapter shows how, in response to SRI's introduction, farming communities reorganized rituals, routines and norms related to rice farming and reallocated plots or fields within farms to different crops and cultivation methods. The chapter explores how SRI interacted with the larger socio-material landscape and plot-level characteristics.

Chapter 3 investigates interactions between work groups carrying out two different tasks, namely land preparation and transplanting, under the influence of SRI. SRI introduces a new task of field marking, thereby demanding changes in the functioning of work groups for land preparation and transplanting. Ploughing teams co-ordinate with transplanting teams to prepare rice plots in accordance with topography, water availability, and cropping pattern. The chapter highlights how these work groups negotiate and collectively select marking patterns, and reallocate tasks in order to accommodate SRI into the rice-farming system.

Chapter 4 seeks to understand how work groups undertaking management of seedling nurseries (seedbeds) are formed, function, and co-ordinate amongst themselves, and their responses to SRI. New kinds of work groups emerge with SRI's introduction under varying farm conditions and farmers' circumstances. The chapter brings forth rearrangements that occur within and between work groups of a similar nature to meet the rice crop's requirements under different cultivation methods, depending upon the capacities of farm households.

Chapter 5 examines the interlinkages between the structure, function and operations of a specific work group, taking the case of transplanting and focusing on the changes that occur in the transplanting operation in response to SRI. The existing diversity in transplanting methods across rice farms caters to the variations in agro-ecological settings; work groups and technical practices are arranged accordingly. New demands imposed by technical practices, skill requirements and labour organization under SRI result in hybridization of practices as well as transformations in work groups, integrating new learnings with past knowledge and experience. The chapter demonstrates the often unobserved constraints, capacities and abilities of farmers to respond to new interventions.

Chapter 6 highlights that smallholders seek to adapt new interventions, seeking complementarity and synergy with the existing crop production system. The study draws attention to the development of more location-specific SRI practices. It also indicates the relevance of task groups in agricultural studies and interventions, and suggests technography as an alternative and effective way of studying agricultural interventions. While raising questions about the relevance of earlier SRI adoption studies, this study calls for a recognition of the importance of the human management component in agricultural development and building upon it, rather than relying only on attempts to improve the crop genotype and/or the field environment from above.

The thesis thus addresses the overall research questions by undertaking an in-depth study of work groups' interactions, examining and explaining the processes by which existing rice cultivation practices (including technical and social components) have been modified as a response to the introduction of SRI. The research helps to understand what farmers do and why they do it, as well as where, when and how they do it and the degree to which their practices might vary from one season or one plot to the next. In the process it also identifies the emerging forms of rice cultivation practices across space and over time under the influence of SRI in a specific agro-ecological context.

Chapter 2

User Adaptations in Water Management of Rice Farms of Uttarakhand

2.1 Introduction

Traditional rice communities in Asia are the largest users of irrigation water, be it surface or ground water. Community-based, farmer-managed irrigation schemes dominate in this region (FAO, 2014b, 2014c).The most common method for irrigated rice in these schemes is permanent flooding. Water scarcity and methane emissions are major environmental incentives to change the water management regimes in irrigated rice. The System of Rice intensification (SRI) offers a set of agronomic principles aimed at sustainable and cost-effective rice cultivation, including a reduced water supply. Here we look at the effects and outcomes of the introduction of SRI on irrigation methods and water management in three community managed irrigation systems in the Tehri Garhwal district of Uttarakhand, India. We are particularly interested in interactional outcomes, i.e. changes emerging from the interaction between the physical properties of the community irrigation systems, the field-level water supply and the social characteristics of water management. Such emergent outcomes provide further insight in the potential of community based irrigation systems to respond to the conditions of sustainable agriculture and the new demands to water management.

The System of Rice Intensification is promoted by a variety of non-governmental organizations (NGOs) in Asia and other parts of the world as a method of rice cultivation with few external inputs. Lowering the water table is considered to contribute to higher yields in SRI paddy fields, in particular when so-called Alternate Wetting and Drying (AWD) is applied, irrigating the fields in intervals of several days up till ten days (Krupnik et al., 2012). AWD results in a change from aerobic to anaerobic soil conditions, allowing extensive root growth and high tillering to which substantial grain yields are attributed (Stoop, 2002; and Uphoff, 2002). SRI has received substantial criticism from rice researchers, in particular for its claims to achieve much higher yields than with cultivation practices recommended by national and international rice research institutes (Berkhout and Glover, 2011; Prasad, et. al., 2012; Uphoff, et. al., 2015). However, there is hardly disagreement over the potential to save water when applying AWD, a strategy experimented with by formal-sector research as well (Singh et al., 1996; Bouman and Tuong, 2001; Belder et al., 2004, 2007; and Zhang et al., 2008). The added advantages of AWD are reduction in methane emissions, reduced irrigation costs, resulting in increased net returns for farmers (Richards and Sander, 2014). On-station studies and field experiments on SRI claim substantial water saving (Thakur et al., 2011) whereas on-farm studies show mixed responses with respect to farmers' uptake of AWD (Palaniswami et al., 2010; Martin et al., 2012; and Doi and Mizoguchi, 2014). These studies however do not throw much light on farmers' motivations, compulsions or intentions to adhere to or deviate from AWD while practicing SRI.

For rice farmers, irrigation-and-drainage is one of various crop management activities. Likewise, SRI offers a package of cultivation methods throughout the various stages of crop growth. Moreover, in community-based irrigation schemes, water management requires coordination between farmers, most prominently for water distribution. Farmers thus face a number of coordination and crop management challenges that require strategizing, decision making and work in the fields, activities that can be performed individually or require collective action. This raises the question how the introduction of SRI has changed the coordination and implementation of water management and the need to look beyond the water saving potential of SRI alone. This question is addressed here with an analysis of water management in three villages of Uttarakhand: Phalenda, Thayeli and Dakhwangaon, located in the North-Western Himalayas of India. SRI was introduced here from 2008 by two cooperating NGOs, the People Science Institute and the Mount Village Development Association. The village irrigation schemes in this area provide water to terraces where rice is cultivated in the monsoon season. These irrigation schemes are fed by either glacier rivers (in the valleys) or springfed rivers (in the upper fields). One of the reasons why SRI was introduced in this region was to cater to the reducing trend of water flows in the springs (due to degraded catchments) while attending to the food security needs of the local communities. Water management in similar farmer-managed irrigation schemes is known to involve a tight connection between the complex agro-ecosystem and the socio-cultural norms and values attached to the coordination of water management practices (Lansing, 1987).

The results presented here show that what rice farmers considered meaningful and workable adjustments of water management resulted in discussions about and ultimately adjustment of the socio-cultural values and rituals connected to water distribution. The most significant observed changes were in collective water management at field level within *toks* (collectives of fields often having common irrigation schedule), and at village level in connection with decision making over cultural practices concerning the initiation of the paddy season. At the field level this was expressed primarily in decisions about which fields were considered appropriate to apply SRI and thereby save water. Rather than the recommended AWD, farmers continued with permanent flooding in plots under SRI, although maintaining an overall lower water level. At village level the introduction of SRI opened up a discussion about the official declaration of an auspicious day (the *Din Bar*) to inaugurate the growing season, the moment from which farmers are permitted to begin transplantingthe rice fields and thereby water is distributed for preparing these fields on the agreed distribution schedule. Interestingly, the introduction of SRI resulted in different rearrangements and adjustments to the *Din Bar* in each of the studied villages.

In the next section a conceptual framework and methodology is developed for understanding the rearrangements of water distribution as outcomes emerging from interactions among social and technical components of the rice farming system, stimulated by the introduction of SRI. In subsequent sections the characteristics and conditions of the water management practices before the introduction of SRI is sketched, followed by an analysis of the changes resulting from and new practices established due to the new cultivations methods. In the concluding section we draw lessons about the potential of SRI in contributing to water saving in paddy cultivation in community-based irrigation systems.

2.2 The Culture and Performance of Paddy Crop Irrigation

Irrigation management is a socio-technical system, defined here not only as the physical structures of canals, drainage channels, sluices, gates and bunds but comprising also social aspects, in particular the activities of farmers to regulate the inundation of fields, the coordination of water distribution, and water-related customs and ritual practices. Likewise, water delivery and distribution practices in community-based irrigation systems imply much more than the structural and operational design of irrigation systems. Many studies have shown that irrigation infrastructure, decision making and control over water distribution, field-level management practices and the organizational structures of water uses mutually shape each other, requiring a combined analysis of the social, norms, values, and farmer activities that constitutes the 'irrigation culture' (Coward, 1980; Kelly, 1983; Pfaffenberger, 1988; Diemer and Huibers, 1996; Mabry, 1996; Shah, 2012; and Mollinga 2013). The interactions between the social and physical components of irrigation technology are expressed in the various activities related to water management. In the community-based irrigation systems analysed here, these interactions play out in the activities of farmers in the fields and the arrangement at village level.

Kelly (1983) identifies the three dimensions of irrigation as hydrological (natural water flow pattern), technical (physical network of facilities), and social (organizational configuration). He further points out the need to study organizational configurations around the four water management practices i.e. water source control, water delivery roles, application to crops, and drainage. He points out that most studies of irrigation focus on water delivery roles. Each of the practices require certain tasks to be performed, the coordination of which is rooted in the norms, values, roles and routines of the irrigation culture. Pfaffenberger (1988) draws attention to the role of rituals in the reproduction of the social components of the socio-technical phenomenon, by helping to bring order to the coordination of the labour force required for the water distribution practices. Lansing's (1987) case of water temples in South Asia is an example of how such rituals bring together religious rituals and practical arrangements in irrigation technology.

Cultural phenomena are not just restricted to water but also connected to the agricultural practices being performed during the different stages of the cropping season. Therefore, the performance of irrigation tasks has to be understood in the wider context of what Richards 1989; 2010) termed agriculture as performance. Rather than simply the performance of tasks, this notion refers to the creativity and improvisational capacity of farmers to coordinate a series of agricultural tasks under varying conditions. Where Richards primarily refers to climatic and agro-ecological variations that occur from season to season, this notion can be extended to farmers' capacity to respond to introduced changes. This is of particular relevance here given the introduction of changing water management practices as part of the introduction of the SRI. In other words, the introduced AWD method is supposed to work in synergy with other cultivation methods introduced with SRI, most notably ploughing, levelling and marking fields (see Chapter 3) and transplanting of seedlings (see Chapter 5).

According to Hughes' (1989) analysis of socio-technical systems, water management in irrigated rice and concerned social structures are likely to shape each other. Socio-cultural institutions (rules and routines) around water management are therefore likely to be recreated with introduced changes in crop water regimeswith SRI. A complementary way of looking at the rearrangements of water distribution and other components of rice cultivation is by perceiving them as translations of socio-technical configurations and its constituent elements in a farming system, in tune with the Actor-Network Theory in science and technology studies (Law,1992; Latour, 1999; and Law and Hasard, 1999). Where the focus of this theory is primarily on network-building activities of researchers and engineers, in our case farmers are followed as the principal agents of the emerging new socio-technical assemblages of canals, water, fields, plants and people. What Kelly (1983) terms the 'irrigation culture' is not a fixed condition that limits development but the stage on which farmers perform and, at the same time, the outcome of these performances.

2.3 Methods

The study was conducted over three rice seasons from 2011 to 2013, in the villages Phalenda, Thayeli and Dakhwangaon situated in Bhilangana sub-basin of Tehri Garhwal district of Uttarakhand, India.

In 2011, Rapid Rural Appraisals were carried out, including focus group discussions around seasonal calendars, in order to understand the crop cultivation and related irrigation activities across the rice season, as well as changes in roles, norms and behaviours due to introduction of SRI across villages. Semi-structured interviews with key informants shed light on how the recommended water application practice under SRI conflicted with farmers' experiences. In 2012 participant observation of farm operations in all rice plots (n=254) of 30 randomly selected farmers (10 from each village) produced insights into farmers' cultivation performance. Observations included measurements of water tables, planting distances and timing of several operations. During the field observations semi-structured interviews and informal conversations were held with the farmers. It should be noted that 'farmers' could imply men, women and children. Most farm operations (except ploughing) in these villages are carried out by women and therefore in presentation of the results by 'farmer' it is meant woman unless otherwise specified.

All the plots where SRI was implemented were mapped along with canal layouts in 2011 and 2012. Plots where farmers allocated SRI practices changed per season and focus group discussions with self-help groups, composed primarily of women, revealed preferences of farmers for different rice cultivation practices. In the 2013 rice season, daily water depth measurements of 20 randomly selected plots each under three rice cultivation practices (n=20 x 3) in Phalenda, followed by semi-structured interviews with plot owners were undertaken. This led to comprehending farmers' strategies and decision making processes related to water application.

2.4 Agro-ecological Setting

The climate of the region varies from warm (in summer) to temperate (in winter), receiving about 1500 mm of average annual rainfall, most of it during the months of July and August (CGWB, 2011). Almost all resident households are smallholders who practice mixed farming. Their total agricultural lands are less than an acre on average. Farm production is supplemented by livestock rearing, small businesses and remittances from seasonal or permanent migration by household members. Farm holdings mostly consist of fragmented parcels made up of small, irregularly shaped terraced plots scattered along the slopes of the hills. Differences in elevation create distinct categories of lands i.e. upper, middle and lower fields. The cultivated lands have shallow to medium depth, gravelly loam to sandy loam soils of low fertility, and are prone to erosion.

Table 2.1: Characteristics of Study Villages

	Phalenda	Thayeli	Dakhwangaon
Altitude (m above msl)	900-1200	950-1100	1300-2000
Resident Households	113	18	60
Resident Population	471	89	279
Agriculture Work Force	265	60	236
Total Area (Ha)	133	24	79
Agricultural Land (Ha)	80	19	47
Percent Irrigated	58	73	33
Source: Revenue records, RRA and Household Surveys, 2011-2012			

About 60 to 80 per cent of village lands were reported to be cultivated (Village Revenue Records, 2011). The location of the three study villages at different elevations (altitude of 900 to 2000m) influenced water availability for irrigation and thereby the development of the irrigation infrastructure. Dakhwangaon, which is situated at highest elevation thus, had the lowest proportion of irrigated lands as compared with the other two villages (Table 2.1).

Irrigation Infrastructure

All the study villages have small-scale community-managed, gravity-flow irrigation systems. These consist of a network of canals which were laid across the contours of mountain slopes by the communities more than 100 years ago. In the last decade, most of them have been lined and extended by the Irrigation Department or the Minor Irrigation Department. The main canals draw water either from Bhilangana, a glacier-fed river, as in the case of Thayeli and lower fields of Phalenda, or from rain-fed mountainous streams or springs as in Dakhwangaon and the higher fields of Phalenda. Canals linked to Bhilangana are perennial while those fed by rain-fed mountainous streams are seasonal (Figures 2.1, 2.2 and 2.3). The broad, long and lined canals are known as *nahar* whereas the narrower, shorter, and unlined ones are known as *guhls*.

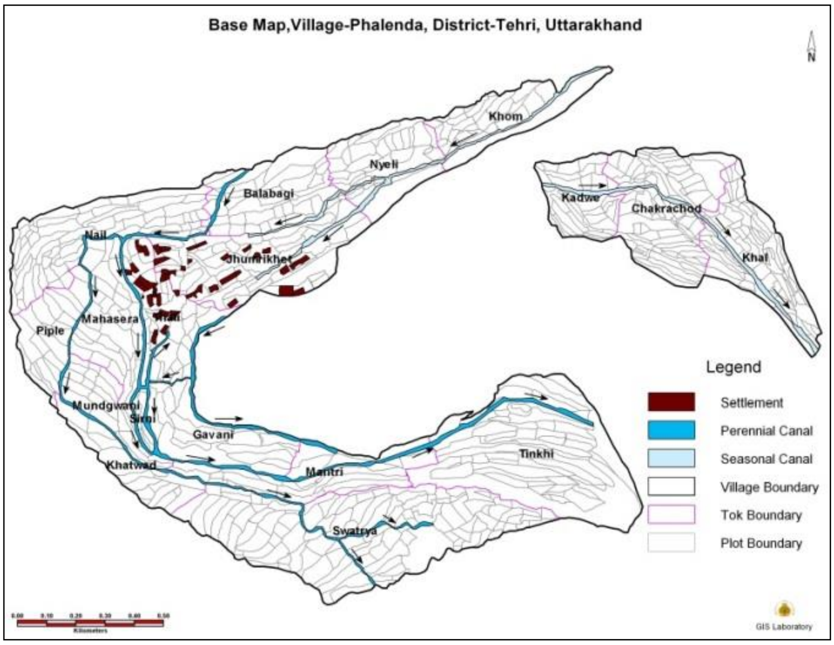
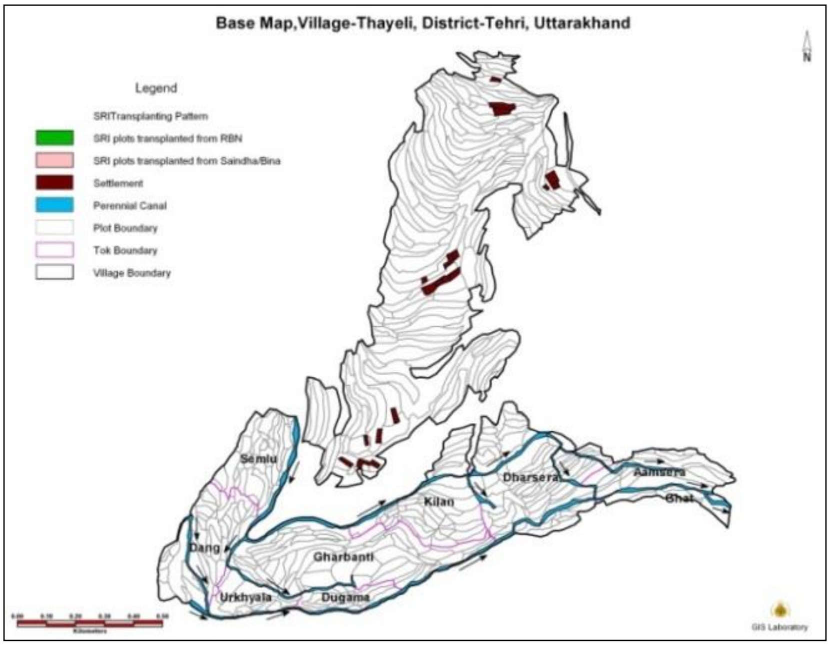


Figure 2.1: Maps of Phalenda and Thayeli with layout of canals



The main canals along with their distributaries and distribution outlets convey water to *toks*, clusters of terraced plots having more or less similar physical characteristics. Not all plots within an irrigated *tok* are directly connected to water channels due to the limited network of distributaries, thereby enforcing cascade irrigation i.e. plot-to-plot irrigation down the slope. Cascade irrigation is most prominent in Dakhwangaon. Typically, a farmer after flooding removes a stone plug at the lower edge of the field so that water can flow to the next plot below. The excess water then drains back into the *guhl/nahar* at the lowest point, which then rejoins the main stream. Each village has its own independent network of canals, (except for one canal shared between Thayeli and Phalenda). From 33 percent of the fields in Dakhwangaon up to 73 percent in Thayeli are irrigated by the canal network. All other fields are rainfed. Farm households of Dakhwangaon also had irrigated plots in neighbouring villages.

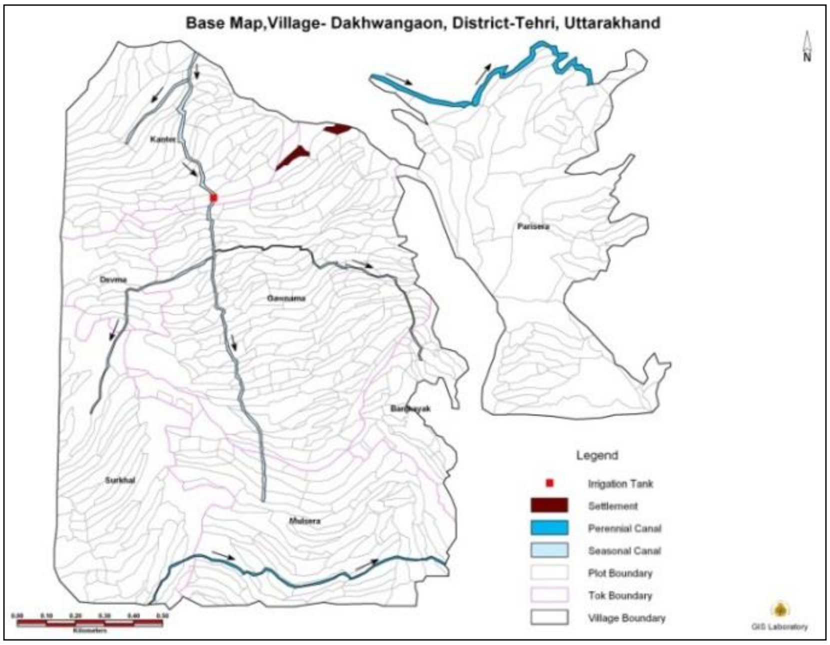


Figure 2.2: Map of Dakhwangaon with layout of canals (Only irrigated plots of village are shown)

Official ownership of the canals is by the Irrigation Department or Minor Irrigation Department of the state government but there is hardly any direct interference in water distribution of these governing bodies and village communities exercise rights of use over irrigation water. The water users pay a nominal tax to the Irrigation Department for maintenance of the lined canals. Rights over water use from canals were linked to land ownership and participation in annual maintenance of the canals, which were transferred with the purchase or inheritance of land. All the village lands are believed to belong to the common village deity. As will become clear, the attribution of sacredness is an important element in the management of water and coordination of farm activities.

Cropping Calendar and Rice Cultivation Systems

The two main cropping seasons are *kharif* (May-October) and *rabi* (November-April). Major crops include rice, millets and pulses in *kharif*; and wheat, mustard and barley in *rabi*. Rice is the main crop in irrigated fields. In the un-irrigated fields two to five crops (mostly millets and pulses) are grown in addition to rice. Crop diversification and mixed cropping is practiced to minimize risk and ensuring sustainability. In un-irrigated plots, un-sprouted direct seeded rice is broadcasted (*Sathi*) while in irrigated plots it is direct seeded (*Saindha*) in puddled plots as well as transplanted. Direct seeding is preferred in plots with access to early irrigation whereas transplanting was done in plots having irrigation later, when rains have started. Seedlings for transplanting are either grown in nurseries (*Bina/Bijwad*) or extracted from *Saindha* plots. Sowing and harvesting time varies according to elevation. Mid–March usually marks the beginning of the rice season with field preparation and sowing of *Sathi*. Most *kharif* crops are harvested by mid-October. The maximum demand for water is in the months of June and July when land preparation and transplanting is at its peak (Table 2.2).

Table 2.2: Cropping Calendar of Villages for Rice Season (Prior to introduction of SRI)

Month / Crop	***Chaitra* (Mar-Apr)**	***Baisakh* (Apr-May)**	***Jeth* (May-Jun)**	***Asad* (Jun-Jul)**	***Shrawan* (Jul-Aug)**	***Bhadon* (Aug-Sep)**	***Asuj* (Sep-Oct)**	***Kartik* (Oct-Nov)**
Irrigated Plots								
Rice through *Bina/Bijwad* (nursery-raised seedlings)		Nursery	Weeding	LP & TP	Weeding		Harvest	
Rice through *Saindha* (direct-seeded)			LP*, Sowing*& Weeding	Thinning & TP	Weeding		Harvest	
Wheat		Harvest						LP & Sowing
Mustard, Barley	Harvest							LP & Sowing
Unirrigated Plots								
Un-Irrigated Rice (*Sathi*) (broadcasted)	LP	Sowing	Weeding	Thinning			Harvest	
Fox Millet	LP	Sowing	Weeding	Weeding			Harvest	
Finger Millet		LP	Sowing	Weeding	Weeding			Harvest
Other Pulses				LP & Sowing	Weeding			Harvest

Source: RRA and Focus Group Discussions, 2011 LP: Land Preparation; TP: Transplanting

* In Dakhwangaon and upper fields of Phalenda LP and sowing under Saindha was done in *Baisakh*

Water Demand across the rice growing season (schematic)

Most of the nursery preparation and sowing and first round of weeding in un-irrigated plots were completed by mid-June, after which transplanting starts. During most of the rice season, the agricultural workforce had to be distributed between irrigated and un-irrigated plots mainly according to required activities, availability of labour and water. Rice cultivation is primarily subsistence-oriented as only 16 (8 each from Phalenda and Thayeli, and none from Dakhwangaon) out of 191 resident farm households in the villages reported selling rice. In Dakhwangaon, farm households had relatively few irrigated plots as compared to those of Thayeli and Phalenda. Therefore, they focused on un-irrigated plots, even more so because they sold the kidney beans and pulses grown in these plots. Farmers here preferred working on irrigated rice plots only when water was available, otherwise they worked on un-irrigated plots. The proportion of irrigated and un-irrigated plots along with diverse cropping patterns thus regulated the presence and distribution of the agricultural workforce of farm households across different locations and over the rice season.

2.5 Rice Water Management Practices

Water management involves practices beyond operation and maintenance of the irrigation canals. It requires spatial and temporal distribution of water matching the demands of the cropping pattern, particularly the sequence of different operations involved in rice cultivation. There is an agreed distribution of water between the different *toks*.

Around mid-May (or mid-April in higher elevations) all users of a canal network get together to construct diversion bunds in streams (in absence of permanent diversion structures) and clean up the waterways. Care and maintenance of the canal networks in each village over the rice season is the prime responsibility of all canal beneficiaries, except in case of major damages when the irrigation department is summoned. Non-participation in this collective activity led to cutting off the water supply or imposition of social sanctions like prohibition in community meetings and celebrations. Once the canals are cleaned, water is released to different *toks* from each canal sequentially from head to tail end. The cycle is repeated once water has reached the tail-end fields. The number of *toks* to which water is allocated on a particular day depends on water discharge and size of the *toks*.

Within *toks*, field preparation starts for the direct-seeded plots as soon as water is released on a 'first come, first served' basis i.e. the first farmer ready with bullocks, ploughmen and workforce can guide water to his/her field irrespective of the field location within the *tok.* Once the *Saindha* plots are seeded, water is continuously distributed through canals from mid–May to the end of June, when the monsoon rains provide water to the fields. Transplanting from *Saindha* plots was initiated after 15th June with the declaration of *Din Bar*, an auspicious day that marks the start of transplanting activities, further explained in the next section. Again water was released in a similar manner and sequentially from head to tail end. Field preparation and subsequent transplanting from *Bina/Bijwad* could only be initiated at the onset of monsoon rains.

Once rice plots are transplanted, *toks* which are fed by perennial canals get water every 3-5 days depending upon the location of *toks.* With adequate rains in July and August, canal outlets are generally closed. Another reason for closing canals was to control the sedimentation of fine silt coming in from river Bhilangana in the rice plots. If rains halted, water was again let in. In Phalenda and Thayeli farmers are allowed to take water even out of turn as usually enough water is available. In *toks* connected to seasonal canals, water shortages caused intervals of even upto 8-10 days between irrigations.

Farmers' general perception is that rice requires waterlogged plots. A major reason for flooding rice plots is that it suppresses weed growth, thereby allowing women to focus on other work (like sowing of finger millet). A farmer of Phalenda remarked "Flooding provides us flexibility for weeding operations in rice plots. Once plots are transplanted and flooded, rest of the work has to be done by hands. We can weed whenever we have the time to do so." In all irrigated rice plots, standing water of 10-15cm was maintained right from the seeding/transplanting day till grain ripening stage. Some farmers preferred increasing water depth to avoid risk of developing water stress conditions. About 15-20 days before the harvest canal outlets were closed.

In Phalenda, a person known as *kullala* was appointed for ensuring fair water distribution between different *toks* and plots in the lower fields, after the transplanting operations. The *kullala* is responsible to divert water to the required field from 15.00 hrs till 10.00 hrs of the next day. In remaining hours farmers could take water at will. This timing enabled the farmers to oversee their distant fields during day hours whereas the *kullala* ensured the irrigation of left over fields especially overnight minimizing chances of stealing. The *kullala* is also responsible for mobilizing labour for repairing minor damages to the canals.He was paid 30 kg of grain per acre of irrigated rice by each farm household after the rice harvest. The *kullala* frees the farmers from continuous coordination of water distribution, and allows time for other activities, primarily in the more distant un-irrigated plots. However, farmers of Thayeli and Dakhwangaon had stopped appointing a *kullala* for a decade, and distributed water themselves. In Thayeli irrigated and un-irrigated plots were close by. In Dakhwangaon, the un-irrigated plots dominated, making payment to the *kullala* too costly.

Availability of water was the main factor influencing the choice to apply *Saindha* or *Bina/Bijwad* in a given plot. *Saindha* was mostly done in *toks* situated at head and middle reach of perennial canals having adequate and continuous access to water. *Toks* with clayey and saturated soils were invariably put under *Saindha*, as transplanting in clayey soils is more laborious. Transplanting from seedbeds was done in *toks* that are either irrigated through rain-fed canals or located at the tail ends of perennial canals. Transplanting thus created a time buffer for late supply of water. Irregularities in the water supply makes farmers apply a relatively substantial water depth. Additional advantages of more water are weed control and more time between turns in water supply, allowing work in the un-irrigated plots or elsewhere.

2.6 *Din Bar*: Welcoming Water for Rice Transplanting

Rice farming is mostly done by women, who carry out most operations from nursery-raising to harvesting, using light hand tools such as hoes and sickles. Ploughing is a task for the men. Labour peaks are in the transplanting and harvesting period, requiring shared and additional family labour. Both activities are initiated on a set day with a series of ritual, called *Din Bar* for transplanting (also known as *Lungalo Din* in Dakhwangaon), and *Koali Din* for harvesting.

Din Bar was decided in accordance with favourable transplanting conditions i.e. around mid- to late-June, with completion of land preparation and sowing activities in un-irrigated plots and with rains expected to start soon. Around the transplanting season, *Din Bar* was jointly decided by the concerned village priest and Gram Panchayat, a local village level governance body/institution. Once the farmers were ready to shift to the irrigated plots, the Gram Panchayat approached the village priest. The village priest then applied the *Panchang*, the Hindu almanac, to propose a suitable date. *Din Bar* was a way of honouring local deities considered to be the owners and protectors of all village lands. Villagers believe that following *Din Bar* would protect the crop from damages by natural disasters like droughts, floods, and hail storms, ensuring good crop growth and substantial yields. Villagers disregarding *Din Bar* would have to face social denunciation. *Din Bar* was the signal to start ploughing and puddling of rice plots by allowing water into the plots and enabling transplantion. *Din Bar* followed the agricultural calendar and also implied the shift of labour and bullocks from un-irrigated locations to irrigated locations to make sure transplanting was done in time. It also ensured that the rice crop within the village would ripen more or less at the same time.

SRI Calls for Changes in Customary Practices

SRI was introduced first in the villages in 2008 by the Mount Valley Development Agency (MVDA), a local NGO supported by the People's Science Institute (PSI), the nodal agency (PSI, 2010) which had prepared and distributed guidelines for promoting SRI in Uttarakhand. PSI's guidelines stated that Raised Bed Nurseries (RBNs) should be established, from which 8–12 days-old seedlings should be transplanted at a rate of one seedling per 'hill' at a spacing distance of 25 cm by 25 cm. Regarding irrigation, the guidelines stated that alternating wetting and drying (AWD) should be applied. The control of weeds was to be done with a mechanical rotary weeder and organic fertilizers were recommended.

For AWD, PSI's training manual on SRI prescribed:

> After transplanting, rice plots should not be continuously kept flooded and irrigation has to be provided intermittently just to keep soil moist. Plots are to be irrigated only at the appearance of hairline cracks in the soil. Irrigation frequency depends on soil type and rainfall. About 2 to 3 cm of water is required for operating mechanical weeders effectively. During the 20 days'period between panicle initiation to grain formation stage, 1 to 3 cm standing water is supposed to be kept in the plot. Irrigation has to be stopped 20 days before harvesting. [PSI, 2008, p.12]

Master Trainers (MTs) of the MVDA trained a person from each village as a resource person to promote SRI and support farmers in various operations. Extension of SRI in villages was done through these Village Level Resource Persons (VLRPs) under the supervision of the MTs.

Din Bar and SRI

In 2008, MVDA undertook the first set of trials on SRI in 52 rice plots of 25 farm households across the study villages. VLRPs and MTs established RBNs on an elevated piece of land in each village during May-June, in consultation with local farmers. In each village the new planting method required adjustment of the cropping calendar, as reflected in Table 2.3.

Table 2.3: Cropping Calendar of Villages for Rice Season of 2008

		Apr	May				Jun				Jul				Aug	Sep				Oct			
		4	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1-4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Phalenda (Lower Fields)	S/B				N				T									H					
	SRI						N		T											H			
Thayeli (Middle Fields)	S/B			N						T							H						
	SRI				N		T											H					
Dakhwangaon (Upper Fields)	S/B	N									T					H							
	SRI								N		T												H

Source: RRA and FGD, 2011 S/B: Transplanted from Saindha/Bina/Bijwad
N: Nursery; T: Transplanting; H: Harvesting

In Phalenda and Dakhwangaon, the transplanting date for the SRI fields was synchronised with the normal transplanting date, which was determined by the declaration of *Din Bar*. In Phalenda, RBNs were established therefore around the first week of June and the seedlings were transplanted into the SRI plots after Din Bar (17th June 2008). Many farmers from Phalenda recalled:

> Though there was profuse tillering in the SRI crop, it did not ripen along with our other rice crops. At the time of transplanting, SRI seedlings were just 8–12 days old whereas our seedlings (from Saindha and Bina/Bijwad) were already 30–40 days old. Therefore the grains of the SRI crop matured late and were subject to damage by stray livestock and monkeys. If SRI seedlings could have been transplanted 15–20 days earlier, we could have got higher grain production with increased yields. [Focus Group Discussions, Phalenda, 15 July, 2011]

In Dakhwangaon, RBNs were established as late as the third week of June and the seedlings were transplanted into SRI plots after the announcement of Din Bar (30th June 2008). By that time, seedlings from Bina/Bijwad and Saindha had already been growing for more than two months. The seedlings from RBNs, having spent fewer days in nurseries, needed more time to ripen. As a result, the SRI crop was harvested almost two months after the crop transplanted from Bina/Bijwad and Saindha. Due to the low temperatures at higher elevations, the SRI fields suffered from late ripening or even non-ripening.

When MVDA's extension personnel approached farm households of Thayeli for SRI, they agreed to advance Din Bar on a trial basis for SRI transplanting. RBNs were established in the third week of May. As many as thirteen out of eighteen households transplanted 8–12 days old seedlings from the RBNs in SRI plots during the first week of June, which was way ahead of the Din Bar announcement (25th June 2008). Farmers recollected that grain yields obtained in SRI plots that year were much higher than plots transplanted from Bina/Bijwad and Saindha.

These initial experiences with SRI indicated that if young seedlings from RBNs were transplanted after the customary *Din Bar,* late ripening and a delayed harvest would be the consequences. In the two villages where Din Bar was observed, seedlings were not supposed to be transplanted before Din Bar. If SRI was to last in these villages, a change of the Din Bar custom would be needed.

2.7 Experiences with AWD

MVDA's programme co-ordinator recalled the experiences of the first year:

> Farmers, habituated to grow rice under flooded conditions since generations, found it very difficult to believe that rice could be cultivated under un-flooded conditions. While irrigating SRI plots, one has to be physically present (unlike in other methods) as young seedlings when subjected to too much water, might suffer from root rot and will die. This requires farm households to do more gap filling. MT and VLRPs themselves took lot of efforts to flood and dry SRI plots alternately. The cascade system of irrigation also forced SRI farmers to allow water through their plots from higher terraces to farmers down slope. The VLRPs under supervision of the MT had to even layout drains and break field bunds if required so that SRI plots might dry in accordance with the AWD prescription, and to check water rot. There were also certain toks and plots which had saturated soils that never dried up, especially with periodic showers. In such locations it was sheer impossible to follow AWD practices. [Interview with Programme Co-ordinator, MVDA, Doni, 19 November, 2011]

In Dakhwangaon, the irregular water supply from seasonal canals caused prolonged dry periods, resulting in high seedling mortality in the first year of SRI's introduction. Drained SRI plots that did not receive water in time also experienced profuse weed growth. A farmer who had given up SRI after the first year commented:

> Under SRI we had to constantly go back and forth to the plot to keep a watch on weed outgrowth whereas in Saindha, once transplanting is done we go back to the plot as per our convenience. There is enough water to take care of the weeds. We prefer to work in un-irrigated plots until and unless we see weeds coming out in irrigated plots. [Personal Interview, Dakhwangaon, 28 July, 2011]

Farm households of Dakhwangaon thus found it difficult to practice AWD due to uncertain irrigation scheduling and also because they were pre-occupied in un-irrigated plots. As late as 2012, another farmer who transplanted seedlings from RBN after drying and marking his SRI plot, could not get water in time causing the weeds to outgrow his rice crop. Some water is required to use the mechanical weeder, a device that slides across the surface of muddy soil while a spiked rotating drum churns the mud and pushes the weeds down into it. This farmer was obliged to plough the plot again and repeat transplanting.

Farm households of Phalenda and Thayeli, having access to perennial irrigation, were better positioned than their counterparts in Dakhwangaon. Still, here farmers found it inconvenient to return to their SRI plots at regular intervals for drying and watering, more so when plots were scattered and located away from the habitat, and this resulted in weed problems. In Thayeli the sandy loam soils were prone to surface hardening upon drying, which caused difficulties in both mechanical and manual weeding. The prescribed mechanical weeding at ten-day intervals after transplanting was also affected by unavailability of water at the appropriate times. Especially in Dakhwangaon and for the tail ends of Phalenda and Thayeli this was a problem. Some farmers of Phalenda who tried out SRI in areas at the tail end of the perennial canal commented:

> Since we did not get water on time after drying, we had to do gap filling repeatedly as many young seedlings were damaged by water beetles that get more active under dry conditions. We even had to use seedlings from Saindha when seedlings from RBNs fell short. [Focus Group Discussions, Phalenda, September 10, 2012]

AWD practice thus required more intensive and extensive management inputs than customary practices with respect to the timing and quantity of irrigation, at both plot and landscape levels. According to the MVDA's SRI programme co-ordinator, AWD could only be followed if farmers of adjoining rice plots, having access to a common irrigation channel, collectively decided to undertake SRI, and this required lot of social organization.

Accommodating SRI within the larger agro-ecological and socio-cultural context thus faced complex challenges. Not only a readjustment in *Din Bar* accompanied by rescheduling of transplanting was required, but it also demanded modified water management practices for young seedlings.

***Din Bar* is Rescheduled**

Farming communities of the three villages responded in different ways to the need of making changes in the *Din Bar* so that early transplanting of SRI plots could be undertaken, as summarized in Table 2.4.

In the second year of SRI, farm households of Phalenda decided to establish RBNs earlier, around mid-May, and transplanted 10–15 days old seedlings prior to the announcement of *Din Bar* (20th June 2009). Incidentally there was a cloud burst, which damaged some rice plots. This disaster was blamed on transplanting of the SRI crop prior to *Din Bar.* Villagers felt that disregarding *Din Bar* in future could bring more disasters. Thereafter, the village community decided to have two *Din Bar*, one each for SRI (around the end of May) and customary methods (around mid-June), so that the earlier-transplanted SRI crop could mature along with the other rice fields. The responsibility of consulting the village priest for the new SRI *Din Bar* was assigned to the VLRP, since he was the one who undertook marking of plots prior to transplanting.

Table 2.4: Rescheduling *Din Bar* due to the introduction of SRI

Village	**Phalenda** Two *Din Bar* from 2010		**Thayeli** *Din Bar* discarded since 2009		**Dakhwangaon** No Change in *Din Bar*	
Method / Year	**Saindha/ Bina/Bijwad**	**SRI**	**Saindha/ Bina/Bijwad**	**SRI**	**Saindha/ Bina/Bijwad**	**SRI**
2008	17 June	-	25 June	-	30 June	-
2009	20 June	-	-	-	2 July	-
2010	18 June	30 May	-	-	29 June	-
2011	13 June	2 June	-	-	15 June	-
2012	11 June	29 May	-	-	18 June	-
Source: Focus Group Discussions, 2011-2012						

By 2012, sixty out of one hundred and thirteen resident farm households of Phalenda had tried to adopt SRI in at least one year. In spite of the perennial canal irrigation system, the proportion of un-irrigated plots in the village was still substantial (42 per cent). At the desirable transplanting time for SRI, crop weeding of *Sathi* and fox millet and sowing of finger millet were done. According to the VLRP, households that could not afford to do early transplanting due to being pre-occupied in un-irrigated plots raised objections regarding transplanting prior to the *Din Bar* referring to the cloud burst incident of 2009. The additional *Din Bar* for SRI crop was thus a compromise between two groups of farm households – those favouring and not favouring SRI.

Farmers of Thayeli recollected:

> Increased grain yields in the very first year of SRI helped motivating us to give up Din Bar practice in the second year. Our male counterparts and children helped a lot in running weeders through SRI plots. This has reduced our work load. Before we used to do transplanting from Saindha, and weeding used to take a lot of our time. All of us therefore readily agreed to convert our plots under SRI. [Focus Group Discussions, Tahyeli, 20 July, 2011]

From 2009 onward farm households of Thayeli totally rejected *Din Bar* practice even for transplanting from *Saindha* and *Bina/Bijwad*. They established RBNs at the time of broadcasting seed in *Saindha* around mid-May and undertook early transplanting of seedlings in the last week of May. Many farm households started transplanting seedlings from *Saindha* along with seedlings from RBNs, so as to finish the land preparation and transplanting operations in one go; this implies that thinning of the *Saindha* fields was also done earlier than before.

In Thayeli, perennial availability of canal water facilitated early transplanting of young seedlings from RBNs. Since the proportion of un-irrigated plots was less (27 per cent), farm households gave more importance to irrigated rice cultivation. Eight out of the eighteen farm households even sold rice. By 2012 all farm households had adapted to early transplantation practice under SRI, and *Din Bar* was effectively abandoned. Almost all plots transplanted from *Bina/Bijwad* and a majority of plots transplanted from *Saindha* had therefore been converted to SRI plots, which had now become the dominant cultivation method for the transplanted fields. Farm households felt that since there was neither any adverse effect on grain yields, nor any occurrence of unwanted happenings in the village, there was no need to consult the village priest for rice transplanting in accordance with *Din Bar*. This does not imply religious practices were completely abandoned as the village priest was still consulted to determine the day of harvesting (*Koali Din*) and other activities.

In Dakhwangaon, located higher, water availability is seasonal and scarce. Early transplanting of young seedlings was not an option. Farmers explained:

> We can neither go for early transplanting nor establish RBNs later, as the crop won't ripen. Since our village is located at a higher altitude it gets cold here earlier. For two years (2009 and 2010), some of us still kept on trying to transplant young seedlings after Din Bar without success. The next year we just took seedlings from Saindha and transplanted them at wider spacing after the Din Bar, and the crop ripened at the right time. This is how we adjusted according to our situation. [Focus Group Discussions, Dakhwangaon, 28 July 2011]

A maximum of 40 households out of the 60 resident farm households had tried to adopt SRI type of transplanting at least once. However, most of these households applied line transplanting of older seedlings uprooted from *Saindha* and *Bina/Bijwad* after the announcement of *Din Bar*. Only two farm households, possessing suitable plots, established RBNs in first half of May and undertook early transplanting of young seedlings without waiting for Din Bar. Elderly farmers of the village however expressed their disregard for this apparent transgression, clarifying:

> We do not consider placement of seedlings as done under SRI by drying of plots prior to transplanting as Lungalo,[3] as there is no water in the plot during that time. We consider Lungalo only those plots where transplanting is done in

[3] i.e. in breach of the *Lungalo Din* custom, equivalent to *Din Bar*.

> water as soon as land is prepared. [Focus Group Discussions, Dakhwangaon, 28 July 2011]

In essence, the cropping calendar in Dakhwangaon focussed on un-irrigated plots (constituting 67 per cent of cultivated lands) and households were not prompted to change the Din Bar (Lungalo Din) practice and reschedule transplanting.

2.8 Young Seedlings Lead to New Norms for Irrigation

In the first two years of SRI's introduction, MTs and VLRPs tried to supervise the recommended AWD practice closely. From 2010 onwards, as number of SRI plots increased, supervision was relaxed and farmers started to adjust the water management.

Based on initial experiences, SRI farmers decided to quit following AWD from second or third year onwards. Discussions with farmers revealed that AWD was no longer recognized as a core component of SRI. None of the interviewed farm households (ten from each village) considered AWD as a component of SRI. Only three farm households mentioned that SRI meant less use of water. A farmer of Phalenda shared:

> We took to conventional flooding practice but with much reduced water depth. Since previous years' experiences had shown that young seedlings under too much water would often not survive, to start with we maintained a low film of water at least upto 15 days after transplantation. The water depth was then gradually increased along with the growth of seedlings so that the young seedlings did not get choked. [Personal discussions, Phalenda, 20 August, 2012]

The water measurements, summarized in Figure 2.4, confirmed flooding practice in SRI plots. In most SRI plots, standing water was always maintained, unless no canal water was available. The above strategy also controlled weed growth and water beetles and implied a more flexible application of mechanical weeding. A water depth of about 4 cm is optimal to operate the weeder. To control water depth, a cut (known as *baga*) was provided in the field bund, which was filled as the seedlings grew. In some fields a small channel was dug in the middle or one of the sides of the plot to facilitate drainage to the lower plots. When the SRI plots were over flooded by lateral flows or seepage through neighbouring plots or adjoining canals, water was drained by breaking the field bund of the SRI plot at the lowest point. Once the water was drained to the required depth, the broken part of the bund was repaired.

The measurements in Phalenda show that the water depth was kept around 2-4cm from transplantation to initiation of flowering.It was increased to about 10 cm during the reproductive phase (when the rice crop is most sensitive to moisture stress), and maintained at this level during ripening after which the plots were drained 15-20 days

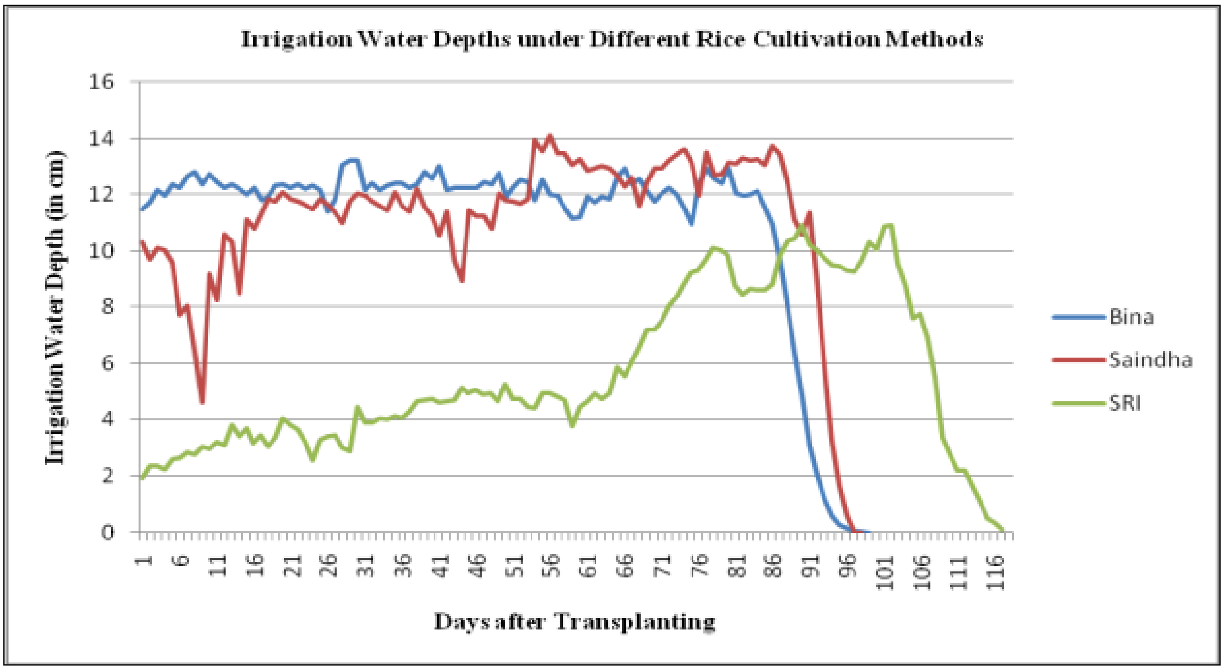


Figure 2.3: Depth of Water under Different Rice Cultivation Method

Source: Mean of Daily Water Depth Measurements of 20 plots each under different rice cultivation methods, Village Phalenda, 2013.

Notes: Transplanting in SRI plots was conducted in end May-beginning June whereas those from Saindha and Bina were conducted in second half of June using older and thus larger seedlings; consequently such crop spends about 96 days in the main field, while for the SRI crop this was about 116 days, all crops being ready for harvesting at about the same time in September. This is contrast to the situation in 2008, when late establishment of RBNs delayed harvesting of SRI crop (See Table 5.3).

(2) There were two occasions in June and July when canals feeding SRI and Saindha plots were closed for repairs leading to drop in water depths

before harvesting (Figure 2.4). Parallel measurements in twenty fields under *Bina/Bijwad* at about 45 days and *Saindha* at about 33 days after sowing, revealed higher water tables. Water depths in *Bina/Bijwad* transplanted plots were kept higher than the *Saindha* plots as a contingency measure. Cross-check measurements in Thayeli confirmed a similar pattern. When shown these figures, the farmers explained that the older seedlings in *Saindha* and *Bina/Bijwad* plots could better withstand higher water levels. Water was not drained from these plots until before harvesting when the grain turned yellow. In 2013 under three occasions (22-25 June, 29-30 June, and 29-30 July), water depths in *Saindha* and SRI plots in Phalenda went down due to closure of canals or as a result of breakages and landslides. Even in these occasions the *Saindha* plots did not completely dry up. Seven out of the twenty SRI plots especially on the 3rd and 4th day did dry up, however without affecting the crop. More fluctuations in water depths were observed in *Bina/Bijwad* transplanted plots depending on gaps in rainfall and irregularities in water distribution.

In Thayeli the farmers took on the responsibility to increase water depths as growth of the SRI crop progressed. One of the farmers doing transplanting with younger seedlings from RBN shared "Under SRI, the thumb rule is to keep the water depth less than half the length of seedlings. SRI plots however have to be visited regularly to check water depths otherwise younger seedlings might die of root rot" [Personal discussions, Thayeli, 5 August 2013]. Since women had to be around for weeding in *Saindha* and other transplanted rice plots they only kept a watch on water depths in the neighbouring SRI plots whereas in Phalenda the VLRP, in charge of water distribution for all toks, was given this additional task.

The situation in Dakhwangaon was different from Phalenda and Thayeli. Except for the two farm households who transplanted seedlings from RBNs, the other households used older seedlings from their Bina/Bijwad and Saindha plots while maintaining a flooding regime and water depth similar as in Saindha. A farmer of Dakhwangaon shared:

> I am the only working woman in the household. If I do not keep water in the plot then weeds grow profusely. That's why I always keep the plot (SRI) flooded otherwise weeding has to be done repeatedly. Once free from un-irrigated plots we can weed the [SRI] plot manually. [Personal discussions, Dakhwangaon, 10 August 2013]

The prescribed AWD practice was not followed in any of the three villages. Instead, farmers developed a new water regime in the fields where SRI practices were applied, based on the requirements of the fields, differences in the agro-ecology and work routines. Young seedlings from RBNs demanded lower water levels, around 2 cm(which was gradually increased to 10 cm as the crop developed). For those transplanting older seedlings from *Saindha* and *Bina/Bijwad* under wider spacing and under uncertainty in water availability, the status quo prevailed - flooding plots to 10-15 cms depth as soon as water was available.

2.9 Irrigation System and Landscape allocate SRI Plots

Early transplanting requires early water availability. Througout the growing season the application of SRI implies a close monitoring of field-level irrigation. Many farmers pointed out that plots that had excessive water and never dried, or plots that lacked water throughout the season were not considered for SRI. The layout of the irrigation infrastructure greatly influenced whether and where SRI could be practiced within *toks*. Further, the location of the plot within a *tok* and the water distribution pattern were important factors.

In 2011 and 2012, SRI practices were mostly tried out on plots located in the command area of perennial canals in the lower-middle fields (Figures 2.5 and 2.6). In Phalenda, rice plots located in upper *toks* were avoided as early transplanting could not be done. A farmer of Phalenda, having her house in the upper portion, shared:

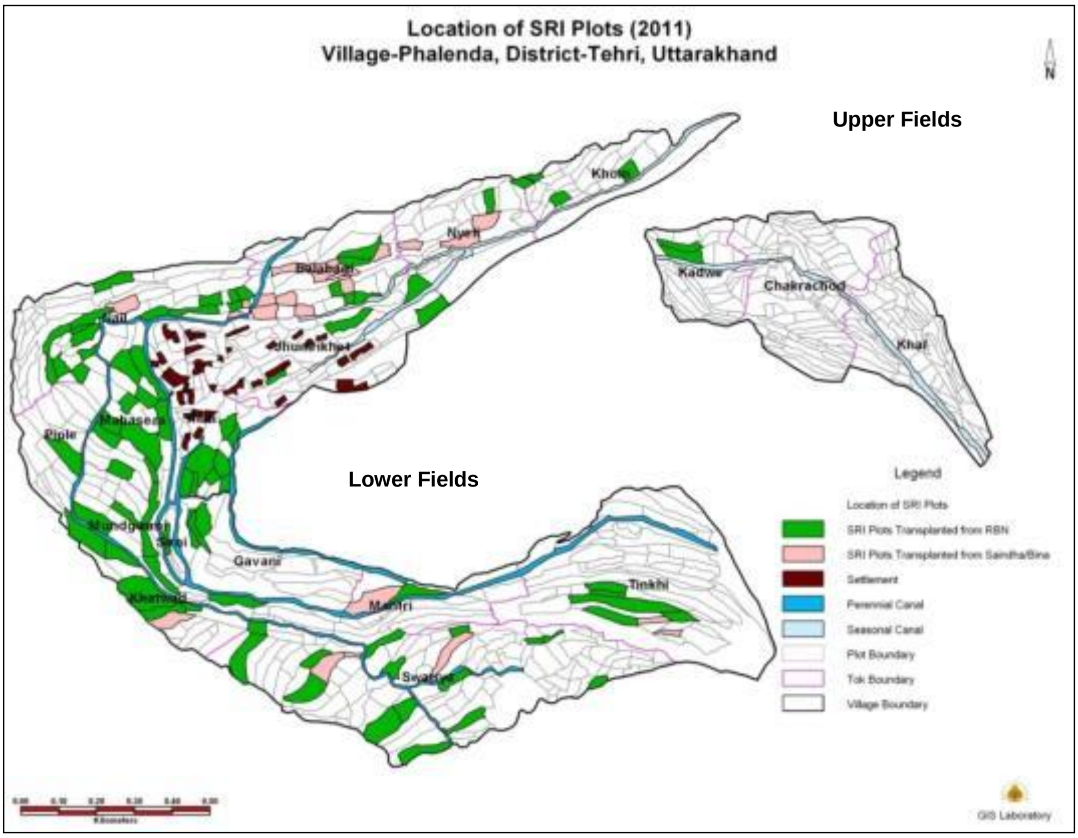
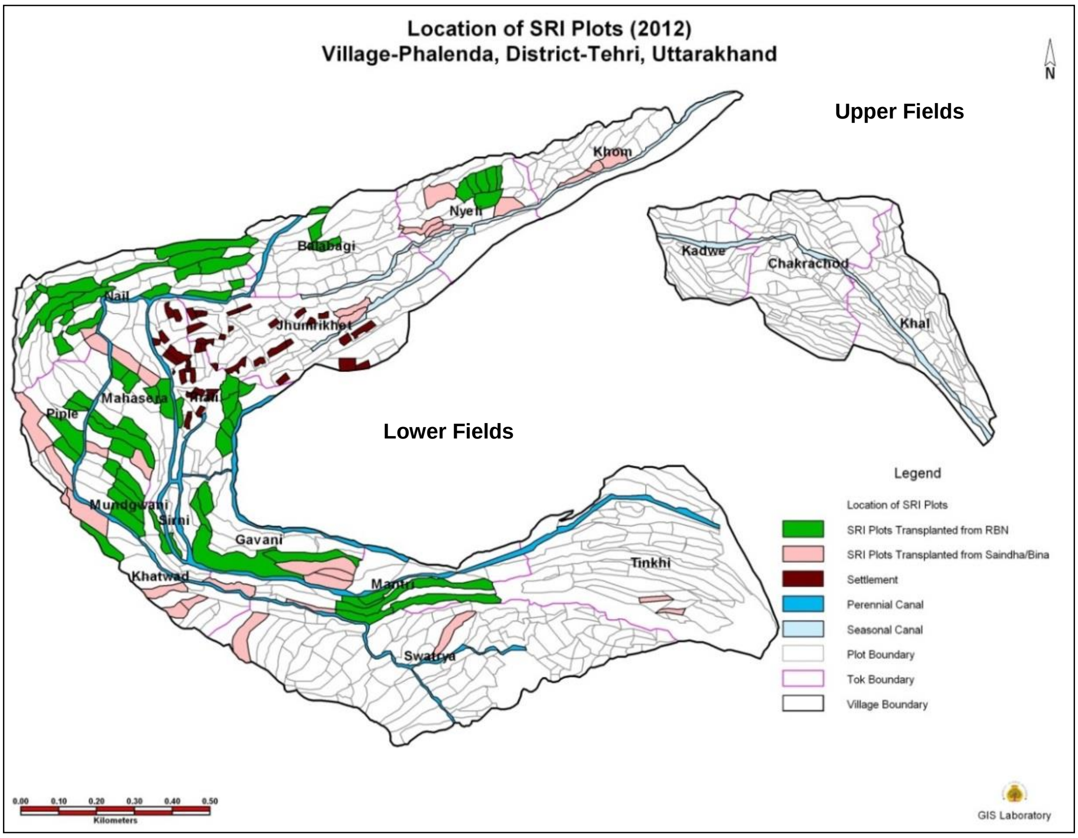


Figure 2.4: Location of SRI plots in Phalenda during rice season of 2011 and 2012



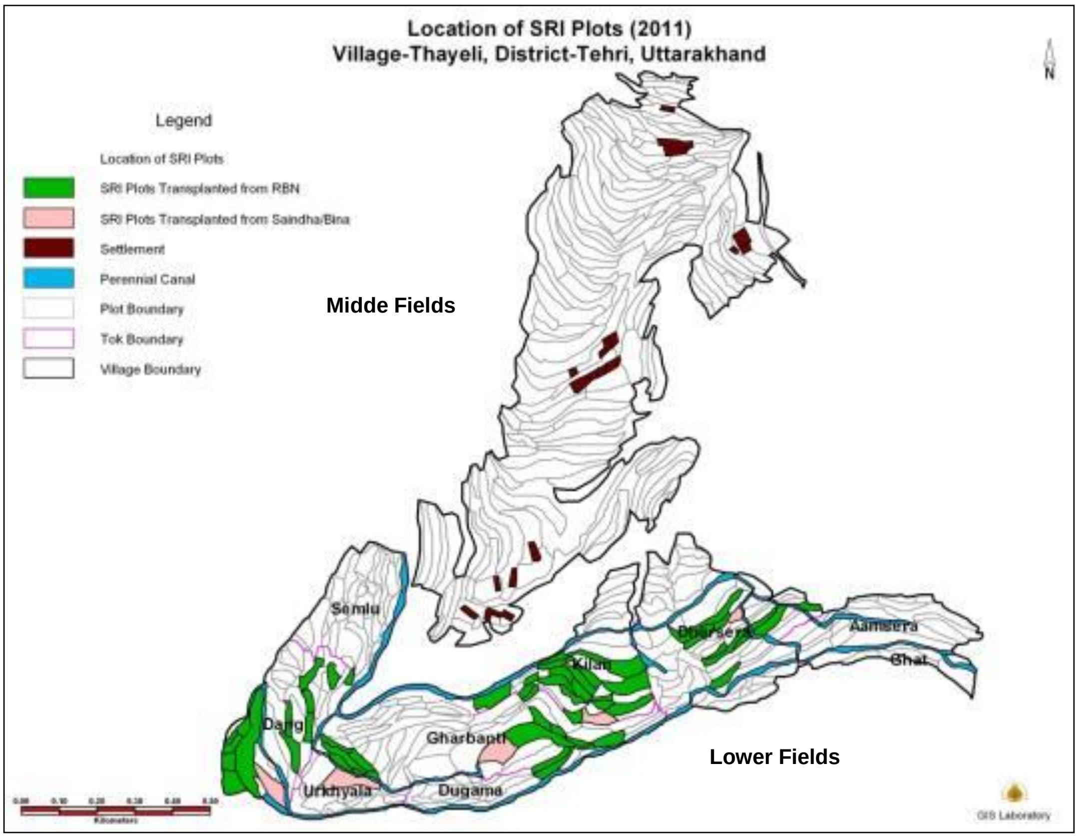
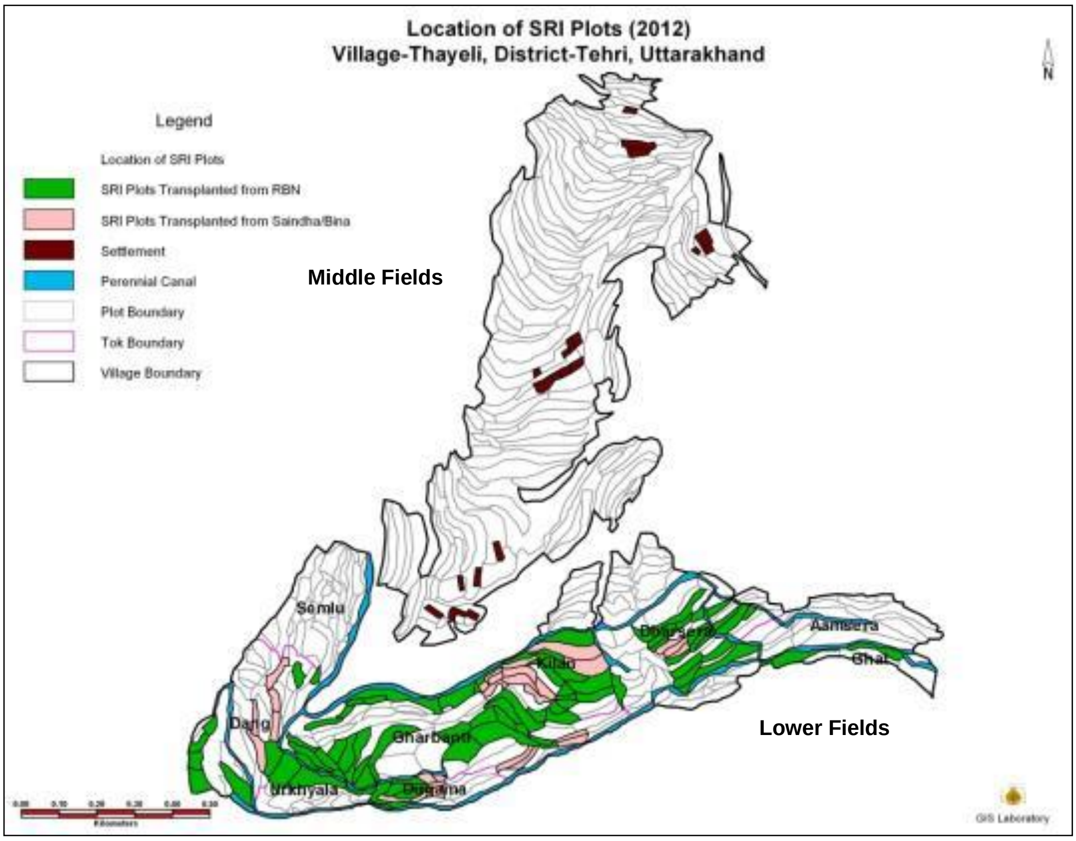


Figure 2.5: Location of SRI plots in Thayeli during rice season of 2011 and 2012



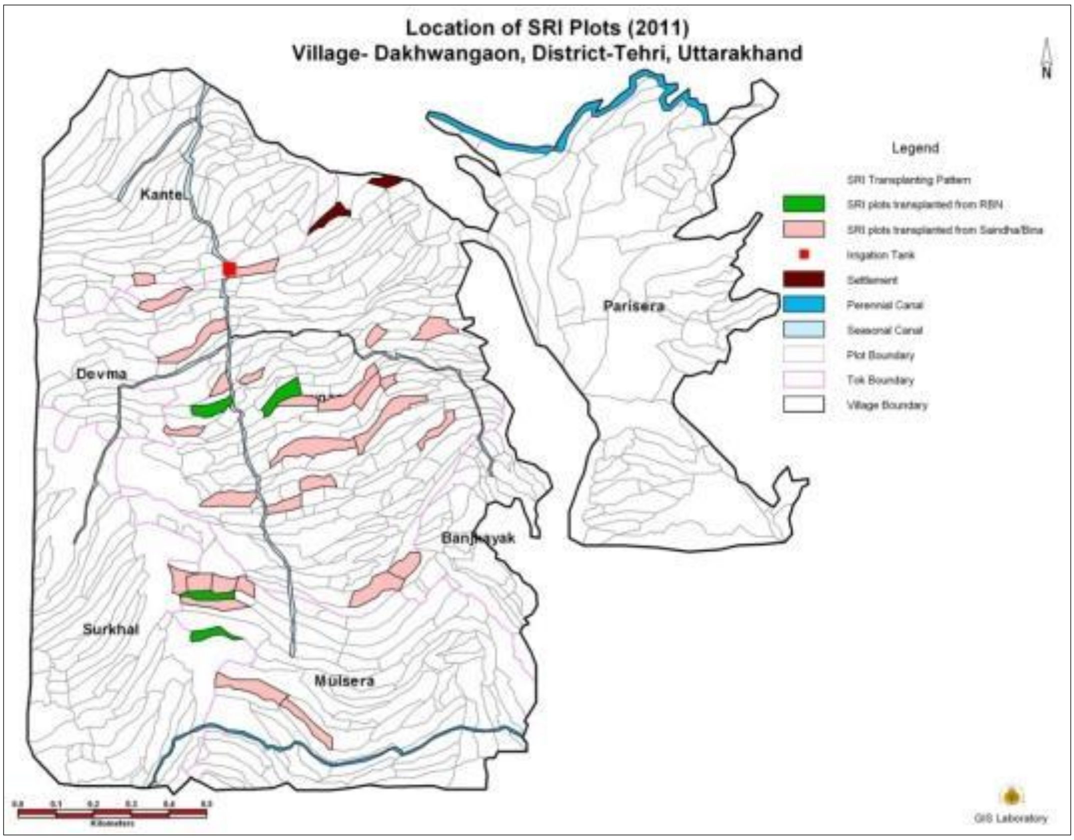
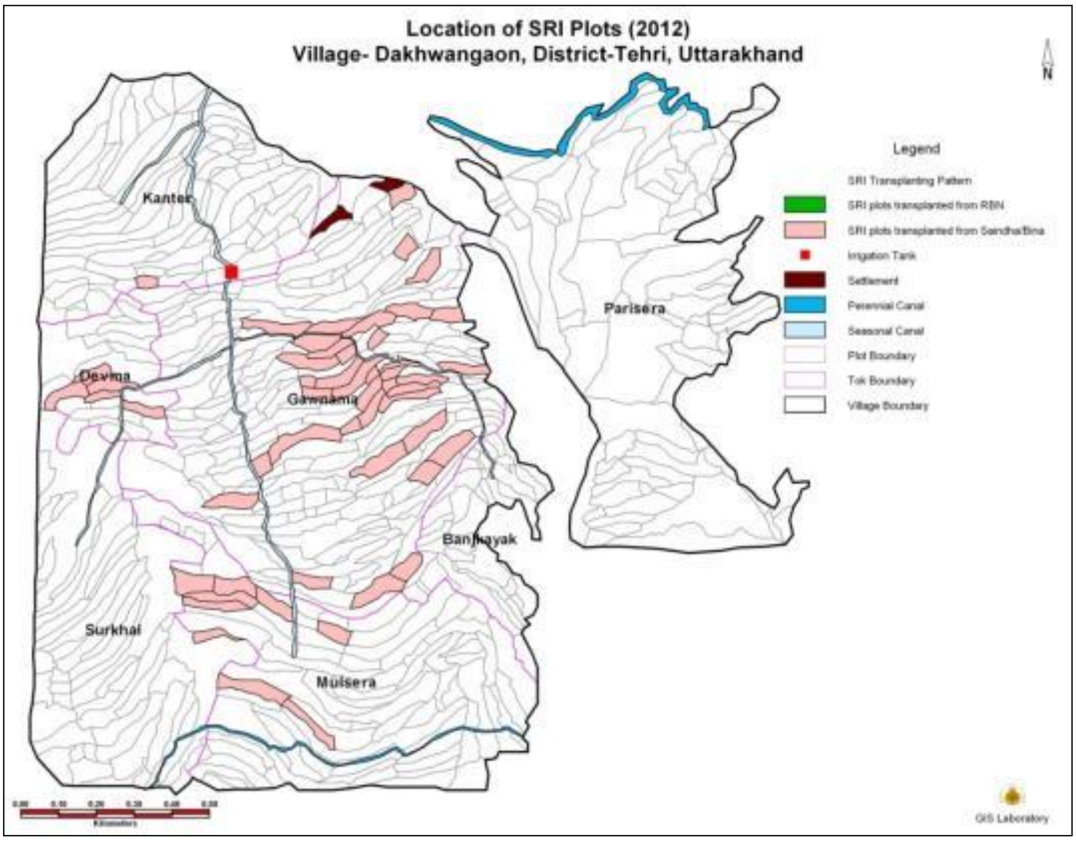


Figure 2.6: Location of SRI plots in Dakhwangaon during rice season of 2011 and 2012



> For those of us having rice plots in upper portion, we cannot do SRI. Even if we have access to water in the lower fields, one must visit the SRI plot regularly. In SRI very young seedlings are transplanted, therefore a lot of attention is required for controlling water depth. It takes us about 0.5 to 1 hour to reach those plots from here. For farm households like us who do not have adequate working hands, it is not possible to visit those plots regularly, especially if one also has to attend to the un-irrigated plots at the same time, besides collecting fodder for our animals and doing our daily household chores. Therefore farm households mostly staying in Gawani [the lower area] or spending most time in Gawani during transplanting are the ones doing SRI. [Personal discussions, Phalenda, August 12, 2012]

In the lower parts of Phalenda and Thayeli too, toks located away from the housing area were less preferred as it was difficult to make regular visits for checking water depths, undertake gap filling and regular weeding. Moreover, farmers stated that SRI fields attracted more monkeys and wild boars. *Toks* which were therefore more prone to such wild animals, located away from the main habitat and near forestlands were avoided. *Toks* having clayey and saturated soils or that are subjected to water inflows from adjoining plots and canals were not considered for SRI because it was difficult to dry, mark and transplant; while the roots of young seedlings were prone to water rot.

In *toks* at the tail end of main canals water reached last which delayed transplanting and therefore were avoided for SRI. Farmers used older seedlings from *Saindha* and *Bina/Bijwad* for these fields though still applying wide spacing to accommodate mechanical weeding. *Toks* located in the middle reach of perennial canals (that are closer to the habitat) therefore were most preferred for SRI. Even in these *toks*, farm households avoided plots adjacent to the main canals as rushing waters damaged young seedlings.

Dakhwangaon had a predominance of seasonal canals and more tightly controlled rotational water distribution system. These features did not leave much choice for selection of plots suitable for adoption of prescribed SRI practices. A few farm locations which had perennial water supply were located relatively far away from the habitat. Farmers expressed their inability to go to such plots regularly for checking water depths, doing gap filling and operating the weeder. However, most farm households of Dakhwangaon planted older seedlings from *Saindha* and *Bina/Bijwad* at a wider spacing within the lines (using eye estimation rather than measurement; see Chapter 3) but only in *toks* close to their homes. Older seedlings from *Saindha* and *Bina/Bijwad* thus provided more flexibility in choice of plots. The VLRP of Dakhwangaon explained: “For better marking we had to select plots where we could control water but with older seedlings and eye estimation we could work in water” [Personal interview, Dakhwangaon, 22 July, 2012] [Also see Chapter 3].

Farmers of Dakhwangaon especially preferred applying wider spacing in plots where rice otherwise tended to lodge. A farmer of Dakhwangoan shared "Every year we consider changing practices for our plots. We see in which rice plot lodging has taken place then we do SRI in that plot next season, as in SRI the best thing is that there is no lodging due to better root growth" [Personal discussions, Dakhwangaon, 21 July, 2012]. In 2012 two farmers of Dakhwangaon who used seedlings raised from RBNs, when asked about their criteria for selecting plots for SRI, stated:

> Every year we select these plots having access to perennial flows from the adjoining mountain stream. Having private canals we can independently control water distribution. The plots also lie outside the village boundary so there is not much objection to doing transplanting here ahead of the Din Bar. [Personal discussions, Dakhwangaon, 21 July, 2012]

In Phalenda there was an increase from 2011 to 2012 in number of SRI plots transplanted from *Saindha* or *Bina/Bijwad*. An increase of 10%–15% of grain yields as compared to the conventional practices was reported by the farmers through application of wider spacing and mechanical weeding with use of older seedlings. In Thayeli, a similar trend was observed. Here it was because one of the main canals had broken down prior to the rice season. Farmers therefore decided not to do any early transplanting, therefore did not raise enough RBNs and used older seedlings instead. In Dakhwangaon too SRI plots transplanted from *Saindha* or *Bina/Bijwad* increased.

In sum, the introduction of SRI led to a change in the water management of particular fields, especially located in *toks* in the middle reach of perennial canals at the lower portion of Phalenda and Thayeli. Farmers thus avoided excess irrigation water in the head end. Similary, at the tail end there was risk of crop loss due to delayed transplanting, weed outgrowth and beetle attacks. Additional factors to select fields for SRI were the *toks* located close to the housing area allowing frequent visits, for example to fill gaps in case of seedling mortality or to do regular weeding. Within *toks* farmers preferred plots for SRI with direct access to irrigation, allowing control over the water depth without creating conflicts with neighbouring farmers. These factors together implied that in Thayeli conversion to reduced water use was applied quicker than in Phalenda, whereas in Dakhwangaon the introduced SRI practices were modified in a way that made little difference to the water management.

2.10 Conclusion

The study illustrates how the farming practices and water management of irrigated rice are closely connected at the level of *toks* and the village. In-field irrigation practices are limited by the rainfall and canal infrastructure, elevation and the layout of plots along the slopes.Within a relatively small space, a range of agro-ecological and socio-institutional elements require reconsideration and adjustments in establishing a new irrigation regime with the introduction of SRI.

Prior to the introduction of *SRI, Din Bar* in each village was scheduled at the community level, in such a way that most of the sowing and first round of weeding in un-irrigated *toks* was over by then, so that bullocks and ploughmen along with women were available for land preparation and transplanting operations in irrigated rice plots. The allocation of *toks* and plots under the different rice farming practices and operations within had to take into account the overall canal layout and water availability, cropping pattern and priorities, availability of farm labour at household level and of bullocks at village/community level. Similarly, limitations of the canal network and the need to allow passage of water through plots for downslope users in the same *tok* led to over-flooding of individual rice plots partly to control weeds and to enable a relatively flexible work schedule between irrigated and un-irrigated *toks* and plots within.

In mountain farming systems the landscape features influence the location of canals but temperature is another important factor, reducing the flexibility for seeding and transplanting in higher villages. The ritual of *Din Bar* served to maintain a critical level of co-ordination across the different *toks* (both irrigated and unirrigated) and between farm households. Rice cultivation and water management even at the plot level was thus embedded in the wider irrigation culture of the local farming community. Water management operations around existing rice farming practices were thus in tune with local agro-ecological characteristics and human management capacity, averting risks as well as aiming for a fair distribution of water among different farm households.

The introduction of AWD along with SRI appeared too complicated to be included in the village irrigation schemes. The interactions of demanding young rice seedlings, restricting cascade irrigation, competing weeds, active water beetles, and conflicting rain-fed crops made AWD no option although a reduction of the crop water depth was established. In subsequent years the adjustments in the water management implied a change in the selection of plots where seedlings from RBNs along with other SRI practices were used. Seedling age appeared the factor most directly related to water management. Where AWD was replaced by an overall reduced water depth, the use of very young seedlings was applied flexibly in combination with older seedlings from *Saindha* fields or *Bina/Bijwad* nurseries. Table 2.5 summarizes the major adaptations in crop-water management practices in the differernt villages. The adaptations related to crop-water management practices in the villages are made at two interlocking levels: canals and community (at village level) influencing *Din Bar*; and fields and farmers (at *tok* level) influencing choice of plots for SRI and water usage practices.

Table 2.5: Major Adaptations in Crop-Water Management Practices in Different Villages

Village / Decision	Phalenda	Thayeli	Dakhwangaon
Setting *Din Bar*	Two *Din Bar*, one each for SRI and customary practices (*Saindha/Bina*)	*Din Bar* practice totally abandoned (both for SRI and other practices)	No change in *Din Bar* practice (due to limited applicability of SRI)
Allocation of Plots under SRI	SRI plots mostly in the middle reach of perennial canals (using young seedlings from RBNs)	SRI plots mostly in the middle reach of perennial canals (using young seedlings from RBNs)	Plots served by seasonal canals (older seedlings from Saindha/Bijwad planted at wide spacing)
Water Application Depth	Water depth increased from 2 cm (around transplanting) to 10 cm (at grain filling)	Water depth increased from 2 cm (around transplanting) to 10 cm (at grain filling)	Water depth of 10-15 cms right from transplanting to grain filling

Earlier studies on adoption of SRI and its different components (including AWD) have tried to explain farmers' behaviour by looking at household level (Moser and Barrett, 2003; and Moser and Barrett, 2006) and/or plot level characteristics (Martin et al., 2012; and Palaniswami et al., 2013), yet overlooking the influences that wider socio-technical characteristics and processes might play, as illustrated by the present study. Most of these studies do not delve into understanding farmers' strategies by exploring farm, plot and landscape level interactions, and socio-technical organizations around water management, therewith overlooking the importance of how farm households and communities organize themselves around water at different stages of crop growth. SRI promises to be an eco-friendly, water-saving technology. However, to realise plot level water savings, access and control over water at the individual or plot level is not enough. Farmers weigh several factors in deciding application of new practices. These include time required and available labour to regularly visit the fields, soil moisture characteristics affecting drainage capacity, and risks of seedlings mortality from water beetles. For smallholders, immediate short-term concerns such as saving time and labour, and harvesting a better mix of crop outweighs the long term sustainability issues of saving water and reducing methane emissions.

The study also shows that farmers do not proceed by weighing all management options in advance and making a decision once and for all. Instead, 'on the job learning' and adjustment of practices in subsequent seasons reflect the experimental capacity of farmers. Informal experimentation and experiences with AWD and SRI under varying conditions and circumstances lead to incremental innovations and adjustments in rice farming practice. In particular, this chapter confirms that household- and plot-level practices depended not only on individuals but also emerged from collective learning and group-level negotiations around crop and water management practices. This fits precisely with the notion that small-scale farming resembles a skilful performance situated in time and space (Richards, 1989b). Richards' metaphor of agriculture as a performance draws attention not only to the isolated individual performer but also the ensemble of performers interacting in a collective endeavour. This chapter highlights how new adjustments in collective performance may bring about community-level changes, such as the change in ritual practice of *Din Bar*.

The performance metaphor allows space for innovation, but it is important to notice that farmers do not just make it all up out of nowhere as they go along. They draw upon a stock of practised skills and procedures, experiences, and rules of thumb for decision making. For example, when adjusting water depths in SRI plots, farmers try to balance several priorities: curbing weeds and beetles in SRI plots, attending to rain-fed plots, checking water rot, while also aiming for higher yields. One of the farmers' innovations documented in this case study was the practice of starting with a very shallow film of water after transplanting and gradually increasing the depth as the plants grow larger. This practice emerged from individual and community-level learning processes, but remarkably it is more or less precisely the practice recommended by international scientific bodies. The knowledge bank of International Rice Rsearch Institute (IRRI) rerecommends: "After transplanting, water levels should be around 3 cm initially, and gradually increase to 5−10 cm (with increasing plant height) and remain there until the field is drained 7−10 days before harvest" (IRRI, 2007).

Further research is desirable to explore the possibilities for applying AWD in cascade irrigation systems. A greater density of field irrigation channels with appropriate control structures, as often proposed (e.g. Guerra et al., 1998), may not be enough by itself. It would also require considerable efforts to adjust water supply distribution schedules to match SRI transplanting and weeding schedules, more so in large-scale irrigation systems that are shared by villages (See Box on Experiences from Srikot Village) having different water requirements. Farmers, agronomists and irrigation agencies would have to come together to work out possible strategies for water allocation and distribution. At the same time the possibility of reducing water depths in SRI fields, compared to existing cultivation methods, also indicates large potential of water saving in rice farming (while maintaining high yields). According to a long-term five season study done by Krupnik et al. (2012) in Sahel, the water-saving in SRI varied between 16-48%, with water productivity at 11-45%. Farmers in mountain farming system and elsewhere would require incentive to reduce water depths in rice plots and a system in place for downslope water users.

Experiences from Srikot Village

Srikot village is located in the Bhilangana block of Tehri Garhwal district of Uttarakhand. The village is linked to a larger canal system drawing water from a seasonal stream (Bal Ganga) feeding six other villages. Srikot is the fifth village in the supply line for getting water. The village's turn to receive water during the rice season comes approximately every 3 to 4 days, depending upon rainfall and the water demands of other villages. Agricultural lands in the village are divided into two parts, supposed to get water alternately on a daily basis through gates provided in the main canal. The gates are operated by the village Irrigation System Controller who is appointed and paid by the Irrigation Department. The main canal located in the upper reach of the village, supplies water through distributaries running down the slope to the rice plots. The rice plots are irrigated mostly plot-to-plot. Water is available for individual plots on rotational basis depending upon availability in the main canal, reach with respect to the concerned distributary canal and the need to share water with others.

SRI was introduced in Srikot by MVDA in 2009. In 2012, 50 of 75 resident households had tried applying SRI's principle of wider spacing while transplanting. Only 12 out of the 50 farm households had established RBNs because canal water availability, needed for land preparation just before transplanting, was unpredictable. The age of seedlings while transplanting from RBNs varied between 15 to 21 days, with delays caused by late rains and low flows in canals in addition to problems obtaining bullocks for ploughing.

The remainder of the 38 farm households used seedlings (aged 30 to 104 days) from Bina/Saindha. Experiences from previous years had shown that unpredictability in water supply after transplanting was a limiting factor in the use of a marker (as also observed in Dakhwangaon) which necessitated drying rice plots just before transplanting. In 2012 MVDA therefore introduced rope marking for spacing seedlings in standing water.

The customary practice in Saindha and Bina transplanted crop in Srikot was to flood rice plots up to the brim of field bunds (10 to 12.5 cm) whenever water was available, regardless of crop stage, which was observed in other villages as well. Farm households using young seedlings from RBNs reported that a lower water depth was maintained during the vegetative phase (about 2–3 cm at the crop establishment stage) by applying water controls, as was done in Phalenda and Thayeli. The water level was gradually increased during the reproductive phase (about 10 to 12.5 cm). Some farm households, when using old seedlings from Saindha and Bina, transplanted at relatively wider spacing using rope markers. They sought to fill rice plots to the brim of the field bunds by applying irrigation whenever water was available, as was also observed in Dakhwangaon. The depth of water in such rice plots on any day fluctuated between a maximum of 12.5 cm to a minimum of 2.5 cm, depending upon water supply, rains, and heat. Only in a few rice plots was some form of intermittent wetting and drying observed, even leading to the development of soil cracks. This was due more to non-availability of canal water than to any intentional water control measures. Farmers of Srikot shared that they flood the SRI plots to kill weeds as there are more weeds (due to wide spacing). Irregularities in the shared canal system along with cascade irrigation thus enforced a higher water depth in SRI plots than prescribed under AWD

Source: Munthali (2012)

The study highlights the complexities of introducing a new concept such as AWD or a new set of practices such as SRI in an already complicated existing system. An alternative extension approach could have been a step-by-step process of introducing practices, which however is likely to take several years. A blanket AWD practice in farms especially having unreliable source of water and cascade irrigation system is not practical unless farm households and other stakeholders are organized around the water infrastructure. At the same time the present study indicates that this does not mean that other SRI practices become irrelevant. Farm households that are unable to practice AWD could still consider using other individual components of SRI, such as wide plant spacing or young seedlings, to reap partial benefits of the system. It underscores that the scope for the individual SRI components is still important beyond the ideal SRI package.

The case of SRI's introduction in Uttarakhand shows that socio-material elements interact intensively and extensively at plot, farm and landscape levels. These elements and processes therefore have to be analysed interactively while studying irrigation systems or introducing new interventions to come out with viable management options. The smallholders of Uttarakhand highlight the need for an integrated approach to understand the relevance of crop-water management culture, and translating them further according to local and changing contexts. The study therefore calls for collaborations between irrigation engineering, agronomy, social sciences and practitioners to arrive at viable crop-water management options in future.

Chapter 3

Marked Rice Fields: The Introduction of System of Rice Intensification (SRI) to Mountain Landscape of Western Himalayan Region

3.1 Introduction

The System of Rice Intensification (SRI) has been offered as an agro-ecological approach to grow rice and more recently other grain crops by reducing the dependency on external inputs. (SRI-Rice,2014). SRI was introduced in the North Western Himalayan region of India in 2006 by the People's Science Institute (PSI) as part of their sustainable natural resources management programme (PSI, 2009). The objective was to cater to the food and fodder needs of the communities while also making farming more sustainable through less use of water and chemical fertilizers, and reduced methane emissions. PSI developed brochures and training materials and trained and extended field support to local non-governmental organizations (NGOs) for the promotion of SRI. In the study area – three villages in the Tehri Garhwal district of Uttarakhand – the Mount Village Development Association (MVDA) was the NGO promoting SRI among farmers. The MVDA appointed a village-level resource person (VLRP) in each village to assist farm households in application of SRI practices. The VLRPs were supported by master trainers (MTs) from MVDA. The communities in this region grow rice in the monsoon season with some additional grain crops, pulses and vegetables. Wheat is the main winter crop. Throughout the year collecting forest products and animal husbandry are part of their farming systems.

The chapter presents the results from a study on the responses by three village communities to the introduction of SRI. Here the focus is in particular on field preparation activities. Much of the debate about SRI has focused on effects of the cultivation method on the crop itself, in particular yield (Berkhout and Glover, 2011). Likewise, studies addressing claims that SRI requires fewer inputs have typically focused on crop-related activities, most notably transplanting and weeding. The premise is that farmers spend substantial time on preparing the rice fields before the seeds or seedlings enter the soil. The introduction of SRI requires substantial coordination and modification of field preparation activities, especially when SRI is practiced alongside with a direct-seeded and non-SRI transplanting.

SRI advocates recommend the transplanting of young, single rice seedlings at wide spacing, intermittent irrigation rather than permanent flooding, and thorough weed suppression by using mechanical rotary weeders (Stoop et al., 2002; Glover, 2014). To facilitate mechanical weeding, it is recommended that seedlings are planted in a regular grid pattern at an optimal spacing of 25 × 25 centimetres. The non-flooded field conditions recommended with SRI create a muddy soil condition that favours weeds. Therefore weed suppression is considered an important element of field preparation before planting takes place (Krupnik et al., 2012). This is typically done by flooding the soil to rot the weeds, and by mechanical means such as thorough ploughing and trampling by cattle.

A muddy soil also enables the use of a marking device that marks the soil surface with the regular pattern to be followed during transplanting. In the study area the common device for marking is rake-like tool introduced by MVDA (Figure 3.1). Drawing this marker across the soil surface in two perpendicular directions, results in a square grid pattern of 25 cm × 25 cm (Figure 3.2). Transplanting is then done by inserting a single 8–12 days old seedling at each intersection of lines. Field marking with such a tool can be done most effectively when the soil surface is evenly levelled and dried to the desired muddy condition.

Figure 3.1: Iron Rake Marker with 6 Clamps

Figure 3.2: Cross Marked Plot

These major new technical elements required new working routines and coordination among farmers. The changes include timely delivery of irrigation, access to bullock teams managed by skilled ploughmen, effective water control on carefully levelled plots, and marking the fields for transplanting. A complicating factor for field preparation in mountain regions is that fields are located at different elevations. Not all fields receive irrigation water and therefore different crops, cultivation methods and water management practices are adopted for different fields. The introduction of SRI practices therefore poses farmers with a serious challenge in their calendar of operations.

Field observations showed that the communities in each of the three villages had applied SRI techniques in different ways, including the use of markers. In very few fields was the recommended grid pattern followed. Mostly a single run with the marker was done, resulting in a pattern of widely spaced parallel lines on which seedlings were planted with shorter distances. In some fields no marker was used at all but plants were placed in rough lines nevertheless, based on eye estimation only. In this paper we examine how and explain why these three different styles of transplanting emerged within SRI practice. The different outcomes are explained by showing how the changes introduced by SRI put substantial demands on the coordination of field preparation activities. We will show that farmers took an active role in deciding how and where to apply the recommendations, and they adjusted the applied methods after one or two years of experimentation.

It is argued that these local reconfigurations of socio-technical system components were far more complex than a simple dinary switch from an established technology to a new one. The management activities of farmers are often defined as goal-oriented activities in which the steps towards these goals are hardly problematized. Dillon (1980, p.258) defines farm management as “the process by which resources and situations are manipulated by the farm manager in trying, with less than full information, to achieve his (or her) goals.” The ‘manipulation’ in this definition is not further elaborated on. Richards (1989, 2001) argues that although certain goals and planning are there, farming is better understood as a skilful performance situated in time and space, in analogy with a musical performance. Meeting challenges such as climatic fluctuations, changes in labour availability or other small or larger problems requires a capacity to adapt and improvise in order to get a good yield by the end of the season.

SRI itself represents a new set of practices that challenges farmers to employ their adaptive and improvisational skills. This is not just an individual challenge because many farm operations require interaction and coordination with neighbouring farmers, in particular when using shared irrigation facilities, tools (such as field markers and weeders) or labour. Field preparation requires coordination across plots and between farm households. It involves the activities of farmers, bullock owners, bullocks and ploughmen, working together in coordination with women transplanting groups, using tools such as ploughs, levelling boards and field markers. These human and non-human actors together form the socio-technical system in the three villages whose reconfiguration constitutes the process of technical and socio-cultural changes simultaneously (Hughes, 1989; Law, 1992; Latour, 1999; and Law and Hasard,1999). New tools (like markers introduced with SRI) are material objects having potential of restructuring relationships and reshaping culture around such systems (Pfaffenberger, 1988).

The research sites

Three villages (Phalenda, Thayeli and Dakhwangaon) having contrasting landscapes, where SRI had been introduced in 2008, were selected in the Tehri Garhwal district of Uttarakhand, India (Figure 3.3). The field study was conducted over two rice seasons, 2011 and 2012. The study followed an ethnographic approach using a mix of tools, principally participant observation, semi-structured interviews with key informants and focus group discussions with community members, to explore and explain the extent and processes of variation in field preparation practices that followed the introduction of SRI.

In 2011, rapid rural appraisals were used to understand the timing of field preparation activities before and after SRI's introduction. Participant observations of farming operations on randomly selected plots further revealed the range of field preparation activities, the roles of different actors and mechanisms of social coordination, along with spatial variations within and between the villages. Focus group discussions with women's self-help groups (SHGs) provided insights into decision-making processes relating to field preparation and marking, and transplanting.

In 2012, detailed field observations were made during field preparation of all rice plots belonging to 30 randomly selected farm households (ten from each village). These observations revealed spatial variations and shed light on the interactive processes influencing the operations involved. A historical narrative of these plots, since SRI's introduction, further revealed changes in practices over several seasons. Semi-structured interviews with these farm households and key informants further explained variables and their roles influencing farmers' choices, and spatial and temporal variations.

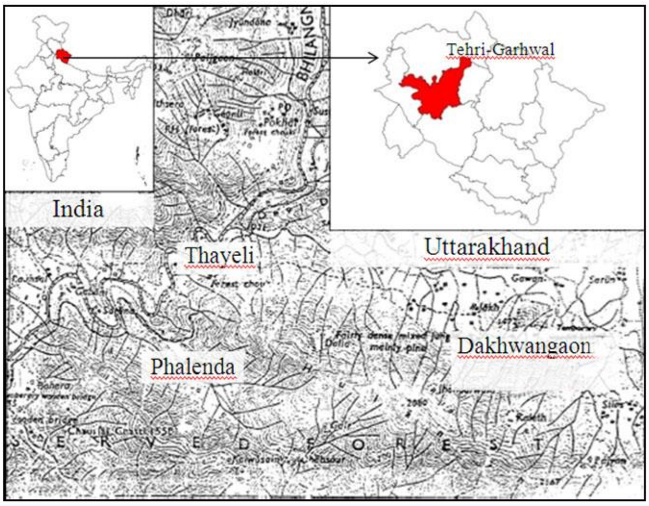


Figure 3.3: Location of Research Sites in Uttarakhand, India

All the SRI plots with marking patterns for the three villages, for both the seasons, i.e. 2011 and 2012, were mapped and compared. Records of transplanting maintained by the local SRI promoting agency, since 2008, indicated temporal changes in marking patterns which helped in triangulation of personal observations and semi-structured interviews. Similarly, records of marking activities for both the seasons were compared to check for change in roles, if any. The multiple case study design along with ethnographic analysis yielded in-depth understanding of elements and processes responsible for variations in the field preparation and marking strategies in rice farming.

3.2 Diverse Landscape and Rice Farming Systems

The three study villages are located at relatively different elevations in the Bhilangana sub-basin of Tehri-Garhwal district of Uttarakhand. Dakhwangaon is located at a much higher elevation than the other two villages (Table 3.1). Being located in an area of steep slopes, the terraces of Dakhwangaon are much smaller in size and more irregular in shape. Due to its high elevation, the village also has a poor irrigation infrastructure with only 33 per cent of the cultivated lands being irrigated, mostly by seasonal canals from rain fed streams. The irrigated terraces served by the perennial canals are also located at further distance from the main habitation.

Farmers here therefore give more emphasis to un-irrigated plots where they grow a variety of crops including millets, pulses and oilseeds, besides rice. Amongst these, kidney beans and some of the other pulses are not only eaten but also produced for sale.

Phalenda is the biggest of the three villages and stretches out over a curved slope with housing areas in the higher and lower areas. The lower fields are mainly irrigated terraces fed by perennial canals, the upper area primarily rain-fed plots and a small proportion of irrigated terraces fed by seasonal canals. Farm households typically have both irrigated and rain-fed fields. Only a few households produce surplus rice, which is mostly sold within the village. A few households sell onion and potato in the winter season.

Table 3.1: Characteristics of Study Villages

Village / Parameters	SRI Villages		
	Phalenda	**Thayeli**	**Dakhwangaon**
Altitude (m above msl)	900-1200	950-1100	1300-2000
Distance from Main Market (Km)	7	10	17
Resident Households	113	18	60
Resident Population	471	89	279
Agriculture Work Force	265	60	236
Bullocks (Households/Pair)	64 (4)	6 (6)	48 (3)
Total Area (Ha)	133	24	79
Agricultural Land (Ha)	80	19	47
Percent Irrigated	58	73	33
Type of Irrigation Canal	Perennial + Seasonal	All Perennial	Mostly Seasonal
Households selling Rice (%)	8 (7)	8 (44)	0 (0)
Source: Revenue records, RRA and Household Surveys, 2011-2012			

Thayeli is the smallest village, with about 70% of the fields being irrigated terraces located relatively nearer to the housing area (as compared to other two villages) at lower elevations and fed by a good network of perennial canals. Farm households have bigger landholdings and larger irrigated terraces compared to the other two villages, and most of them produce surplus rice. The farm households therefore give much more importance to irrigated rice cultivation in comparison to rainfed crops.

In Phalenda and Dakhwangaon un-sprouted seeds are broadcasted (*Sathi*) on the rain-fed fields. On some of the irrigated plots sprouted seeds are broadcasted (*Saindha*) in puddled plots. For some fields, seedling nurseries are created (*Bina/Bijwad*) by sowing un-sprouted seeds in dry conditions. Farmers later also transplant seedlings uprooted from *Saindha* plots during thinning operations. Transplanting, whether done from seedlings grown in *Bina/Bijwad* nurseries or using seedlings uprooted from *Saindha* plots, is known as *Ropai*. *Saindha* is followed where limited water is available to undertake direct seeding in all the rice plots before the onset of rains. Transplanting from *Bina/Bijwad* is practiced in plots that receive irrigation later from rainfall, while *Saindha* is practiced in plots with assured irrigation.

Among all the rice cultivation practices, farm households prefer *Saindha* as it reduces the need for additional ploughing and saves on the labour required for field preparation and transplanting. This preference is partly due to the declining availability of bullocks and ploughmen, which is due to labour migration. *Saindha* was most prevalent in the lowlands of Phalenda and Thayeli where there is perennial availability of water. Transplanting from nurseries (*Bina/Bijwad*) was more prevalent in Dakhwangaon and the higher parts of Phalenda.

3.3 Field Preparation: A Synchronised Multi-Actor Operation

Field preparation in irrigated rice consists primarily of ploughing and levelling. Ploughing crumbles the soil and crushes weeds and crop residues, while levelling allows for an even distribution of water over the field. In all villages, plots are prepared for *Saindha* around mid-May in the lower parts and a month earlier at higher elevations. For the transplanted fields operations start mid-June and last for about two weeks. Field preparation starts with clearing the plot, followed by manuring, dry ploughing, clearing corners, cutting old bunds, repairing water channels, irrigating, wet ploughing, raising new bunds, crushing or removing weeds and crop residues from the previous season, and finally levelling. Farm households of Dakhwangaon applied farm yard manure (FYM) during preparation of the rice fields whereas those in Phalenda and Thayeli applied FYM only in the winter (off) season. Some farmers preferred removing crop residues while others ploughed them under. The gap between dry and wet ploughings, as well as the number of levellings, depended on availability of draft animals.

The equipment used for these operations includes a spade (for bund making), a plough and a leveller. The latter is a bullock-drawn wooden plank, which is dragged over the field two or three times, with the ploughman standing on it to weigh it down. Ploughing and levelling operations were undertaken by ploughmen, whereas women members of the farm households performed the other tasks, often helped by children. In the absence of an able male household member, a ploughman is hired. This arrangement can be made *ad hoc*, ranging from a single day's employment to permanent or seasonal hiring, for payment in cash or in kind or in exchange for labour. Hired ploughmen usually bring their own team of bullocks and equipment. Field preparation thus requires coordination and planning of the ploughing team, household labour and water. There is about two to four days of flexibility between field preparation and transplanting. As ploughing teams are scarce, some households purchase bullocks prior to the season or borrow from relatives in other (lower/higher) villages where the season starts later/earlier.

Households sharing bullocks followed the sequence of water distribution amongst plots but also considered walking routes for the bullocks as they had to return to the housing area without disturbing levelled fields. Transplanting is typically done on the same day as the final levelling of plots. Farm households sharing bullocks usually also organised transplanting together. The importance of timing for field preparation and transplanting is accentuated with the customary declaration of *Din Bar*, an auspicious day for initiating field operations along with transplanting.

3.4 Field Preparation and Social Co-ordination

PSI's SRI training manual (PSI, 2008), stressed the importance of thorough field preparation. Precise levelling was recommended to facilitate both field marking and the application of intermittent irrigation, known as alternate wetting and drying (AWD). Proper levelling facilitates field marking because it prevents water accumulation in lower spots, which submerges the marks and makes them invisible. Additionally, removal of crop residues from the previous season was recommended to allow smooth operation of the marker and, later on, the weeders.As simple as these additional tasks may seem, this entailed a much more extensive reconfiguration of the operations involved in field preparation.

Rearranging Water and Bullocks for Field Preparation

The initial trials with SRI revealed that transplanting of young seedlings from RBNs had to be undertaken earlier than the normal time otherwise the crop matured late (Table 3.2). This entailed advancing field preparation activities to the period between the end of May and the beginning of June for SRI plots, especially in higher elevations (such as Dakhwangaon). This meant that field preparation for SRI fields had to be done earlier, during a time when farming operations were being carried out on rainfed, non-rice fields. Timely, early access to water and bullocks thus became a critical point of difficulty for field preparation under SRI.

Table 3.2: Synchronised Transplanting vs Synchronised Harvesting

		May				June				July				August				Septem-ber				Octo-ber		
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
Syn-chronized Trans-planting	S/B		N						T										H					
	SRI						N		T														H	
Syn-chronized Harvesting	S/B		N						T										H					
	SRI		N		T														H					

S/B: Transplanted from *Saindha/Bina/Bijwad* N: Nursery; T: Transplanting; H: Harvesting

Additional levelling under SRI required bullocks to work in each plot for a longer time. In the three villages no additional efforts were made in levelling SRI plots because of limited availability of bullocks, particularly in Phalenda and Thayeli. Nevertheless, fields were reasonably well levelled. Out of forty randomly checked SRI plots, 15 had standing water at lower spots, where transplanting marks became invisible (Figure 3.4).

Figure 3.4: Water Puddles in a Cross-Market Plot

Farmers in Dakhwangaon could not arrange water at an earlier date than normal, which impeded early field preparation under SRI. In Phalenda and Thayeli water availability was not a constraint, but bullocks were scarce. In Phalenda there were 32 pairs of bullocks, one for every four households and in Thayeli three, one for every six households. The VLRP appointed by MVDA to support SRI farmers in Phalenda commented "Limited number of bullocks has limited area coverage under SRI" [Personal interview, Phalenda, 15 July, 2011]. In Phalenda ploughing teams were still busy preparing rain-fed fields (42 per cent of cultivated lands) in the higher areas, located about half an hour's walking distance from the irrigated plots. Fields in Thayeli were closer together, and more fields were put under SRI there than in Phalenda and Dakhwangaon, despite the fact that bullock availability was proportionately lowest in Thayeli.

Challenges in Field Marking: Dependency on VLRP becomes a bottleneck

As noted above, marking in SRI plots was best done in muddy conditions. Soil conditions appeared quite critical to the performance of the field marking task and there were ramifications for the pattern of transplanting across the three village communities. Fields with clayey soils easily became hard when drying, making transplanting a tough job. If the fields were too dry, the marker had to be pushed rather than pulled, requiring considerably more effort. In Thayeli, higher infiltration rates due to sand and silt levels in the soil meant that marking had to be done quickly (Figure 3.5).

Figure 3.5: Marking quickly-drying sandy soils

But the VLRP of Thayeli was carrying out field marking even in wet plots, to speed up the process, because there were too many plots to be marked and subsequently transplanted in a timely manner.

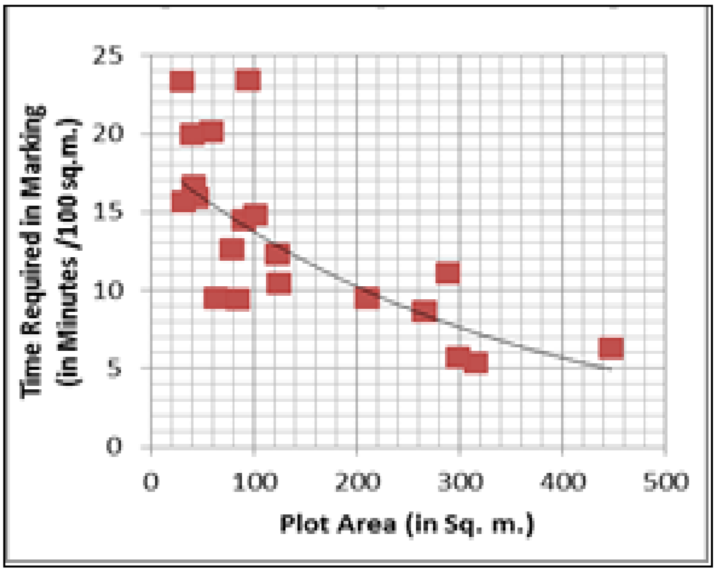


Figure 3.6: Time required for marking 20 randomly selected plots by VLRP, Thayeli

Overall, the original design of the marker did not leave sufficiently distinct marks in the various fields and the tool was modified to improve it. An additional piece of iron rod was welded onto the clamps, resulting in deeper marks. The time required for marking per unit area varied between plots. Much more time was needed for smaller and irregular plots (Figure 3.6). Irregular plots, as in Figure 3.7, require much 'corner work', meaning improvising by using a stick or by pushing a hand or foot over the soil.

Figure 3.7: Marked plots with irregular plot shape

Most farmers were reluctant to mark the fields themselves and relied on the VLRP for this important task. In Phalenda only nine men including the VLRP, and three women had taken up marking on their own plots; in Dakhwangaon only three men and two women including the VLRP had done so. In all situations, farmers took up marking only when the VLRP was not available. We came across several instances where, in spite of VLRPs' efforts to demonstrate marking to interested men and women, the marking was half done by the farmer and had to be completed by the VLRP. On the other hand, the VLRPs were often dissatisfied with the marking carried out by other farmers. Women preferred the VLRP to do the marking because it allowed them to transplant fields one after another with the entire transplanting team.

Marking: A Specialized Skill

Our own attempt to mark plots was an eye opener to the skill required in marking. The marker was supposed to be held by the handle at waist height and pulled while moving forward in the plot; this meant that the engagement of the tines with the soil was actually behind the VLRP during the task. When we (researcher and research assistant) tried operating a marker for the first time, it hardly moved to begin with. The VLRP directed us to hold it at the correct angle and height. He told us that no one had told him so but he had figured out this technique himself, through experience. The next problem was where to begin from. The VLRP again advised that one should start from centre of the plot, which was usually the longest stretch. Each successive strip of marking had to be overlapped with last line of marking from the previous round, which was difficult to do with the operational part behind us. For cross-marking, lines had to be drawn at right angles to previous marking. Defective marking hindered the operation of the mechanical weeder between rows at a later stage. With improper marking there was a risk of cutting tillers while operating the weeder. It was observed that lines under cross marked plots did not always intersect at 90 degrees.

Table 3.3: Workforce for Marking

Village	2011				2012			
	Marked SRI Plots	Marking Done By			Marked SRI Plots	Marking Done By		
		Women/ Children	Men	VLRP		Women/ Children	Men	VLRP
Phalenda	95	3	15	77	95	5	18	72
Thayeli	60	0	0	60	103	5	0	98*
Dakhwangaon	10	1	3	6	11	2	6	3**
TOTAL	**165**	**4 (2%)**	**18 (11%)**	**143 (87%)**	**209**	**12 (6%)**	**24 (11%)**	**173 (83%)**

Source: VLRP Records, 2011 and 2012 * 1 plot by Master Trainer, ** 2 plots by Master Trainer

Four years after SRI was first introduced, farm households mostly depended on VLRPs to carry out marking (Table 3.3). This was generally considered normal, and some farmers saw this as part of the contract with MVDA who paid an honorarium of Rs. 1,000 per month to the VLRP. However, the MT explained:

> VLRPs were just supposed to guide farmers in the use of markers and not mark plots themselves. In most of the villages however, it has now become customary for them [VLRPs] to mark SRI plots. It has become difficult for them to get out of this circle as they also have bonds to maintain within the village. Thus the cycle goes on and on. [Personal interview with MT, MVDA, Doni, 19 November, 2011]

In various instances it was observed that when the VLRP was not available for marking, the farmer decided not to follow any SRI recommendation on that particular field.

A farmer from Phalenda shared:

> Marking of my plots is done by the VLRP himself. In 2010, I wanted to do SRI in all of my plots through cross marking using seedlings from RBNs. The VLRP did cross marking in only two plots, and other two he did one way marking. I even waited for two days for him for my fifth plot. When he did not come, I decided to use seedlings from Saindha and put them on line by eye estimation. Thus ultimately I had SRI in five plots, two cross marked, two one-way marked and one without marking. I wanted to do all plots through cross marking but since marking was to be done by the VLRP it happened according to his will.[Personal discussions, Phalenda, 20 August, 2012]

Reliance on the VLRP in Thayeli

Five farm households of Thayeli had a conflict (on issue related to milk co-operative) with others. In 2011 when women members of these households were subsequently removed from the common SHG, they did not do SRI to show their discontent and eventually asked MVDA to form a separate SHG and provide them with a separate marker and weeder. In 2012, MVDA did so and asked the VLRP (whose family belonged to the other SHG) to undertake marking in the plots of the newly formed SHG. When asked why they did not do SRI in 2011 the women members of SHG replied "We were not sure whether the VLRP would undertake marking in our plots because of the conflict otherwise we wanted to do it. We neither had a separate marker and weeder to undertake SRI on our own." In 2012 all women members of both the SHGs undertook SRI. [Focus Group Discussions, Thayeli, 25 July, 2012]

Other farmers also complained that, in spite of their request for cross marking, the VLRP was only able to do one-way marking because there were many plots to be marked, and some of the plots were too wet to be cross-marked. The VLRPs were seen to prioritise plots belonging to their associates and relatives and influential persons in the village. Other farmers had to compensate him with additional cash payments or food in order to persuade him to do cross marking or to have their plot marked in time. At the same time, the VLRP also put some pressure on farmers with whom he had some affinity to do proper cross-marking. Thus the marking pattern had a lot to do with the VLRP's influence rather than the choice of the farm households owning the plot. A certain level of clientelism emerged around the VLRP.

Re-organizing Labour for Transplanting

Drying fields interrupted the sequential sharing of ploughing teams for field preparation and women's labour for transplanting. To practice SRI as recommended, fields had to be dried to a specific condition: muddy enough to allow smooth transplanting, and dry enough to make the marks visible. The drying period was determined by soil texture and soil moisture conditions. The drying mostly took one or two days, sometimes three when water was seeping through bunds from neighbouring plots. Farm households following SRI typically puddled their plots and left it overnight for water to seep in, so that marking could be undertaken the next day. They even tried reducing the time lapse by avoiding saturated soils but rains, lateral flows, and seepage would still often result in delayed drying. In 2012, in 34 per cent of the randomly checked plots marking could be undertaken after 24 hours (Table 3.4).

Table 3.4: Time Required for Initiating Marking in SRI Plots after Field Preparation

Village / Time Delay	Phalenda	Thayeli	Dakhwangaon	Total
≤ 24 hours	11	14	8	33 (66%)
25-36 hours	6	5	2	13 (26%)
37-48 hours	2	1	0	3 (06%)
49-60 hours	0	0	0	0 (0%)
≥ 60 hours	1	0	0	1 (2%)
Source: Field Observations of Randomly Selected Plots (n=50), 2012				

Delays in drying and subsequent marking resulted in a higher seedling age than recommended in the PSI guidelines for SRI. A woman from Phalenda who had never done SRI shared:

> I wanted to do it [SRI] at least in one plot, but my husband disallowed as it involved inconvenience. He said that we would have to leave the plot after preparation for today, tomorrow, and maybe day after. So who'll wait till then? Our relatives even offered seedlings but we never used them. [Personal discussions, Phalenda, 20 August, 2012]

Other farmers expressed their unhappiness about waiting overnight or sometimes even for days for puddled plots to dry. Disruptions to the rhythm of operations during field preparation and transplanting were considered a major demerit of SRI. Women undertaking SRI complained about being left behind in transplanting operations as compared to their non-SRI fellow women. They found it inconvenient to reconvene labour groups for transplanting on different days, especially if not all the farm households sharing a bullock pair were practicing SRI.

However, farmers of Phalenda and especially Thayeli who had the benefit of a perennial water supply gradually accepted delays in transplanting or made adjustments. For example, some plots in Phalenda and Thayeli were only half marked because the other half was still under water, and transplanting began in half-marked plots.

Farm households of Dakhwangaon found it more inconvenient to come back to their SRI plots a second time to complete the transplanting process, as their plots were more scattered and located some distance from the housing area. A farmer of Dakhwangaon shared:

Though marking speeds up transplanting [due to reduced seedling density], the plot has to be left to dry. It increases our work because reconvening women for transplanting again is difficult, and that too in dry soil. There should be a way to mark plots in standing water. [Personal discussions, Dakhwangaon, 22 July, 2012]

Farmers reported as well that it was difficult to organize labour at the desirable, early time of transplanting because they were occupied with their un-irrigated plots.

3.5 Spatial and Temporal Variations in Marking: A Socio-Technical Decision

Field observations of SRI plots in 2011 and 2012 showed new and contrasting patterns across farms, villages and even seasons. The predominant form was one-way marking, maintaining only a row-to-row spacing of 25 cm. In some fields transplanting was done by placing seedlings in lines by eye estimation without using a marker (Figure 3.8).

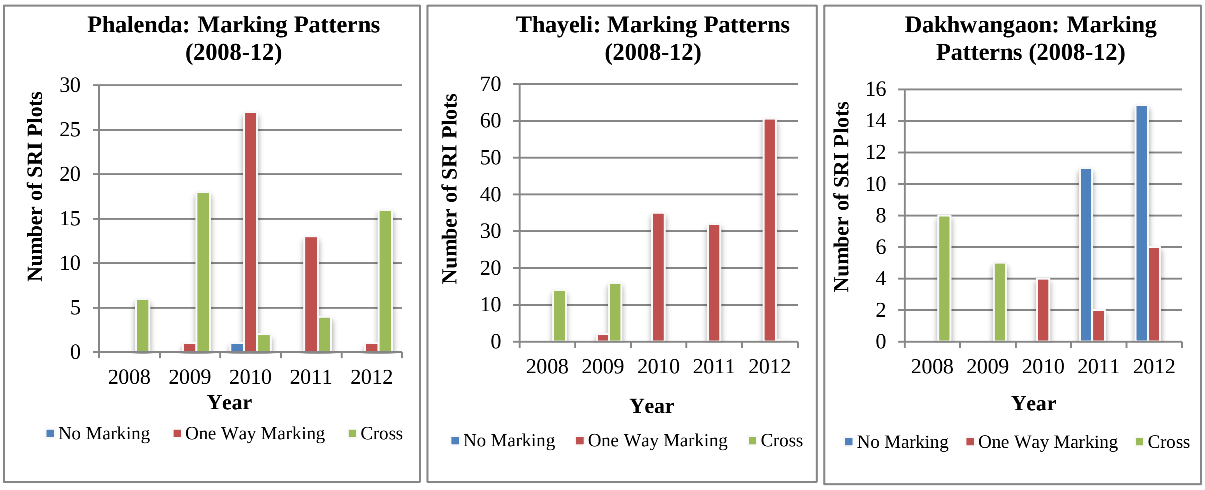


Figure 3.8: Marking Patterns of SRI plots of 30 randomly selected farmers (10 from each village)

Women explained that the initial years of SRI, i.e. 2008 and 2009, taught them that transplanting in cross-marked plots demanded greater attention and care while stepping between squares in marked grids, otherwise the markings would be obliterated or seedlings might even be trampled. During field observations, irregularities in plant spacing were often seen in transplanting, especially that done by elderly women in cross-marked plots. Women also recalled that weed growth in cross-marked plots increased their workload, and iftransplanting was not done properly in cross-marked plots then weeder would subsequently cut the crop.

One-way marking was therefore proposed by farmers as an alternative because it not only reduced the time lapse between field preparation and transplanting, but also one-way transplantation (known as line transplanting) was considered easier. Older farmers complained that grid marking gave fields a ‘barren look’. In one-way marking the plant-to-plant spacing within rows was shorter, resulting in a higher planting density, thereby reducing the need for gap filling in case of seedling mortality. Subsequent use of the weeder in only one direction was also considered easier.

In 2010 an increase in the number of SRI plots created a growing demand on VLRPs for marking and this made them reluctant to undertake the more laborious cross-marking. One farmer of Thayeli remarked:

> In 2008 I was the VLRP of the village. That year when SRI was introduced in our village I did cross marking myself. It took a lot of time. Subsequent cross-weeding also required time. Therefore I shifted to one-way marking from the second year onwards. [Personal discussions, Thayeli, 20 July, 2011]

Based on the feedback from farmers MVDA relaxed the norm of square transplanting from 2010 onwards and advised farmers to do marking in at least one direction. Just like the VLRPs, the MVDA itself had targets to meet as in 2010 it had made its own SRI promotion programme to increase the area under SRI.

The marking patterns developed differently across the three villages, as follows.

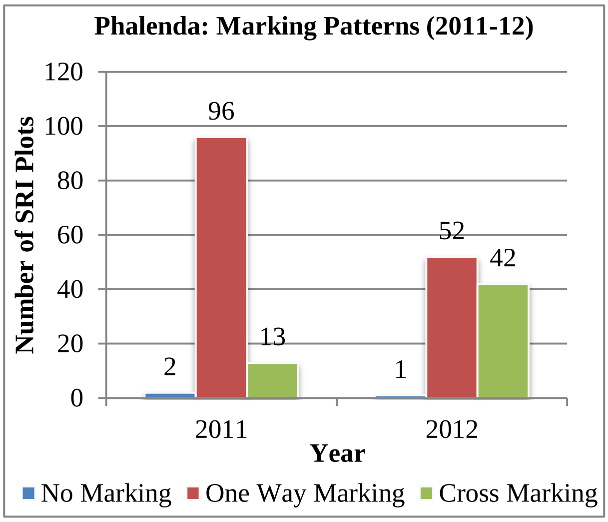


Figure 3.9: Marking Patterns of all SRI plots of Phalenda, VLRP'S Records, 2011 and 2012

Phalenda: Figures 3.9 and 3.10 show that there was an increase in cross-marked plots between 2011 and 2012. In 2011, marking continued to be done primarily by the VLRP through use of a marker in one direction only, with the exception of nine farmers who insisted on cross-marking. These individuals were convinced that additional grain yields resulted from grid transplanting. They did cross-marking in 13 plots and one-way marking in 7 plots. Three of them used the marker themselves,including the VLRP on his own fields. Of the 52 farmers using SRI in line, marking was done in 89 plots and two plots were observed to have approximate line transplanting through eye estimation continued to be done primarily by the VLRP through use of a marker in one direction only, with the exception of nine farmers who insisted on cross-marking. These individuals were convinced that additional grain yields resulted from grid transplanting. They did cross-marking in 13 plots and one-way marking in 7 plots. Three of them used the marker themselves,including the VLRP on his own fields. Of the 52 farmers using SRI in line, marking was done in 89 plots and two plots were observed to have approximate line transplanting through eye estimation.

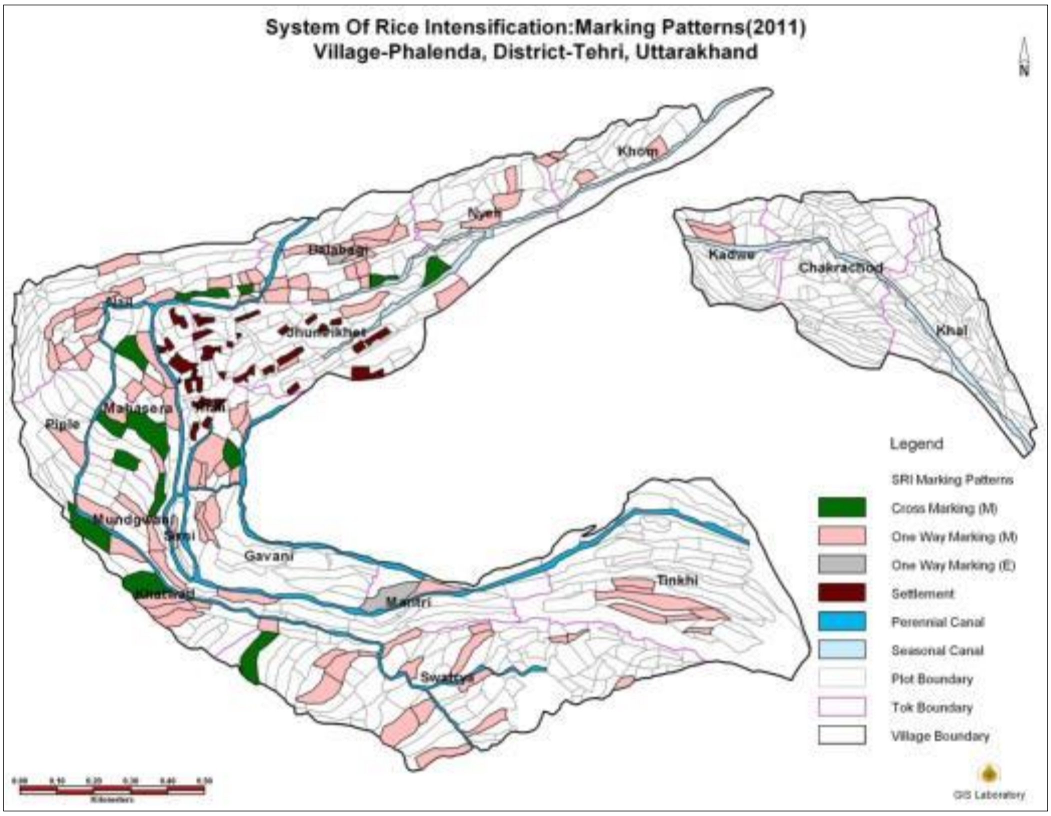
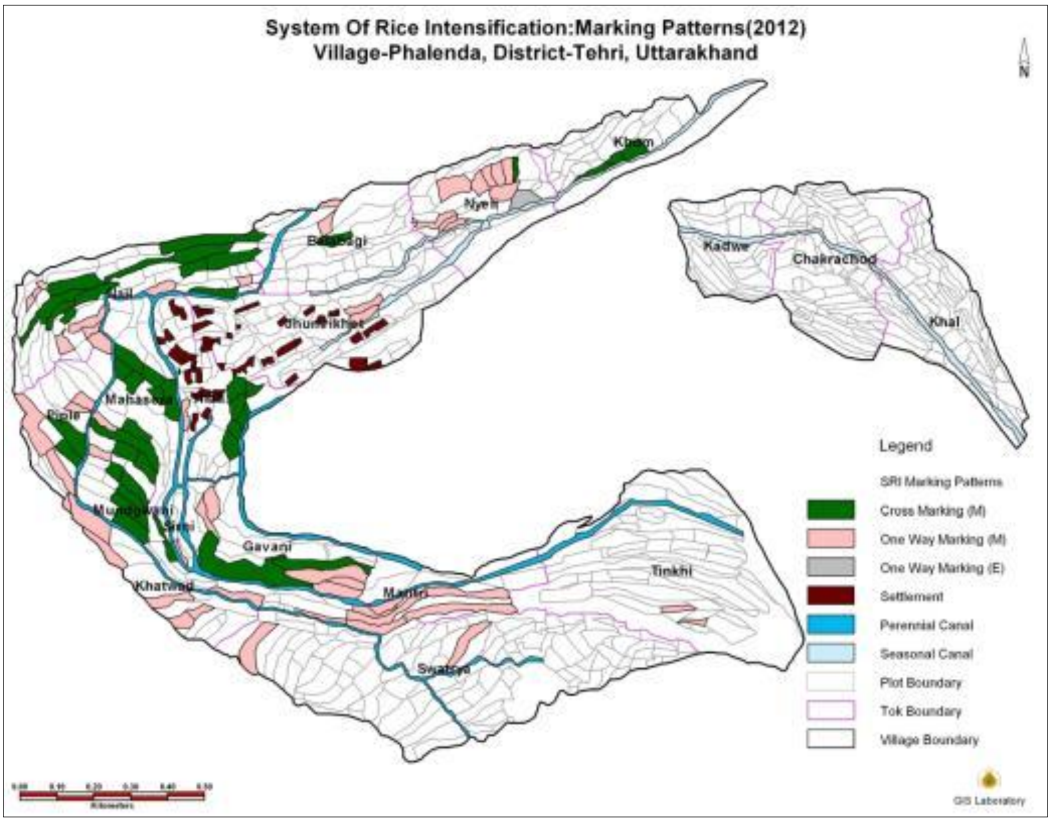


Figure 3.10: Marking Patterns of SRI plots in Phalenda (2011 and 2012)



Farmers of Phalenda said that both in 2010 and 2011 they suffered yield losses as a result of switching to line transplanting from square transplanting. To address this, in 2012 many farm households decided to reduce the number of SRI plots but apply cross marking inthem, thus striking a different balance betweenworkload and grain yield. As many as 22farm households went in for cross marking in 42 plots (six done by themselves and rest done by VLRP) in addition to eight plots that were line marked by five households. On investigation, a farmer explained:

> We saw that cross marking [transforming into grid transplanting] results in more grain yields. We therefore decided to put more efforts in doing one or two cross-marked plots rather than spending our energy on a larger number of plots doing one-way marking. [Personal discussions, Phalenda, 21August 2012]

Another farmer pointed out:

> Cross weeding with the weeder is not possible with one-way marking. Weeds then tend to remain between hills, which have to be removed by hand. It is therefore better to do cross-marking and grid-transplanting to reduce the workload. [Personal discussions, Phalenda, 21August 2012]

Thus, cross-marking increased in the village but at the cost of a greater burden on the VLRP's shoulders.

Thayeli: Data for 2011and 2012 showed very few changes in marking patterns (Figures 3.11 and 3.12). Early availability of water, lower elevation and location of fields favoured application of SRI principles. The number of SRI plots almost doubled in 2012. The VLRP however expressed his inability to carry out cross-marking of such a large number of plots, the more so because of the rapid infiltration of water in the sandy soils.

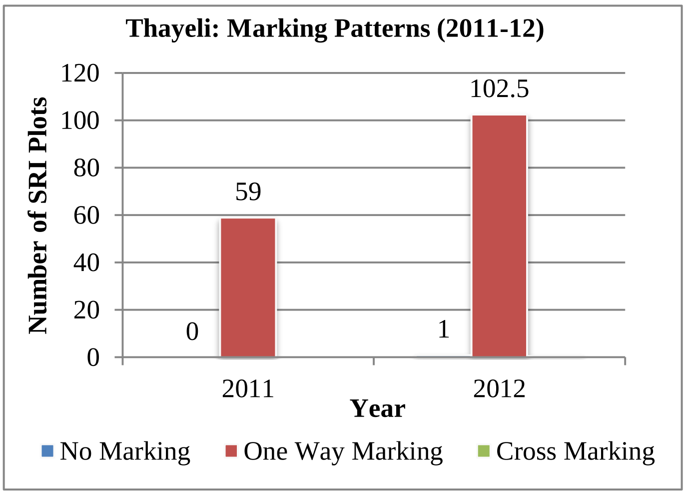


Figure 3.11: Marking Patterns of all SRI plots of Thayeli, VLRP's Records, 2011 and 2012

A farmer from Thayeli remarked:

> Cross-marking not only helps to save seed but also transplanting time if done by experienced women. Cross-marking itself however takes a lot of time, especially when we have so many plots under SRI in the village. [Focus Group Discussions, Thayeli, 15 November, 2012]

> Another woman added that "When we dry the plot for marking, the soil hardens quickly, making transplanting difficult. Cross-marking would further increase the difficulty". [Focus Group Discussions, Thayeli, 15 November, 2012]

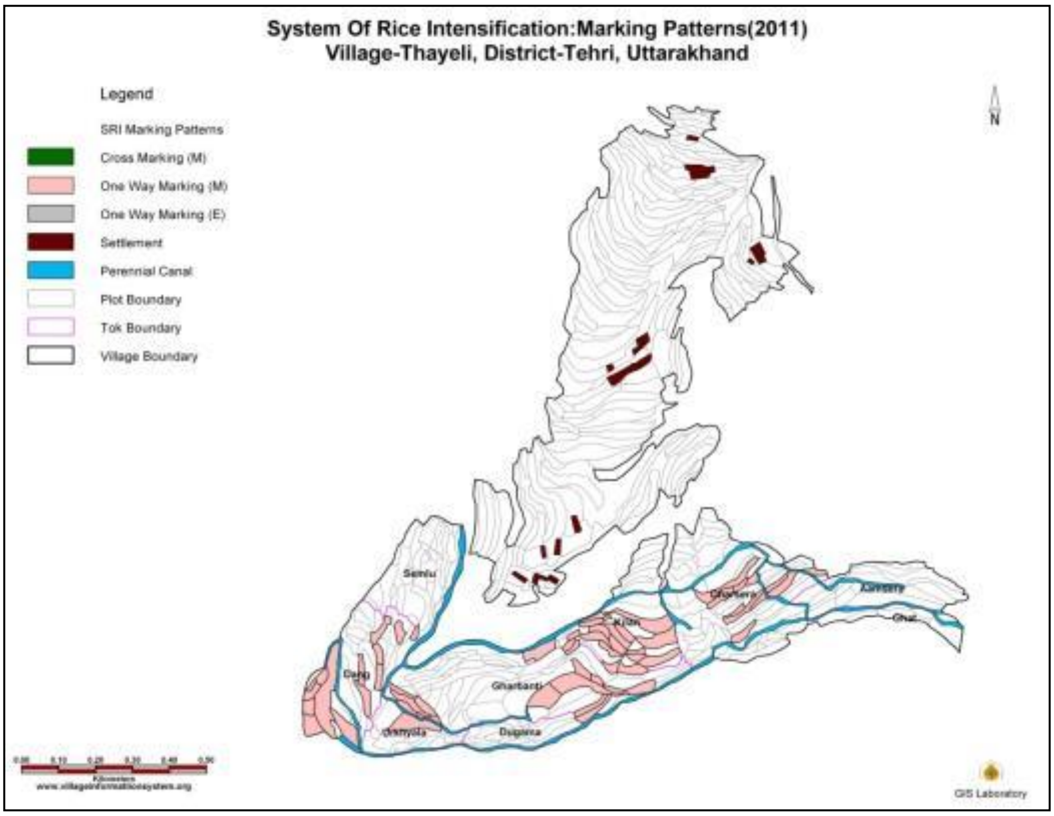
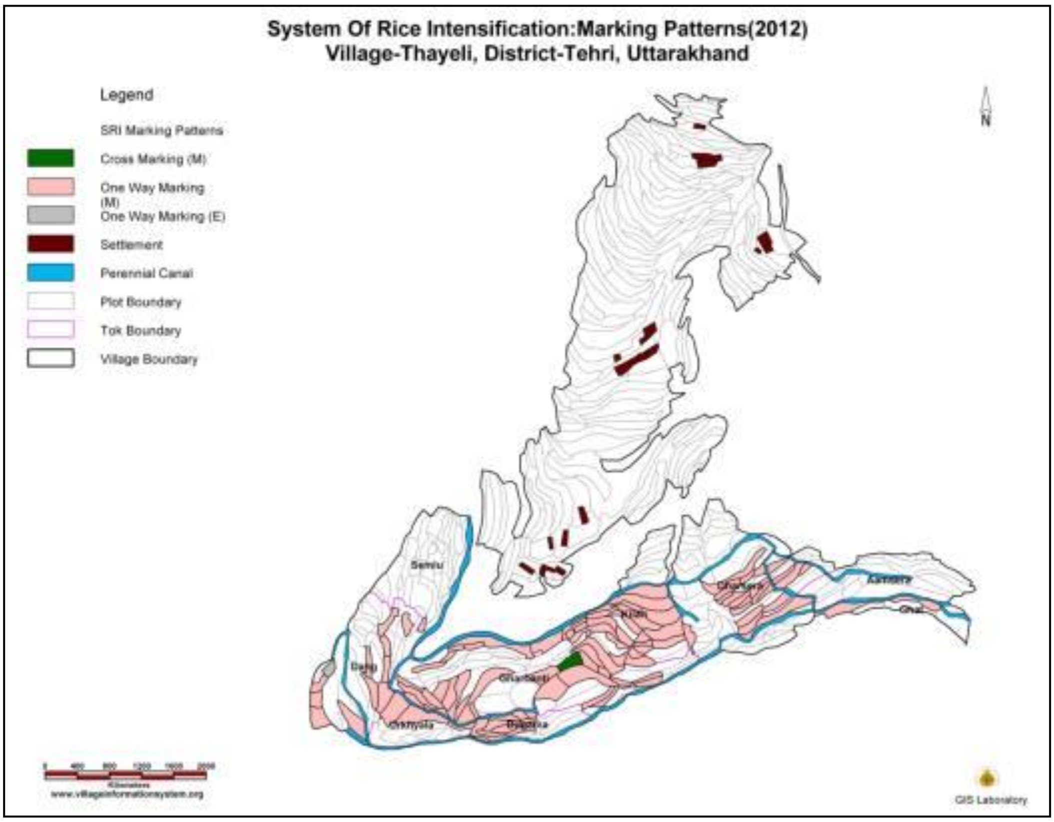


Figure 3.12: Marking Patterns of SRI plots in Thayeli (2011 and 2012)



Consequently the VLRP of Thayeli had a hard time in meeting demand for his marking services. There was one plot in 2012 that was half cross-marked and half one-way marked by the MT, at the request of a farmer who wanted to compare grain yields between line and grid transplanting. She reported that the portion of the plot planted with a grid produced a higher grain yield.

Dakhwangaon: Our data showed no cross-marked plots in 2011 or 2012 (Figures 3.13 and 3.14). The number of plots covered by line marking had also decreased proportionately. The seasonal canals in Dakhwangaon provided water in turns at weekly intervals and therefore farmers did not want to dry plots in preparation for marking, fearing that they would not be able to get water again after transplanting. A farmer commented:

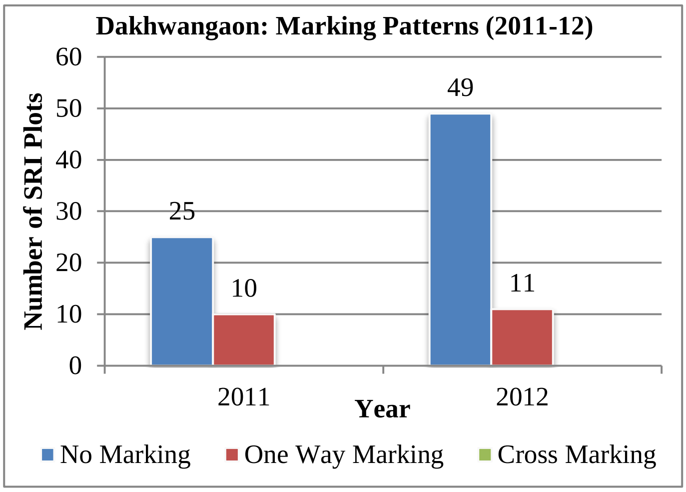


Figure 3.13: Marking Patterns of all SRI plots of Dakhwangaon, VLRP's Records, 2011 and 2012

> We have a shortage of water. Since we get water only once every five to six days, if we dry our plots for marking that will dry the plot too much. It not only increases our work [reorganizing labour and transplanting in dry soil] but the seedlings become vulnerable and the plot also becomes more prone to weed growth and insect attacks. [Personal discussions, Dakhwangaon, 22 July, 2012]

The person who was the VLRP of Dakhwangaon until 2012 marked only her own plots:

> Though cross marking was time consuming I did it in my own plots for 2008 and 2009. My plots had to be dried and I could get water only after six or seven days. Many of the rice seedlings dried up, deprived of water. I had to do lot of gap-filling, repeatedly. I therefore decided to switch over to one-way marking in 2010, thinking that I could reduce gaps by spacing seedlings closely within the lines. In line transplanting, therefore, not many gaps could be seen. I still faced difficulty while transplanting young seedlings in dry hard soil. I had to do it myself along with my daughter because others did not join us. They were busy transplanting their own plots in their own way. Since 2011 therefore I have decided to do away with marking altogether and I am now doing transplanting in lines, through eye estimation only. [Personal interview, Dakhwangaon, 22 July, 2012]

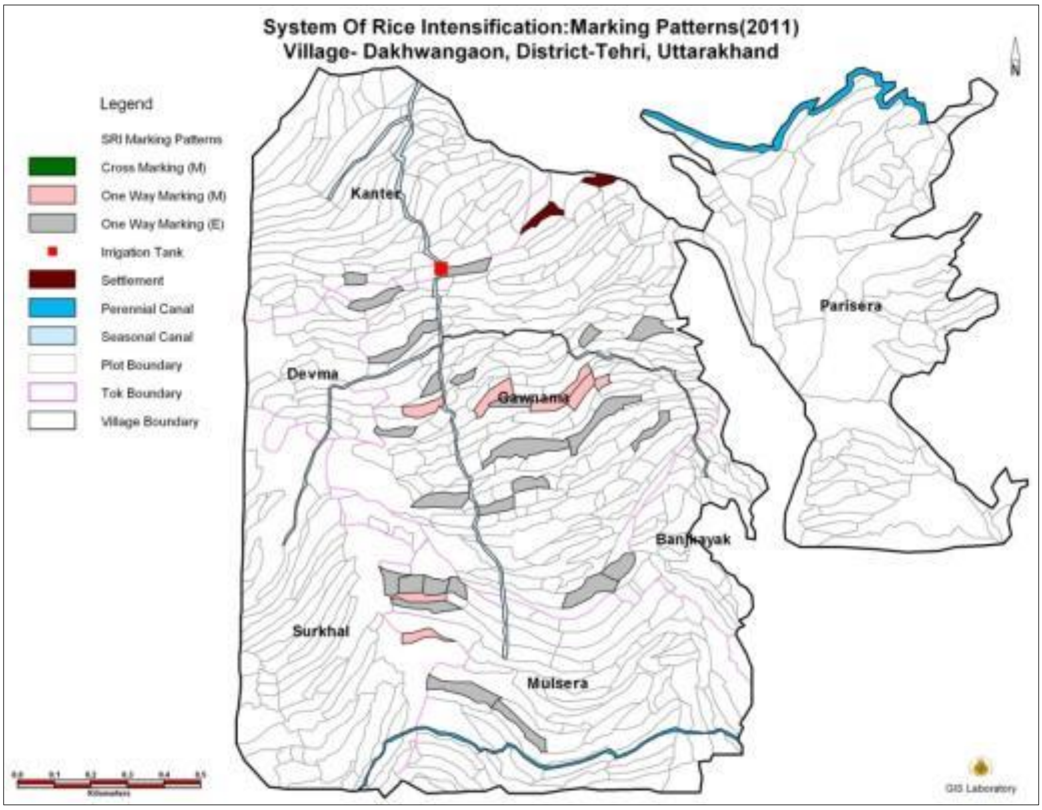
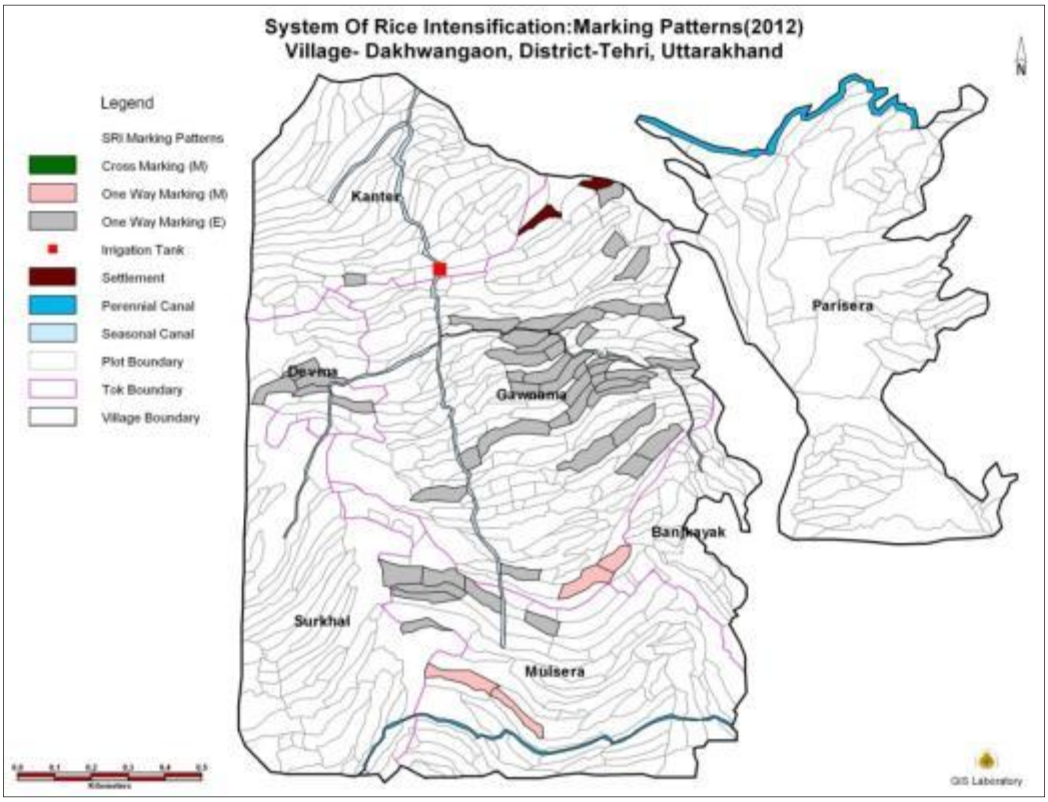


Figure 3.14: Marking Patterns of SRI plots in Dakhwangaon (2011 and 2012)



Most farmers in Dakhwangaon stopped marking from 2010 onwards, preferring transplanting in lines by eye estimation. In this way, transplanting could be completed in a single day because it neither involved drying of plots nor marking. Suspecting underperformance on part of the VLRP, in 2012, MVDA appointed a new VLRP but that did not change the situation and farmers continued transplanting by eye estimation. In 2012, three farm households and the MT marked eleven out of sixty SRI-like plots in one direction only. The exceptional farmers were those who selected plots that were close to irrigation sources and therefore not subject to prolonged water shortages. One such farmer who followed SRI since 2008 shared:

“In the first year, cross marking in our plot was done by the MT. In the second year cross marking was done by us. It took a lot of time. From the third year therefore we are doing one-way marking only”. [Personal discussions, Dakhwangaon, 29 July, 2011].Others preferred plots that were comparatively smaller in size, so that lines drawn by eye estimation could be kept straighter. After four years of SRI there was only one marker present in Dakhwangaon, compared to three or four in the other villages.

3.6 Conclusions, Discussions and Implications

The thorough and timely preparation of a rice plot for transplanting requires complex socio-technical coordination that extends beyond individual plots and farm households. The introduction of SRI required a reconfiguration of various operations, through interactions between farmers, men and women, bullocks and their owners, ploughmen, irrigation canals, fields and rice seedlings. SRI faced farmers with new tasks including additional ploughing, levelling, drying, and field marking. Integration of these tasks implied not just following instructions given by the MVDA but the active reorganisation and rescheduling of these and related tasks through several ‘rehearsals’ over the seasons.

This played out differently in the three villages (see Figure 3.8 and Table 3.5). Within five years after the introduction of SRI, different marking patterns emerged in the villages. The limited uptake of cross marking and the dominance of one-way marking and line transplanting without marking resulted from a range of factors: elevation of the field and proximity to the housing area, water availability, plot size, plot shape, the proportion of irrigated and un-irrigated lands, distribution of water, availability of ploughing teams, connections with the VLRP, and the ability to organize labour for transplanting.

The operation of marking led to a reconfiguration of relationships among the actors performing this task. The most prominent case is the role of the VLRPs. Appointed as farmer-trainers to guide marking, they became the default operators of the marking device. This role change was an effect of the skills they had acquired in marking and the reluctance of farmers to take up marking themselves. Farmers expected the marking to be done by the VLRPs who then had to develop working routines that allowed them to meet the demand.

Table 3.5: Socio-technical Elements influencing Decisions related to Marking

Marking / Decision-Influencing Elements	Grid Marking	Line Marking	Eye Estimation
Landscape			
(Natural Environment)	Lower elevation		Higher elevation
(Built Infrastructure)	Perennial Canals - Reliable and adequate water supply		Seasonal Canals - Unreliable and limited water supply
Farm Household			
(Economic Issues)	Large number of irrigated plots, Good access to farm labour and bullocks	Few/Large number of irrigated plots, Poor/good access to farm labour and bullocks	Very few irrigated plots, Poor access to farm labour and bullocks
(Social Relationships)	Very good relationships with VLRP, ploughmen, and women transplanting groups	Fair relationships with VLRP, ploughmen, and women transplanting groups	Poor relationships with VLRP, ploughmen, and women transplanting groups
Plot			
(Plot Characteristics)	Medium plot size, Regular shaped plot, Head reach, Independent water control, sandy-loam soils	Bigger plot size, Irregular/regular shaped plot, Head/ Tail reach, Dependent/ independent water control, sandy soils	Small/Big plot size, Irregular plot, Head/tail reach, Dependent for water control, wet soils
(Access from hamlet)	Nearer to hamlet	Near/Away from hamelt	Away from hamlet

The case study presented here resonates with observations made by Richards (1986) in Sierra Leone, where Mogbuaman farmers experimented with new practices according to climate, soils and topological variations while also organizing labour, which acted as a major limiting social factor to newly introduced agricultural innovations. The adaptive processes documented in the present study and their interactions with the larger agro-ecological system (including rainfed, non-rice plots and forests) also echoes the way the Ifugaos of Luzon, the Philippines, have shaped and managed their local landscapes of irrigated rice terraces, swiddens and woodlots as a 'composite system' (Conklin, 1980). The complex interactions and mutual dependencies within such composite systems need to be appreciated when seeking to introduce a new set of farming practices to such a setting, because changes to one crop cultivation system may have implications for the wider production system and landscape management practices.

Over successive seasons, we saw an increase in the number of farm households of Phalenda reverting back to cross marking in fewer but quality plots, while continuing with one-way marking in a greater number of plots. The evident goal was to achieve a balance between increasing rice production and other concerns, within the constraints of labour and water availability, while respecting the need for timeliness in SRI operations, being sensitive to the skills required for precise transplanting, and trying to maintain relationships with the VLRP and other members of the community.

The emergence of line transplanting by eye estimation as an alternative practice, especially in Dakhwangaon, can be seen as a product of circumstantial adjustments to accommodate the inability to effectively dry plots for marking. The farmers resorted to eye estimation in response to the competing goals of increasing rice production (through increased spacing) managing uncertainties (in water availability) and maintaining non-rice production (through distributing labour between cropping systems). These adjustments were accomplished over several cropping seasons rather than in a single step, based on abstract logical analysis. We can think of this in technographic terms as a type of 'situated action' (Jansen and Vellema, 2011). The transplanting groups were not directly involved in field marking, yet the activities of marking and transplanting were nevertheless connected through their interaction in a sequence of activities undertaken in the same place, and other over successive seasons or 'rehearsals' of the farming performance they mutually shaped each other.

The observed patterns of marking are the product of collective learning and the experiences of plot owners, VLRPs and even women transplanting groups. Learning occurred across time (between seasons) and, through interactions with other community-members and the landscape, across space. This interaction of social and environmental learning has been conceptualised by Stone (2010) as a process of 'skilling', which underpins the ability of individuals and communities to manage their crops and farming systems.

The present case study of the introduction of SRI to rice farmers in Uttarakhand illustrates the fact that the integration of new technological practices might require several seasons, suggesting a need for ongoing support and facilitation. It also suggests that on-farm experimentation is desirable to guide such integrating processes. In a complex and diverse mountain farming system, incremental or progressive promotion of new practices, especially a relatively complex technology such as SRI, might be more workable and effective than an attempt to change existing practices in one step.

Different methods and tools of field marking have evolved over several decades of SRI practice across different regions, including marking lines with ropes, rods and frames or marking the soil with rakes and rollers (Uphoff, 2007; Thiyagarajan and

Gujja, 2013). The metal rake marker currently available in the case study area does not seem to be practical enough. The readily available alternative option of using a rope with regularly spaced tags on it, which may allow transplanting to be done immediately on completion of land preparation, also needs to be field tested. More generally, studies need to look into how farmers and farm communities respond to different kinds of markers and marking techniques. This study illustrates that a particular type of marker might not be suitable for all types of soils, plot sizes and shapes, and farm conditions.

Adaptations in practices are accompanied by organizational adaptations as well. With the introduction of SRI, farm households have to work out new and different forms of social coordination to ensure timeliness in land preparation (through rearrangements of bullocks and water), effective marking (by building relationships with VLRPs), and labour organisation (by reforming transplanting groups of skilled women). This builds new structural relationships between concerned actors, resulting in changes in the social structure of communities over the seasons. We have already seen how the customary ritual of *Din Bar* was changed to allow for timely availability of water and bullocks (See Chapter 2). We will also see how marking and line transplanting has led to changes in the composition of transplanting teams (See Chapter 5). Here we discuss how field marking has shaped the VLRPs' status within the socio-technical system of SRI in the village communities.

In the study villages, the VLRPs were regarded as indispensable for marking. The marker was regarded as a specialist's tool and the VLRPs who use them were regarded as specialised functionaries in the socio-technical system – as possessors of privileged knowledge and skill, and consequently holders of a certain power and status in the communities. In Phalenda, the status of the VLRP grew to such an extent that he was able to bypass the *panchayat* representatives in order to influence the date of *Din Bar* in consultation with the village priest. This confirms that material objects have both functional and symbolic aspects, structuring relationships within a socio-technical system and shaping the culture that goes with it Pfaffenberger (1988).

Chapter 4

Seeding Socio-Technical Transformations:Raised Bed Nurseries of Rice Farms in Uttarakhand, India

4.1 Introduction

Intensification in Asian wet-rice technology has taken place over many centuries by increasing land and labour productivity through skilful application of various practices (Bray, 1986). Most Asian rice producers are subsistence smallholders, traditionally banking on family labour extended for some labour-intensive operations with exchange labour or wage labour. The mountain farmers of the Himalayan region are smallholders known for growing rice in coordination with other farmers, sharing resources and labour. With increasing economic development and accessibility, off-farm opportunities have opened up for this region. This has resulted in the out-migration of men, leading to a feminization of mountain farming, a decrease of the agricultural workforce and disintegration of mountain farms (ICIMOD, 2010; Hurni, 2013).

Agricultural techniques that women farmers of the Himalayan region can handle and can save time are now being sought (Hoermann et al., 2010). The System of Rice Intensification (SRI), a new way of growing rice, has recently been introduced in the area and offers the potential of 'achieving more with less' – less seed, water and labour – while increasing yields and climate resilience (WBI, 2009). SRI emphasizes improved management of seedlings, water, weeds and fertilizers. SRI thus seems to create an opportunity to further intensify rice farming without additional labour. But SRI's implications, in terms of changes in the application of skills and techniques and the institutions of collective farming in mountain farming systems, is worth investigating. This paper examines the mountain farmers' response to SRI with a special focus on the seedling raising practices.

SRI recommends the use of young and healthy seedlings for transplanting at a much wider spacing than in customary practice, while also avoiding transplanting shock (Stoop, et. al. 2002). It therefore calls for a change in the way seedlings are raised. Henri de Laulanié, the French priest–agronomist who is considered the founding father of SRI, mentioned the use of a 'garden-like' nursery with well-drained soil but did not provide more details about the planting media, seed rate and nursery raising practices (Laulanié, 1993). There are several recognized methods of nursery raising under SRI. Most promoters usually recommend use of a dry-bed nursery, meaning an elevated, level piece of ground also known as a raised bed nursery (RBN). Other alternatives include growing seedlings on foil or mats, banana leaves, plastic trays or bamboo baskets. In various places different planting media for SRI nurseries have been tried out (Uphoff, 2007; NAIP 2012).

Studies on different nursery types usually focus on input use and costs, or assess the growth of seedlings on different planting media under experimental conditions (Baskar, et. al. 2012; Dhananchezhiyan et al., 2013; Haldar, et. al. 2012; Kathiresan and Nazeer, 2012; Lokanadhan, et. al. 2012; Mishra and Salokhe, 2008; Sarwar, et. al. 2011; Veeramani, 2011; Vijayakumar, et. al. 2012). Mishra and Salokhe (2008) in particular compared the effects of moist, drained beds and saturated, flooded beds. They concluded that seedlings grown on drained beds performed significantly better when they are uprooted at an early age. Hence, the raised bed nursery (RBN) is generally considered the most appropriate way for producing young seedlings for SRI. RBNs can produce healthy and robust seedlings within a few days, which can be uprooted before the roots get too deeply anchored or mutually entangled, so that the roots don't get torn and damaged, and the seedlings can be easily separated. All this helps in minimizing transplanting shock and facilitating transplanting of single seedlings as recommended under SRI. In the mountain farms of Uttarakhand, this however implies a fundamental change from existing practices.

There are no studies elaborating on the social implications of introducing RBNs to areas where they haven't been used before in terms of required labour, skill or coordination. Here, we present results of a study on the social implications and how they interact with the technical requirements of RBNs. The results reveal that rice farmers' practices in establishing and managing RBNs diverged from recommended practice. Some farmers refrained from using seedlings from such nurseries. Other farmers, instead of raising their own RBNs, made arrangements with fellow farmers to procure seedlings suitable for SRI. This is a remarkable outcome because farmers traditionally did not share seedlings.

Nursery raising is a socio-technical assemblage involving farmers, soil, seeds, tools and water. A newly introduced artefact such as RBN in rice farming is expected to be perceived differently by diverse farmers, resulting into changes in relationships between the artefact and the concerned social groups, giving rise to multiple alternatives (Bijker et al., 1989).To understand the emergence of diverse social forms and cooperative practice of establishing and managing RBNs, the notion of the task group is introduced, as developed by McFeat (1974). Sigaut (1994) introduces a similar notion, the skill-producing group, and recommends studying the 'structure (what is it made of?)', 'function (what is it for?)' and 'workings (how does it work?') from a combined social and technical perspective. Harringtonn and Fine (2000) further suggest analysis of how such such groups (re)produce institutional structures and rules by exploring perational features of small groups such as recruitment of members, allocation of roles and status, decision making processes, contestations and conflicts resolution, reproduction and metamorphosis. These concepts thus help to recognize and discuss the emergence of task groups and socio-technical changes going on as a consequence of the introduction of RBNs into rice farming.

The study was conducted in three villages, Phalenda, Thayeli and Dakhwangaon situated at different altitudes (900m–2000m) in Bhilangana block of Tehri Garhwal district of Uttarakhand, India. SRI had been introduced in these villages in 2008 by Mount Valley Development Agency (MVDA), a local agency. Field work was conducted over two rice seasons of 2011 and 2012. The choice of different villages and two seasons was made to record and account for spatial and temporal changes, if any, in the seedling-raising practices and processes involved. The multiple case study design yielded in-depth understanding of structure, functioning and workings of nursery/seedling raising task groups in three different settings.

In 2011, Rapid Rural Appraisals were carried out to collect data on different seedling-raising practices and nursery/seedbed establishment routines across the villages. Participant observations of randomly selected nurseries/seedbeds revealed details of tasks undertaken in different nursery forms, composition of work groups, role of various actors, organization of resources and coordination required. Focus Group Discussions with women's self-help groups (SHGs) – since nursery raising activities are primarily done by women – shed further light on farmers' operational choices related to location, plot and cultivation tasks, as well as dynamics of nursery raising. Discussions also revealed changes in the scheduling of RBNs in different villages following the introduction of SRI and why these changes occurred.

Participant observations during training programmes and semi-structured interviews with key informants revealed how the recommended RBN practices were conceived and conveyed by the training agency. Nursery raising records maintained by the promoting agency from 2008 to 2012 revealed the emergence of different types of RBN management practices. The records also indicated changes in the role of intermediaries in RBN-raising activities over the years.

In 2012, records were maintained for all RBNs (n=87) with respect to location, ownership, input use, labour contributions, and practices. Detailed field observations were recorded of all rice nurseries/seedbeds raised by 30 randomly selected farmers (10 from each village practicing SRI). These together with semi-structured interviews further led to understanding of decision making processes relating to composition and practices of nursery management / seedling-raising groups.

4.2 Customary Seedling Production

There is more than one way of producing seedlings for transplanted rice. Farmers can create dedicated nurseries or replant seedlings from thinning direct-seeded fields. These two practices are common in villages in Uttarakhand (Kediyal and Dimri, 2009). Transplanting from nurseries is known as *Bina* in Phalenda and Thayeli, and *Bijwad* in Dakhwangaon. Thinning directly seeded plots, known as *Saindha*, means that irrigated, direct-seeded fields are used as a seedbed for transplanted plots. *Saindha* thus refers to irrigated and direct seeded plots that are also used as a source for seedlings that are transplanted to other fields.Production of seedlings under these two practices involved operations related to seedbed preparation, seeding and post-seeding activities until seedlings were uprooted.

Operational requirements

Plots with fertile soils were preferred for establishing nurseries. *Bina* nurseries were established in locations with limited water availability, where transplanting is delayed until the start of rains (which varies annually). Early and adequate water availability in other locations encouraged direct seeding. However, fields needed to be cleared from the previous harvest, which takes considerable time and therefore most farmers practice *Saindha* to the extent that time and conditions permit and create seedbeds for the remaining fields. For fields located at a higher elevation (> 1000 m), seedbeds were created in fields where mustard or barley, which were grown as a winter crop, had been harvested. Fields transplanted either from *Bina orSaindha* were located close to the seedling source. Seedlings were 30 up to 80 days old, constituting a heavy load to carry over longer distances. Another important factor was access for bullocks. Fields at the end of the ploughing roster, or fields that had been prepared by hoe, were typically put under *Bina*.

Table 4.1: Customary Seedling Producing Practices

Seedling Source / Features & Operations	*Bina* (Nursery)	*Saindha* (Direct Seeded)
Location	Limited access to irrigation	Adequate access to irrigation
Date of Establishment (Uplands)	14 April–30 April	14 April–30 April
Date of Establishment (Lowlands)	25 April–31 May	10 May–31 May
Seed Treatment	No	No
Use of Sprouted Seed	No	Yes
Bed Size (m^2)	7–127 (Average 48)	45–540 (Average 156)
Bed Size : Transplanted Area	1:15 (Average)	1:3.25(Average)
Bed Type and Height	Dry and Roughly Levelled	Wet and Levelled
Manure Use in Bed	Not applied	Applied (in Dakhwangaon only)
Irrigation	Irrigation every 7–10 days	Standing Water
Mulching of Bed	No	No
Weeding of Bed	Once with hoe before uprooting	1–2 times with hand before thinning
Uprooting/Thinning (DAS: Days after Seeding)	30–80 DAS	30–80 DAS
Source: Rapid Rural Appraisal, Field Observations and Focus Group Discussions, 2011-2012		

Farm households start making seedbeds after sowing rain-fed crops like rain-fed rice (*sathi*) and fox millet *(jhangora*). *Bina* nurseries and *Saindha* plots were prepared and seeded ahead of the monsoon, from mid-April till late May (Table 4.1). Dates of establishment varied across and within villages, being earlier at the higher fields of Phalenda and in Dakhwangaon so that the rice crop would mature before temperatures drop at the end of the summer.

In sum, *Bina* and *Saindha* plots were selected based on water access, soil fertility, elevation, distance between seedling source and transplanted field, the winter crop, ploughing schedules and availability of labour. The decision was mostly taken by women as they were responsible for all operations except ploughing. In case of *Saindha,* male members of the household were consulted because they were responsible for ploughing.

Seed Treatment, Bed Preparation and Broadcasting

Older and more experienced women select rice seeds from the previous crop. Several different rice varieties are grown in the villages and allocated to different plots. Overall no seed treatment was applied for *Bina; indeed,* some farmers preferred to use the term *Kurwari Bina*, implying use of un-soaked and un-sprouted seed in these nurseries. For *Saindha,* seeds were pre-germinated by soaking them in water for 12 to 24 hours.

Bina nurseries were established under dry condition either in smaller plots or parts of larger plots. Bed sizes varied depending on the number of plots served. Bed preparation was done primarily by two to three women of the same farm household, using a hand hoe or spade. For larger nurseries other women, mostly relatives, helped. Preparation started with breaking clods, loosening the soil and removing crop residues and weeds, and ended with levelling. Once the bed was prepared, lines were marked, un-sprouted seeds were sown in rows, and then the seeds were covered with soil. No farm yard manure (FYM) was applied in *Bina* as farmers preferred to apply it in the main rice plots prior to transplanting. *Bina* nursery establishment could take 20 minutes up to three hours, on average 60 minutes, depending upon the bed size and the number of women involved.

The group preparing a *Saindha* plot included two to five persons, typically from several different households. After removing or burning crop residues, a first dry ploughing is followed by removal of grasses from bunds, letting water in and a second wet ploughing. After bund repair and levelling, moving over the field two or three times with bullock-drawn wooden plank, women (occasionally a man) broadcasted sprouted seeds. Farmers of Dakhwangaon applied farm-yard manure (FYM) prior to the first ploughing. Field preparation and seeding of *Saindha* took about 2.5 hours, ranging from one up to seven hours. All operations, except ploughing and levelling, were done by women with very few tools. Coordination between households was needed for sharing bullocks, ploughmen and water.

Irrigation, Weed Management and Uprooting

Once seeding was completed in *Bina,* the nursery bed was irrigated intermittently in coordination with other households. Before the onset of monsoon rains, water is scarce and the first irrigation of the seedbeds was done 7–10 days after seeding (DAS) and repeated once a week or every other week, a task performed by both men and women. The seedbed was weeded once with a hoe, usually by one to three women of the household. It took about one to three hours to weed a *Bina* nursery, depending upon its size and the number of workers. Weeding was done about 15 days before seedlings were uprooted for transplanting. In Phalenda and Thayeli seedling age at transplanting was 30 to 45 days, in Dakhwangaon 60 days.

The weeding in *Saindha* plots was a task for women, usually undertaken twice in Phalenda and Thayeli at 10 to 20 day intervals after seeding, and once in Dakhwangaon at about 20 to 40 day intervals. In Dakhwangaon most activities were concentrated in rain-fed (*Sathi*) plots, which far outnumbered irrigated rice plots. Weeding a direct-seeded field means bending over in the flooded fields and raking the muddy soil with the hands until filled with weeds that are then put in piles at the side of the field. It took one to several days for women of a household to do all their fields. Thinning was undertaken 25–45 DAS (on average 31 DAS) in Phalenda and Thayeli as compared to 61–77 DAS (on average 68 DAS) in Dakhwangaon, usually at the onset of rains.

During the same period when *Bina* and *Saindha* plots were established, farm households also prepared plots for sowing *mandwa* (finger millet) and weeded fields where millet and rain-fed rice was grown. The workforce available to individual farm households had to be distributed among different activities and fields. The co-existence of *Bina* and *Saindha* alongside rain-fed (non-rice) plots allows flexibility in rice cultivation operations, allowing farmers to use seedlings of different ages. SRI and its RBNs constituted a third variation in this rice farming repertoire. How was this third option integrated into the local cultivation system?

4.3 Recommended seedbed preparation for SRI

Agronomic studies on rice seedlings show that performance of the young plants in the seedbed can have a significant effect on rice yields (Sarwar et al., 2011; Patra and Haque, 2011). Stoop (2011) and Mishra and Salokhe (2008) stress the importance of aerobic, moist soil conditions for growing seedlings and propose these should be taken up as guidelines for SRI. These parameters impose certain major demands on the way seedlings have to be raised in terms of fertilization, soil moisture regime (irrigation), and seedling density in the seedbed. The local organization responsible for promoting SRI in the three study villages, the Mount Valley Development Agency (MVDA), based its information about RBNs from the People's Science Institute (PSI), the coordinating NGO for SRI in Uttarakhand. PSI itself followed the guidelines of WASSAN (WASSAN, 2006), Secunderabad for practicing SRI. It advocated the use of RBNs for SRI, in particular fertilising the seedbed and using low seeding density. The recommended package of RBN is outlined in Table 4.2.

Table 4.2: Recommended Nursery Raising Practices for RBNs

Features &Operations	Recommended Practices
Location	At corner of main plot or as near as possible
Date of Establishment	No recommendation
Seed Treatment	With Cow Urine
Use of Sprouted Seed	Yes
Bed Size (sq.m.)	50 sq. m. per ha of area transplanted
Bed Size : Transplanted Area	1:200
Bed Type and Height	Moist, 15 cm above soil surface
Seeding Density (seed in gram/sq. m. of nursery area)	100
Manure Use in Nursery Bed	Fine layer of compost on top of Nursery Bed
Irrigation	Sprinkling water on a daily basis
Mulching of Nursery Bed	Recommended up to emergence of shoot
Weeding of Nursery Bed	Not required
Uprooting/Thinning (DAS: Days after Seeding)	8–12 DAS i.e. with emergence of 2–3 leaves

Source: PSI's SRI Training Manual

Location and Timing: TheRBN is preferably located near the main plot, better even in the corner of the field where the seedlings are to be transplanted. One square metre of seedbed would serve for about $200m^2$ transplanted rice. This 1:200 rate is much less than for *Bina* and *Saindha* (see Table 4.1), resulting from the recommended 25 × 25 cm grid pattern of single seedlings in SRI, which amounts to a transplanting density of 16 plants per m^2. The recommendations did not specify the appropriate timing for establishing a RBN with respect to the subsequent growth cycle of the crop and its harvesting time.

Seed Selection and Treatment: Seeds were selected through soaking in salt water and removing floating chaffy seeds. The selected seeds were to be further treated with cow urine for protection from pests and diseases. Selected and treated seeds were to be soaked in water for 24 hours, wrapped in a moist jute bag for 24–48 hours, during which time they were moistened again every 6–12 hours, to achieve pre-germination.

Bed Size and Preparation: A dry seedbed one metre wide would allow access to all plants from both sides. The length depends on the size of the field for which the seedlings are being prepared. The bed should be raised 15 cm above ground level. A spade and hoe are used to loosen the soil, break clods, remove stubbles and stones, raise the soil surface and cover it with a layer of fine compost. A loose soil structure makes it easier to remove the young seedlings for transplanting.

Seeding Density and Broadcasting: Seeds were to be sown before the root sprouts entangled. The recommended seeding density is 100 grams per square metre, resulting in a seed ratio of 5 kg per hectare of transplanted rice. The sprouted seeds were to be thinly broadcasted over the bed and covered with a fine layer of soil.

Watering and Weed Management: Seedbeds have to be watered on a daily basis. Water was to be gently sprinkled over the bed or could be admitted into a channel surrounding the bed. No weeding was required, as seedlings were to be uprooted within 12 days.

Protection and Uprooting: Initially the nursery was to be protected from direct sunshine, birds and heavy rains by dry paddy straw mulch which was to be removed once the leaves emerged. Seedlings were to be uprooted at the two-leaf stage (about 8–12 days old) together with their intact seeds and transplanted preferably within 30 minutes.

These recommendations were introduced to the villages in 2008 by the MVDA. MVDA's staff having farming background as Master Trainers (MTs) selected interested farmers as Village Level Resource Persons (VLRPs) to mobilize and guide fellow farmers to take up SRI. The Master Trainers also approached women in the study villages through established self-help groups (SHGs). The VLRPs recollected that in the early years, the training programme lasted for two days. In these training programmes, a PSI staff member explained the principles of SRI. The new concept of RBN was also briefed about as an integral part of the method, and the process of seed selection and treatment was demonstrated in the training session. Subsequently, the MTs and VLRPs guided interested women to establish RBNs in the fields. Monitoring and follow-up support was done by the VLRPs. The VLRPs also assisted other women in establishing additional RBNs in the villages. From 2010, the MVDA promoted SRI without direct support from PSI.

During the 2011–2012 period, the observed training sessions hardly covered RBNs. The MTs explained that over the years the women became skilled in establishing RBNs and became less dependent on the VLRPs for establishing RBNs. In case someone needed help, this was given by other farmers. Notebooks maintained by the VLRPs about their daily field activities during the rice season confirmed the decreasing role of MTs and VLRPs in RBNs (Figure 4.1). For example in 2012 the VLRPs were present during bed preparation in only 48 out of the 87 RBNs (55 per cent) and contributed actively in only eight nurseries. The role

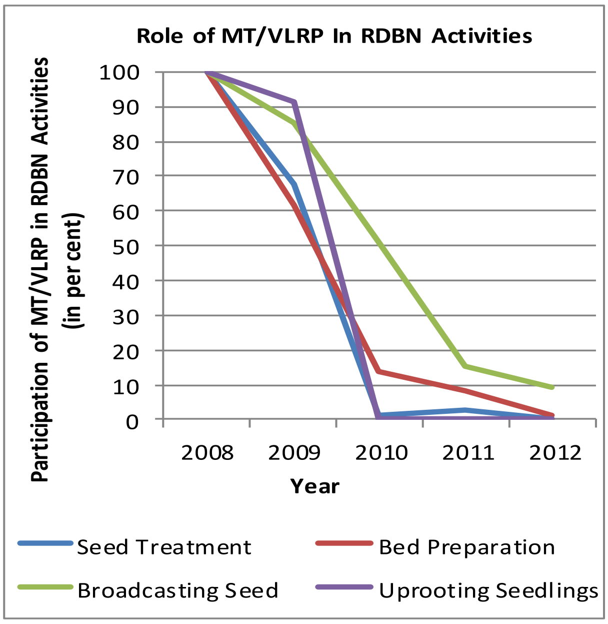


Figure 4.1: Role of MT/VLRP in RBN Activities
Source: VLRP Records of RBNs 2008-2012

of MT and VLRPs with regard to RBNs had changed from that of an instructor to facilitator and supervisor.

4.4 Readjusting Seedling Production

After four years of working with RBNs farmers used seedlings from different sources and locations. Out of the 30 randomly selected farm households only nine households were depending exclusively on RBNs. All other farmers using RBNs also used seedlings from *Bina* and *Saindha.* Table 4.3 shows that farmers from Dakhwangaon hardly used RBNs whereas most farmers using RBNs were in Thayeli. Out of the 14 farmers practising RBNs, 5 farmers preferred to have the nurseries in someone else's plot. Why did these differences emerge?

Table 4.3: Village wise Proportion of Farmers Accessing Different Seedling Sources (30 Farmers)

Village / Seedling Source	Phalenda		Thayeli		Dakhwangaon		Total	
	Number of Farmers	Number of Nurseries	Number of Farmers	Number of Nurseries	Number of Farmers	Number of Nurseries	Number of Farmers	Number of Nurseries
Bina	4	5	1	1	6	6	11	12
Saindha	6	10	2	4	10	23	18	37
RBN (on own plot)	3	6	5	12	1	1	9	19
RBN (on Other's plot)	2	6	3	6	0	0	5	12
Total	**10**	**27**	**10**	**23**	**10**	**30**	**30**	**80**

Note: Farmers are getting their seedlings from multiple sources
Source: Field observations of 10 randomly selected farm households from each village, 2012

Women shared that RBNs were very convenient, requiring less space, seed, water and hardly any weeding and transport of young seedlings was easy. However, RBNs had to be established relatively early at a time they were busy in un-irrigated plots and water availability was limited (see below). It also required some experience and skill before one could prepare the RBN properly and broadcast the seeds thinly. Once established, RBNs had to be attended regularly for timely removal of mulch and watering.

Rescheduling and Relocating RBNs

In 2008, many SRI plots transplanted with young seedlings from RBNs were established late in the season; especially at higher elevations this caused late ripening or even non-ripening of grains. Therefore RBN preparation and seeding had to be advanced, to allow timely ripening of the crop (See Chapter 3). Farm households in Thayeli and Phalenda, having access to water and labour for early transplanting, decided to establish the new nurseries earlier so that the SRI crop could mature along with crops transplanted from *Saindha* and *Bina* (Table 4.4). Access to water was a pre-requisite for early transplanting. Farm households, not owning bullocks, also had to negotiate with the ploughman for early transplanting, as bullocks were occupied at that time in preparing the rain-fed fields.

Table 4.4: Rescheduling of the dates of establishing RBNs

Village / Rice season	Phalenda (900 m-1200 m msl)	Thayeli (950 m-1100m msl)	Dakhwangaon (1300 m – 2000 m msl)
RBN under SRI(2008)	5 June – 9 June	22 May - 25 May	23 June – 30 June
RBN under SRI(2009-2012)	14 May – 25 May	12 May – 22 May	4 May – 14 May*
Source: Focus Group Discussions, 2012 msl: above mean sea level * Only 3 out of 60 farmers			

In Dakhwangaon temperatures are lower than in the other two villages and the majority of fields are un-irrigated. Only three out of 60 farm households had access to water and could establish RBNs in early May, implying transplanting by the end of May, much ahead of transplanting from *Saindha.* These three households raised one RBN each on their own plots while others preferred to use older seedlings from *Saindha* and *Bina*, whiletaking advantage of the low planting density recommended for SRI. For most farmers, establishing early RBNs would be futile because early transplanting was not possible without early water. Farmers here also preferred working in un-irrigated plots (sowing finger millet and weeding *sathi* and fox millet) instead of establishing RBNs at that time. In Phalenda, some farmers, who were unable to establish RBNs earlier, selected relatively early growing varieties such as *Barik Boniya* and *Barik Anaj* for their RBNs so that the crop could ripen along with other varieties.

Plots for RBNs were selected by taking into account water availability, accessibility from the home, and options for ensuring close monitoring and aftercare. RBNs were preferably located in readily accessible locations so that they could be kept under constant watch by their owners. RBNs required more aftercare compared to *Saindha* and *Bina* because they had to be irrigated regularly, monitored for mulch removal, and protected from birds and stray animals. *Bina* and *Saindha* did not require much attention after being seeded because the larger bed with high seeding density meant that there was a higher tolerance for seedling mortality. Women therefore preferred raising RBNs in plots having access to water and located much closer to their homes. In 2012, 86 per cent of RBNs were found to be located within 20 minutes' reach of nursery plot owner's house (Table 4.5). In Phalenda, farmers whose irrigated plots were located far away from their homes had no choice other than to rely on neighbours to care for their RBNs once they had been established.

Table 4.5: Walking distance of RBNs from owner's house

	Phalenda	Thayeli	Dakhwangaon	Total
Total RBNs	54	30	3	87
Reach from House (in minutes)				
Within 10 minutes	43	11	2	56 (64%)
11-20 minutes	0	19	0	19 (22%)
21-40 minutes	0	0	1*	1 (1%)
41-50 minutes	11*	0	0	11 (13%)
Source: Field Observations of 87 RBNs, 2012 *Nurseries of 4 farmers who could not find suitable location near their home in terms of access to water				

Reorganizing Tasks in RBNs and Customary Practices

RBNs were mostly established by women, just as women were primarily responsible for nursery management in traditional systems. Men's participation occurred in only four out of 87 RBNs. The number of persons involved in bed preparation ranged from one (in 30 per cent of nurseries) to a maximum of three (in 22 per cent of nurseries). Because the nursery area was reduced, women found it quite easy to manage RBNs. They acknowledged that RBNs reduced the burden on their time compared to other methods of growing seedlings. None of the RBNs took more than half an hour (average 16 minutes) to establish.

Field observations of all 87 RBNs in 2012 revealed that in 60 nurseries (about 70 per cent) untreated seeds were used, as it was difficult to get cow urine on time. Cows were not only scarce but also urine collection was considered a tedious task. Women similarly found it easier to use pre-germinated seed saved from *Saindha* for sowing RBNs, instead of going through the process of seed treatment. In 24 nurseries (about 30 per cent), farmers were even observed to use un-sprouted seeds in order to complete all the work in a single day instead of waiting for two to three more days, especially in cases of delayed nursery establishment. These farmers also preferred soaking seeds in water for five or six hours instead of waiting for 24 hours, since they believed that the use of mulch on bed would provide enough warmth and moisture to stimulate germination.

A ranking exercise conducted with 60 women across villages revealed that broadcasting seed and bed preparation were considered as the most skilful operations in RBN raising. The seedbed needed to be properly prepared (in terms of height, compost use and drainage) to enhance seedlings' growth and easy uprooting. Farmers who had not elevated the nursery beds sufficiently (as observed in 10 nurseries) encountered difficulties later as the roots had grown too deep and seedlings got damaged while being uprooted. In 26 nurseries (about 30 per cent), manure was not applied during bed preparation because fine compost was not readily available and past experience showed that use of fresh dung resulted in pest infestation.

Table 4.6: Nurseries with different Seeding Density in RBNs

Village / Seeding Density in RBN	Phalenda	Thayeli	Dakhwangaon	Total
	Number of RBNs			
Up to 100 g/m^2	16	2	1	19 (22%)
101-150 g/m^2	23	5	0	28 (32%)
151- 200 g/m^2	12	10	0	22 (25%)
201- 250 g/m^2	3	8	1	12 (14%)
More than 250 g/m^2	0	5	1	6 (7%)
Total RBNs	**54**	**30**	**3**	**87**
Source: Field Observations of 87RBNs, 2012				

Seeding density in RBNs was found to vary (Table 4.6). Nurseries seeded under the supervision of VLRPs and experienced women were more sparsely seeded than others. In most nurseries (78 per cent), seeding density exceeded the recommended rate of 100 g/m^2. In about 20 per cent of nurseries it was even more than twice the recommendation. Women reported that nurseries were densely seeded intentionally, as they preferred to transplant more than one seedling per hill and also as a contingency for replacing seedlings in case of mortality by root rot or insect damage: surplus seedlings helped when gap filling. Gap filling, if undertaken with a different variety, resulted in the crops ripening at different times, which posed difficulties at harvesting time. Though the seeding density in RBNs was higher than the recommended rate, it was observed that seed used per hectare of area transplanted was less than 10 kg for 54 per cent of these nurseries (the average was 12 kg per ha considering all RBNs), which was much lower than the existing practice of using 80–100 kg seed per hectare under *Bina* and *Saindha* systems. Women were pleased with the greatly reduced seed rate per hectare under SRI.

Mulching was invariably practiced in RBNs. In the absence of paddy straw, leafy branches of local trees were used as an alternative. For irrigation, women preferred to fill the channel around nursery beds with sufficient water for two or three days, which eliminated the need to irrigate on a daily basis. Since the nursery-raising period was short, women did not have to undertake weeding, which was required in the cases of *Bina* and *Saindha*. A little cleaning-up work was required two to four days after the removal of the mulch. Weeding was undertaken in RBNs only when uprooting was delayed beyond 14 days (in 2012 one such weeding was undertaken in 20 nurseries, i.e. in 23 per cent of the total).

A spillover effect of RBNs was observed in *Saindha* plots and *Bina* nurseries, especially in Phalenda and Thayeli. Women in all three villages confirmed that with introduction of SRI they had started transplanting seedlings from *Saindha* and *Bina* at a much wider spacing than before, which resulted in broadcasting seeds sparsely in *Saindha* and lowering the nursery seeding density in *Bina*. Seeding density in *Saindha* among farmers practicing SRI was found to be 30 per cent less than those who were not doing SRI. A few women in Phalenda and Thayeli were observed dividing *Bina* nurseries into multiple smaller, slightly raised beds but without using compost and broadcasting untreated, unsprouted seeds. The beds were irrigated every two to three days. When bullocks became available, seedlings were uprooted and transplanted far ahead of the customary practice. Weeding was undertaken if required.

Raising multiple RBNs individually or jointly

The area of RBNs established in 2012 ranged from 1 to 10 m^2 (average 3.6 m^2) as compared to 7–127 m^2 (average 48 m^2) under *Bina* and 45–540 m^2 (average 156 m^2) under *Saindha* (Table 4.1). The smaller size of RBNs prompted farm households to establish multiple nurseries on the same plot. Over several years the proportion of multiple RBNs outnumbered single RBNs raised on a single plot (Table 4.7). In 2012, only 26 plots were used to raise 87 RBNs, of which only eight plots had single nurseries whereas in rest as many as 79 nurseries of 34 farmers were raised. Farm households doing SRI in different locations could now situate their RBNs in a single plot instead of spreading them over several sites. This meant that less effort was required for the necessary aftercare, while transport of the lightweight bundles of young seedlings, even to distant plots, did not present much difficulty. Seedlings of several different rice varieties could be grown in multiple RBNs in a single plot.

Table 4.7: Expansion of multiple RBNs (2008–2012)

	2008	2009	2010	2011	2012
Plots under RBNs	11	24	38	27	26
Total number of RBNs	17	34	100	71	87
Number of plots with single RBNs	6	16	7	4	8
Number of plots with multiple RBNs	5	8	31	23	18
Number of multiple RBNs	11	18	93	67	79
Source: MVDA's Records of RBNs, 2008-2012					

Women decided upon the number of RBNs to be raised according to the number and size of main plots to be transplanted and the number of different rice varieties to be grown. Farm households generally preferred to raise more RBNs than required, fearing that seedlings might fall short, especially if gap-filling was required in case of seedling mortality after transplanting. Mortality was relatively more common with young seedlings due to uncertainties in water supply and soil conditions, and problems with pests such as water beetles. Surplus seedlings were sometimes distributed to other households after reserving some seedlings for gap filling, which was rarely practised under customary practices.

Table 4.8: Types of multiple RNBs raised on 2012

Strategy / Village	Number of multiple RBNs		Plots under multiple jointly raised RBNs	Jointly raised multiple RBNs belonging to		Farmers taking seedlings from others without raising RBNs
	Individually raised	Jointly raised		Plot owners (PO)	Other farmers (OF)	
Phalenda	26 (7)	24 (14)	5	10 (5)	14 (9)	14
Thayeli	8 (3)	21 (10)	3	7 (3)	14 (7)	2
Dakhwangaon	0 (0)	0 (0)	0	0	0	0
Total	34 (10)	45 (24)	8	17 (8)	28 (16)	16

Source: Field Observations, 2012 () Number of Farmers

Interestingly, multiple RBNs established in a single plot did not belong only to the plot owner. Farmers often came together to jointly raise RBNs in a common plot. In 2012, out of the 79 multiple RBNs there were 45 jointly raised nurseries established in 8 plots, of which only 17 belonged to the plot owners; the remainder belonged to 16 other farmers (Table 4.8). Women explained that individual farm households often felt constrained while selecting a suitable plot for an RBN and/or were too busy attending to their un-irrigated plots to provide aftercare to an established RBN. This encouraged them to join forces with other households to establish multiple RBNs in a common plot at a suitable location and share responsibilities for aftercare. The emergence of jointly raised multiple RBNs fitted with the tradition of collective transplanting operations.

Task groups were formed for jointly raising RBNs based on a variety of considerations, including the location, kinship, group affinity, and past experiences of transplanting jointly. Farmers of the same sub-caste, especially those belonging to the same SHGs, favoured raising nurseries together. In 2012, out of 24 women who came together to raise 45 RBNs in eight plots, 19 (79 per cent) were members of SHGs, whereas five did not belong to an SHG. The possibility of raising RBNs jointly in a common plot also helped individual households to cope with contingencies (e.g. if someone was ill or away). In such situations, task group formation might be spontaneous, but with due consideration to relationships and trust. First timers were always allowed to join others for raising RBNs, depending upon affinities.

Women raising multiple nurseries on a common plot usually preferred to select a plot located near an irrigation channel. Since the RBN plots also had to be transplanted subsequently, smaller plots were preferred within a suitable location, which could easily be prepared later by hand using a hoe or spade rather than a bullock pair. Otherwise, bullocks brought in for field preparation at a later stage could potentially damage plots that had already been transplanted.

In 2012, fifty multiple RBNs were established in Phalenda by 21 out of the 113 farm households (19 per cent). Seven of these households established 26 RBNs individually on their own plots while 14 households jointly raised 24 RBNs in five plots. The seven farmers who preferred raising multiple RBNs independently had fewer social affiliations and wanted to do transplanting at their own convenience, avoiding possible conflicts relating to nursery removal and work distribution with others. In Thayeli, the pattern was quite similar. As many as 29 multiple RBNs were raised by 13 out of the 18 farm households (83 per cent) in the village. Three households raised eight RBNs individually in their own plots while 10 households preferred to establish 21 RBNs jointly in three plots. In Dakhwangaon there was no demand for seedlings from RBNs because it was impossible to transplant early, therefore there was no scope for jointly raising multiple RBNs.

Fourteen households in Phalenda and two in Thayeli obtained surplus seedlings at transplanting time from RBNs belonging to other households. These were households that could not establish RBNs on time (due to pre-occupation with other activities at nursery-raising time or not having suitable sites to establish nurseries). Nursery owners gave seedlings to others based on kinship, by prior arrangement, or on a first-come, first-served basis.

Sharing and Negotiating Around RBNs

Women managing multiple RBNs often established them on a common plot, shared seed and compost, and joined forces for seed treatment, bed preparation, seeding, removal of mulch, and irrigation (Figure 4.2 and Table 4.9). Sharing of resources and labour was observed in six out of the eight common plots, mainly in Phalenda, where multiple RBNs were jointly raised in 2012. Since the seed requirement for RBNs was small, plot owners did not mind sharing seed with others. Compost was less readily available and as a scarce resource was shared among nursery growers for bed preparation.

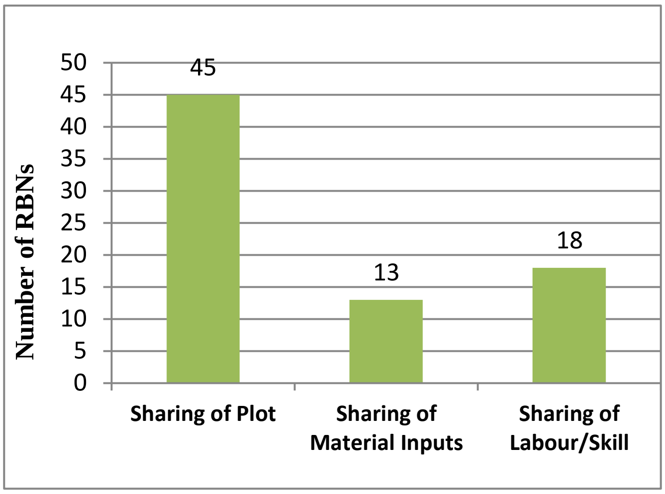


Figure 4.2: Sharing of Input/Skill in Jointly Raised RBNs
Source: Field Observation of RBNs 2012

Farmers who lacked the time to raise an RBN themselves might provide seeds to others to establish an RBN on their behalf. A woman of Phalenda stated:

> I am the only working woman in my family. We have more unirrigated plots than irrigated plots. During that time I am too busy in the unirrigated plots to raise a nursery. I do not even know how to raise a nursery. Therefore I just prefer giving seed to another farmer to raise my nursery. I don't have to do any work in the nursery. [Personal Discussions, Phalenda, 31 August, 2012]

Women did not mind raising nurseries for others, since it did not involve much time or effort. They would be repaid with labour in return. Members of jointly raised RBNs were also found to be sharing bullocks for land preparation, exchanging labour for transplanting, and drawing seedlings from one another's RBNs in case of a shortfall.

In jointly raised RBNs, more skilled operations, such as bed preparation and broadcasting, were assigned to those members considered to be more experienced and efficient. Even in individually raised RBNs, less experienced farmers and beginners invited some of the more experienced women to help out in sprinkling sprouted seeds on the beds, as seeds were to be sufficiently spaced for good seedling growth. Beginners acknowledged that jointly raised RBNs gave them an opportunity to learn the skills of nursery raising through practicing under supervision of other experienced women. Tasks such as irrigation, weeding (if required), and uprooting of seedlings were distributed among members of the task groups.

Table 4.9: Jointly Established RBNs reporting Sharing of Material Inputs and Work

Village	Total Number of Joint RBNs	Number of Joint RBNs reporting sharing of							Nursery Plots with Shared Work
		Seed	Compost	Seed Treat-ment	Bed Prepa-ration	Seed-ing	Removal of Mulch	Irrig-ation	
Phalenda	24	3	7	5	4	5*	9	11	5/5
Thayeli	21	0	3	2	0	2	6	6	1/3
Total	45	3	10	7	4	7	15	17	6/8

Figures represent number of nurseries in which sharing of inputs was reported
Source: Field Observation of RBNs, 2012.
*In addition, VLRP undertook seeding for 8 RBNs in two plots

In Phalenda, sharing of work was observed in all the five plots where RBNs were raised (Table 4.9). Here, 42 per cent of agricultural lands were un-irrigated, located on higher slopes away from the irrigated lower fields. During the desirable time for RBN establishment, women were busy in these higher plots. The women establishing RBNs made seedbeds for others or took care of the seedbeds belonging to women who were working in the upper fields. Turn-taking in seedbed management was frequently reported.

In Thayeli, joint seedbed preparation was less common. With irrigated plots close to compounds and few rain-fed fields (27 per cent), most farmers were able to establish an RBN on their own. The only plot where work sharing was observed was managed by a group of six women, two of whom had three to four years of experience in raising RBNs, who in turn mobilized four other women who had not done SRI before.

The joint preparation of multiple RBNs on one plot created some minor tensions among farmers. One issue was that plots used for RBNs also had to be transplanted once the nurseries had been uprooted. The common nursery plot might be subject to a delay in transplanting compared to plots hosting individual RBNs. Plot owners had concerns about delays in transplanting while waiting for others to uproot their individual nurseries. Moreover, fertile topsoil was removed along with the seedlings and carried to other farmers' plots; and there was a risk of mixing different varieties through seeds left behind in the nursery plot. These adventitious seeds could grow and ripen at a different time from the variety transplanted into the nursery plot, creating difficulties at harvesting time.

To overcome these problems, some plot owners even used *Saindha* seedlings instead of RBN seedlings, to overcome a delay in transplanting. Plot owners often requested nursery groups to grow the same varieties as their own, and to remove the soil from the roots of seedlings when they were uprooted from the nursery. Our discussions with nursery owners of jointly raised RBNs also revealed grudges about inequity in work distribution among the farmers. However, no public incidents or openly played-out conflicts were observed. In the words of one of the farmers, who regularly offered her plot to others for raising nurseries: "There are always conflicts and tensions within our own families.For us social bonds have more value than few days' delay of transplanting or other such trifling matters" [Focus Group Discussions, Phalenda, 17 September, 2012]. Another woman stated "The village is like a family. We have to support each other. We cannot say no to a person who doesn't have a suitable plot for raising a nursery. One has to face certain losses if one expects to get benefits from others" [Focus Group Discussions, Phalenda, 17 September, 2012].

Farmers' experiences and learning around RBNs helped them in rescheduling nursery establishment dates, relocating nurseries at suitable locations, establishing multiple and joint nurseries in common plots, reorganizing and negotiating nursery raising tasks, while making adaptations in other nursery forms as well. Farm households now have the options of (1) raising single or multiple RBNs individually, (2) raising single or multiple RBNs jointly with others, (3) obtaining seedlings from owners of RBNs during transplanting, or (4) undertaking early transplanting from *Saindha* plots and *Bina* nurseries, without establishing RBNs.

The MT of MVDA recorded that, with the introduction of SRI, the number of plots covered through transplanting from *Saindha* and *Bina* had decreased, both in Phalenda and Thayeli. In Dakhwangaon, RBNs were hardly used. In the former two villages, farm households not having bullocks were especially likely to use RBNs and abandon transplanting from *Saindha*. The latter practice required ploughing of the broadcasted field and later the transplanted field. The manual preparation of RBNs saved a round of ploughing and also saved costs. By 2012, most farmers of Thayeli had entirely replaced transplanting from *Saindha* to transplanting from RBNs. The remaining *Saindha* plots were used for gap filling in SRI plots, when required.

4.5 Conclusions, Discussions and Implications

The study explored the socio-technical transformations that took place around the raising of rice seedlings in nurseries with the introduction of SRI in three villages characterized by different agro-ecological settings. The existing transplanting practices in the villages allowed much flexibility to use seedlings of different ages, ranging from 30 to 80 days old, from different sources. It provides the women flexibility in establishing rice nurseries or seed beds within a given time frame according to the availability of water, labour and ploughing teams. The flexibility also applies to the diversity of fields, created by elevation differences, and therewith fluctuations in temperature, and irrigation infrastructure. Task groups around *Bina* and *Saindha* largely consisted of members of the same farm household. The composition and size of the task group itself was flexible as the subsequent activities, from creating the bed up to the stage of uprooting of seedlings, involved different numbers of women.

With the advent of SRI, farmers began to experiment with an additional form of seedling production, the RBN. This new source of seedlings in a sense restricts the flexibility in seedling age, because SRI calls for young seedlings. The young seedling age implies that RBN requires a net saving of time for seedbed management. The RBN, however, requires different set of material and labour inputs, triggering off processes of organisational and operational changes in nursery raising task groups as well as adaptations in the recommended package and customary practices. The elevations of fields, water availability in canals and overall cropping pattern primarily influence the possibility of effectively establishing RBNs at the village landscape level. The establishment of RBNs had to be rescheduled to enable timely ripening of the crop. As a result we observed hardly any use of RBNs in Dakhwangaon. In the other two villages, the extent of uptake of RBNs in its different forms was largely influenced by the individual farm characteristics (Table 4.10). The usage of inputs (like cow urine and compost) and choice of operations (like seed selection, seed treatment and seeding density) varied across farm households, guided by the farm characteristics and farmers' preferences and priorities. Farm households make choices on the overall strategy to get all the fields planted and from there carve out the best combination of seed and seedling management. This creates a set of activities across fields and over time from which task group formation emerges. The exact task group composition is further determined by social characteristics, in particular membership of self-help groups, kinship and past working experiences.

New kinds of nursery raising institutions were created around RBNs, ranging from a single or multiple RBNs managed individually by a farm household in its own plot to a more complex arrangement whereby multiple RBNs were jointly raised by several farm households on a common plot. The choice was based on the farm situation and varied across sites belonging to a , between households, and also across seasons. The small size and short duration of RBNs, along with the reduced efforts required in bed preparation and sowing (especially as skills are gained over time or through collaboration with others) did not preclude taking on additional responsibilities to establish and manage nurseries for others, or giving away surplus seedlings to late comers and first timers. Farm households could therefore pursue crop establishment practices of SRI even without having an RBN on their own plot or actively participating in the nursery-raising activities.

Table 4.10: Socio-technical elements influencing decisions related to nursery raising

Decisions / Level	Not Using Seedlings from RBN at all	Using Seedlings from RBN of others	Having RBN in someone else's Plot	Having RBN in one's own Plot
Landscape				
Natural Environment	Higher Elevation	Lower Elevation		
Built Infrastructure	Seasonal Canals: Unreliable and limited water supply	Perennial Canals: Reliable and adequate water supply		
Farm Household				
Economic Issues	Insufficient labour; Pre-occupation with unirrigated plots and off-farm activities	Insufficient labour; Pre-occupation with unirrigated plots and off-farm activities	Limited labour; Pre-occupation with unirrigated plots and off-farm activities	Adequate labour; More irrigated plots
Social Issues	Lack of knowledge; Poor social relationships	Lacking skill and experience; Good social relationships	Lacking skill and experience; Good social relationships	Skill and Experience; Good social relationships (if sharing plot with others)
RBN Plot	Unavailability of water for early seeding; Poor access to suitable plot			Good access to water and suitable plot

The study also illustrates that there was a transformation in the nature of seedling-raising groups, from being largely family-based to jointly raised nurseries. This reconfiguration was done in order to make SRI transplanting manageable. SRI had to be incorporated within the diverse and complex system of wet rice cultivation alongside un-irrigated crops, taking into account the existing shortage of agricultural labour and the predominance of female labour. The tradition of transplanting in groups and the way SRI was introduced through SHGs also facilitated the transformation process.

The different options of coming together present different constraints and opportunities to nursery growers (Table 4.11). These arrangements are made through informal negotiations between farmers requiring seedlings.

Table 4.11: Constraints and Opportunities for Negotiating Group Formation around RBNs

	Not Using Seedlings from RBN	Using Seedlings from RBN of others	RBN in someone else's Plot	RBN in one's own Plot
Constraints	-	Dependent on other's choice of variety, surplus availability and maintaining relationships	Risk of mixing of varieties, and maintaining relationships	Risks of delayed transplanting of the nursery plot, mixing of varieties, losing top soil (if sharing RBN plot)
Opportunities	Take advantage of wider spacing with older seedlings	Sharing Labour during transplanting	Sharing labour post seeding at the RBN plot	Available labour from others for transplanting

RBNs provided a learning space for women with regard to material as well as social aspects of farming. Collective working meant that nursery growers were able not only to access scarce inputs such as cow urine and compost, but also exchanged knowledge about the new farming method and acquired skills for RBN bed preparation and seed broadcasting. RBNs thus seemed to function like informal 'farmer field schools' (SUSTAINET EA, 2010) in which the more experienced nursery growers functioned as facilitators, replacing the VLRPs and MTs over several seasons. The RBNs also provided space for social interaction and building social capital, and helped in deciding with whom to tie up in the next season and on what terms. Thus the RBNs brought about changes in tasks as well as task group cultures over time. RBN task groups were potential platforms for building upon the adaptive capacity of farmers while introducing new technologies.

The members of an RBN group, including the owners of the plots on which the RBNs were hosted, might have conflicting interests and expectations. This could lead to tensions around sharing of labour, the risk of delayed transplanting, mixing of varieties, and loss of fertile soil. The tensions usually did not escalate into conflict because common interests prevailed. The participants apparently believed that the arrangements were valuable enough to make it worthwhile managing the difficulties rather than just rejecting RBNs and young seedlings altogether. Women in the villages also recognized that RBNs have strengthened personal relationships. One of the debates in SRI literature has been around its alleged agro-ecological services but SRI in the form of RBNs seems to result into an interesting form of shared activity. Our analysis of these RBNs makes clear that SRI should be analysed as a case of 'social performance' rather than just an individual performance (Richards 1993). The abstract concept of an RBN was converted into practice through a socially embedded process of problem solving, leading to the reorganization of tasks and reconfiguration of task groups in the local context, in order meet material (seedlings for transplanting) as well as social (maintaining harmonious relationships with others) needs.

Chapter 5

Changes in transplanting operations and labour sharing for mountain rice farms in Uttarakhand

5.1 Introduction

In most irrigated rice fields of Asia, the rice crop is established in the field through manual transplanting. Transplanting involves as series of operations to acquire an "even stand of optimum number of optimum-age seedlings" at the appropiate time for crop development and high grain yields (Datta, 1981, p. 230). According to IRRI (2007), one hectare of rice might require 30 to 40 person-days to transplant, depending upon the soil type. When moving from this quantified notion of labour to a qualitative assessment of transplanting, factors like careful handling of seedlings, mode of transport from nurseries to fields, planting distance and coordination within the team of people, usually women, doing the transplanting become apparent. In short, transplanting requires skilled labour (IRRI, 1985; Bray, 1986). Women farmers in Southeast Asia, who specialize in transplanting, are known to possess vast and sophisticated knowledge and skills including ability to co-ordinate required labour for carrying out transplanting operation at the optimum time according to local agro-ecological conditions (Dey, 1985; Bray, 1986). The System of Rice Intensification (SRI) advocates a different way of transplanting compared to most customary transplanting practices. The three main features of transplanting according to SRI recommendations are the use of much younger seedlings, one plant per hill and a regular,much wider, spacing in a grid pattern. The question addressed here is what the implications of these recommendations are for the skilled activities of woman when transplanting rice.

The standard SRI recommendation for transplanting is the use of healthy young seedlings to be established preferably at the rate of one seedling per hill in widely-spaced hills (Stoop et al., 2002; Uphoff et al., 2002). The ideal seedling age and recommended practice for transplanting is at the two-to-three leaves' stage, usually reached in 8 to 12 days after seeding; at that stage the subsequent rooting and tillering will be most profuse (Thakur et al., 2010; Toriyama and Ando, 2011). Seedlings are recommended to be transplanted quickly after uprooting, at a shallow depth possibly in a square pattern to facilitate subsequent mechanical weeding in cross directions. The young seedlings of SRI supposedly suffer less transplanting shock and retake growth readily. Together with the SRI recommendations following the transplanting phase, alternating wetting and drying and mechanical weeding, this creates growth conditions that enhance root growth, tillering and ultimately increased crop yields (Uphoff, 1999; Stoop et al., 2002; Uphoff 2003; and Mishra et al., 2007). The interaction between agronomic and physiological mechanisms during the transplanting phase and the effect on yield is complex and far from straightforward. Issues such as coordination of activities, available labour and other social factors further add to the complexity. The interaction between agronomic practices and social issues of timing, coordination and skill are the central issues in this chapter.

The introduction of these new SRI transplanting practices is expected to confront rice farmers with complex adjustments in farm management operations and their timing. Careful uprooting of the young seedlings, having marked muddy levelled fields, and organizing of women’s group - all have to be coordinated and properly timed for. Women have to avoid damaging the delicate young roots during uprooting and transplanting. A single young seedling has to be placed in the soil with a smooth movement of hand and fingers. Transplanting under SRI is considered to be more difficult and skill demanding (Styger et al., 2011). Understandably, there is ample variation in the way farmers follow the SRI recommendations. The results presented hereare based on a study of mountain farms in Uttarakhand in the North Western Himalayan region of India. SRI had been introduced there first in 2008, and shows diverse transplanting characteristics within and across villages and among the women constituting a transplanting group.

Earlier studies on SRI while highlighting the issue of deviations of transplanting practices from the standard recommendations provide little explanation about underlying causes (Moser and Barrett, 2003; Moser and Barrett, 2006) . Some recent studies point out that explanations lie within plot characteristics and household composition but do not further specify how (Palaniswami et al., 2010; Lya et al., 2012; Martin et al., 2012; Doi and Mizoguvhi, 2013; Palaniswami, et al., 2013).Likewise, an increase of labour for SRI has been repeatedly raised in the literature, as measured in time and related to economic costs and benefits with a limited qualification of the nature of the required labour (Moser and Barrett, 2003; Namara et al., 2003; Anthofer, 2004; Barrett et al., 2004; Latif et al., 2005; Satyanarayana et al., 2007; Sinha and Talati, 2007; Senthilkumar et al., 2008; Tsujimoto, et al., 2009; and Lya et al., 2012).

This chapter looks at the various technical elements and organizational aspects of transplanting rice in the mountain farming systems of Uttarakhand following the introduction of SRI in 2008. The analysis addresses questions on how local transplanting practices were adjusted to accommodate the new method, and how the SRI principles were interpreted and adjusted to fit with local social and agro-ecological arrangements. The paper shows that reconfigurations in transplanting are made at two interconnected levels: labour practices and labour organization. These reconfigurations took a different shape in each of the studied villages, based on the local agro-ecological conditions. The paper argues for a more integrated approach that combines the elements of time, knowledge and skill to properly understand labour use and its organization in agricultural practices, especially during the peak demand for labour, and how these have to be readjusted (in socio-technical respects) upon introducing a new system.

Hunt (2000) identifies three dimensions of agricultural labour: time, knowledge and skills, the latter two, he argues often being overlooked. Evaluating the time dimension can be a complex exercise. For example, the time spent in organizing resources is often not counted when measuring labour use in transplanting. Bray (1986) also sees labour primarily as skill, showing how the rice systems of Asia intensified over centuries with skilled labour as the main technological driver of this development. Transplanting among rice communities of Southeast Asia is mostly undertaken through women's groups. The concept of the task group (McFeat, 1974; Sigaut, 1994) helps to identify the relationship between the composition and working of such transplanting groups. Group formation, McFeat argues, emerges with and around the completion of a commonly defined task. Rather than a certain group of farmers adopting an innovation, it is newly introduced tool or farming method that adopts a group through the task the innovation requires.

The concept of 'agriculture as performance' recognizes farmers' adaptive and improvisational capacity with regard to application of time, knowledge and skills (as labour components) in interactions with materials and artefacts (Richards, 2010). The performance notion in combination with an analysis of the groups involved in transplanting can help understand how 'social change' is (re)organized collectively to deal with socio-technical constraints, more so with the introduction of SRI under diverse conditions and circumstances. Focusing on transplanting, the questions to be answered are how labour groups organise and perform transplanting and what changes in group formation and task performance occurred with the changes introduced in transplanting practices under SRI?

Data on transplanting practices were collected in three villages, Phalenda, Thayeli and Dakhwangaon, located at different altitudes (900m – 2000m) in Bhilangana block of Tehri Garhwal district of Uttarakhand, India. SRI was introduced in these villages in 2008. Field work was conducted over two rice seasons of 2011 and 2012. Rapid Rural Appraisals followed by discussions on cropping calendars helped recognize different rice systems, their transplanting routines, labour demand and organization during transplanting time. Semi-structured interviews with key informants (especially representatives of the local SRI promoting agency) and participant observations during training programmes led to understanding the recommended SRI transplanting practices. The interviews also revealed initial experiences under SRI, and changes in practices as well as the role of the extension agency and its personnel over the years.

In 2011, participant observations of randomly selected plots during transplanting, under different wet rice systems across the villages were made. These revealed differences in locations and characteristics (source of seedlings, seedling age, and hill and seedling density) of different transplanting practices along with composition, organization and working of transplanting groups. Differences across the villages, if any, were also recorded. Focus group discussions were held with transplanting and women's self-help groups in the different villages to understand different transplanting techniques, choice of practices, organization and coordination of groups, initial challenges with SRI's introduction, changes incorporated, and reasons thereof.

In 2012, detailed field observations and measurements of all the wet rice plots of 18 randomly selected farmers (6 from each village including SRI and non SRI farmers) were undertaken. Observations for different practices regarding size of the transplanting groups, age of individuals and their experience in SRI type of transplanting were noted and compared to see their influence on the measured transplanting characteristics and time requirements of individuals and group as a whole. Follow up semi structured interviews with the farm households led to comprehend decision making processes related to choice of practices, composition of transplanting groups, roles and rules of groups and members, and changes incorporated across seasons. Focus Group Discussions and semi-structured interviews with the concerned transplanting groups and individuals (of different age groups) respectively helped to compare perceptions about transplanting characteristics, skill and knowledge requirements, and labour organization and coordination.

Transplanting records were maintained from 2008 to 2012 by the local SRI promoting agency;these showed changes in transplanting characteristics over years. The above were cross checked with farm households who were selected for detailed field observations. The mix of participant observations, field measurements, focus group discussions and semi-structured interviews helped in cross-checking information on choices and dynamics of transplanting. The multiple case study design along with ethnographic analysis yielded in-depth understanding of the changes in transplanting practices includingthe operation and organization of the transplanting groups that have occurred under the influence of SRI as presented in the following sections.

5.2 Customary Transplanting Techniques: Landscape, Task Groups and Practices

There are two wet rice cultivation systems in the villages (Table 4.3). The first, known as *Saindha*, involves direct seeding of sprouted seeds in puddled plots while the second, known as *Bina* in Phalenda and Thayeli and *Bijwad* in Dakhwangaon, means transplanting seedlings from dry, slightly raised bed nurseries. Seedlings are also taken from *Saindha* plots during thinning operationsand transplanted into available plots. In the same season under the dry system known as *Sathi*, rice seeds are sown by broadcasting in the rainfed upland terraces. Other crops grown in these plots are millets and pulses. The mix of different kinds of rice plots facilitates rotational cropping, economical and equitable water use, and spreading of available labour for different crops across the rice (*kharif*) season.

Wet Rice Landscape: Transplanting requires water for field preparation. Terraces in the upper slopes (having gravelly loam soil) with limited access to water, are typically transplanted from *Bina-Bijwad* nurseries after the monsoon rains start. Some of the terraces located in the lower fields (having silty or sandy loam soils) with early access to water from perennial canals are direct-seeded. These *Saindha* fields provide seedlings for transplanting on remaining lower terraces later in the season*.* The number of direct-seeded plots, the method farmers prefer, is limited by the time between harvesting wheat from the previous (*rabi*) season and sowing rice and, secondly, the availability of water in the early rice season. Vice versa, more direct-seeded fields limits growing wheat as a second crop and increases the chances conflicts over water may emerge. Some *Saindha* plots were sown with mustard and barley in the winter season, crops that can be harvested earlier. Plots having saturated soils were also put under *Saindha* as wheat could not be grown there in the previous season. All other irrigated plots that had wheat in the winter season are transplanted after the arrival of water with seedlings acquired from thinning from *Saindha* plots.

An increased proportion of rice plots was transplanted from *Bina-Bijwad* in Dakhwangaon and Phalenda upper fields, where water was a limiting factor. Moreover, later transplanting operations from *Bina-Bijwad* and *Saindha* saved time to sow and weed other crops (*Sathi* rice*,* millets and pulses). Farmers reported that the number of direct-seeded fields increased especially in lower fields of Phalenda and Thayeli over the last two decades, with the development of water infrastructure. Moreover farmers preferred the direct-seeding because it requires a single round of ploughing. Over the years bullocks and available labour have become scarce with increasing off-farm job opportunities. In Dakhwangon, the higher altitude reduces the rice season and only a short-duration variety is grown together with other crops. In the other villages early and late varieties of rice were also grown, adding the options to spread the peak labour periods.

Transplanting Groups: Uprooting of seedlings from *Bina-Bijwad* and *Saindha* was largely done by a small group (2-3 members) of women from the same household, owning the plot to be transplanted.On the day of transplanting, women of the concerned household requested available women from other households for transplanting. The group thus created is known as *padiyal*. Women from other households (usually 2-3 families) joined in and received help during transplanting their own plots. Farm households which had their own bullocks and adequate work force, arranged the work preferably within the household. Farmers having direct-seeded fields only, did not have to join the*padiyals*. In Phalenda and Thayeli, with the largest number of transplanted fields, relatives living outside the village came over to help in transplanting.

Usually, the *padiyal* was formed by women whose plots were ploughed by the same pair of bullocks*.* Family ties, same sub caste, self-help groups, friendships and ownership of plots in the irrigation unit (*tok*) were additional factors in *padiyal* formation. Transplanting groups could be formed on a day to day basis among the women available and also differed across seasons due to changes in bullock ownership and overall changes in the composition of households. Group size generally ranged between 2-6 members and consisted mainly of women in the 18 to 50 years' age group, although a woman at the age of 70 was participating in one of the groups.

Transplanting Practices: The actual date of transplanting was based on field location, water and the availability of bullocks, ploughmen and women. Seedlings of *Saindha* and *Bina-Bijwad* were usually uprooted one or two days prior to the probable transplanting date. The advanced uprooting was done to minimize delays in transplanting once the fields are prepared. Seedlings were uprooted by pulling them out of the soil without much concern about the possible damage done to the roots. Uprooted seedlings were tied together in bundles of 90-100 plants and rinsed in water to remove soil to reduce the carriage weight.

Once a *padiyal* was formed, they go from field to field. While transplanting, bundles of seedlings were thrown across the main plot. Members of the *padiyal* picked up the bundles while moving through the water standing closely while transplanting seedlings. Women transplanted by moving backwards, ending at where they could step out of the field without trampling seedlings. Each woman holds a bundle of seedlings in one hand while the other hand is used for selecting seedlings (inattentively) and pushing them into the soil/mud randomly at about a hand's length i.e. about 15 cm. Time required for transplanting ranged from 10-75 minutes per woman per 100 sq. m. (Figure 5.1) depending upon the group size (less time was required per individual for a larger group). On average a one acre plot would require 4-6 person days for a single woman to transplant.

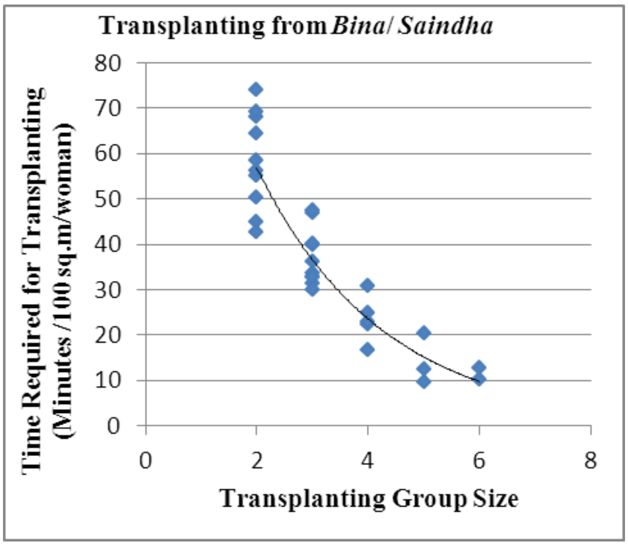


Figure 5.1: Time Required for Transplanting under *Bina* and *Saindha*

Bina–Bijwad nurseries were established from mid-April to end May (earlier at higher elevations like Dakhwangaon and the upper fields of Phalenda in order for the crop to mature on time). In the 2011 and 2012 seasons, transplanting from *Bina* in Phalenda and Thayeli was done using seedlings of at least 25 days old (Table 5.1). About 3-7 seedlings per hill were transplanted randomly. In Dakhwangaon, where transplanting was delayed depending upon onset of rains and availability of irrigation water, age of seedlings ranged from 68-100 days. About 4-12 seedlings were transplanted per hill, which also depended upon the seedling age (more plants for older seedlings).

Saindha plots were seeded around mid-May to end May (except for Dakhwangaon where seeding was done in the second fortnight of April). After 20-25 days from seeding, thinning (*Chattai*) was undertaken during which weeds were carefully removed. At the same time densely placed seedlings were uprooted and used for filling gaps in the same plot, as well as for transplanting other available plots. In Phalenda, some farmers uprooted all the seedlings from one side of a densely seeded *Saindha* plot and re-transplanted them at a wider spacing in the same plot. We observed farmers using seedlings of 20-35 days (See Table 5.1). In Dakhwangaon, seedling age easily extended beyond 60 days and for some plots even up to 100 days. About 4-13 seedlings per hill were transplanted at an estimated optimal density, depending on the age of the seedlings. Farmers showed awareness that thinning and transplanting in combination with weed control affected crop yields. Farmers also shared that the tillering capacity of seedlings decreased with age, reason why the number of seedlings per hill was increased for older seedlings. Women in Phalenda and Thayeli explained that before the arrival of SRI, the common practice was to transplant 4-10 seedlings per hill of 30-45 days-old plants from *Bina-Bijwad* seedbeds and *Saindha* fields. Transplanting older seedlings also reduced the rounds of weeding.

Table 5.1: Transplanting from *Bina-Bijwad and Saindha*

Parameters / Village	Seedling Age in Days	No. of Seedlings/Hill	Hill Spacing in cm	Hill Density in No./sq.m.	Plant Density in No./sq.m.
Bina-Bijwad					
Phalenda	29-50 (37)	3-7 (4)	7- 26 (14)	33 – 45 (40)	99 – 205(132)
Thayeli	25-30 (27)	3-6 (5)	8 – 27 (16)	50* (50)	250* (250)
Dakhwangaon	68-100 (74)	4-12 (7)	7 – 22 (15)	39 – 72 (54)	263-372(309)
Saindha					
Phalenda	25-35 (31)	2-6 (3)	5 - 20 (16)	31 – 43 (37)	99 – 152 (122)
Thayeli	20-30 (26)	2-6 (4)	5 - 28 (16)	32 – 43 (36)	129 – 175 (150)
Dakhwangaon	64-101 (75)	3-13 (7)	5 – 20 (15)	42 – 76 (52)	269 – 428 (360)
Source: Field Observations, 2011-2012 (): Average *Only 1 plot					

5.3 Transplanting with SRI

SRI was introduced in the study villages in 2008 by the Mount Valley Development Association (MVDA), a local grass root level organization based in Tehri-Garhwal district of Uttarakhand. MVDA followed the technical guidelines of People's Science Institute (PSI), the central agency for promoting SRI in Uttarakhand. Master trainers

(MTs) of the MVDA trained a local farmer from each village as a village resource person (VLRP) to support fellow farmers in various SRI practices. Extension of SRI in the villages was done through the VLRPs under supervision of MTs.

Recommended Transplanting Practices: According to the Programme Manager of MVDA the recommendations were to transplant one single 8-12 days' old seedling per hill (having 2 leaves) from Raised Bed Nurseries (RBNs) at a uniform grid spacing of 25 cm, indicated by the crossing point of lines drawn in the wet soil with an iron rake marker. Uprooted seedlings had to be carried from RBNs to the fields in small baskets and polythene bags. The *padiyal* members were advised to stand in a line (along the width of the plot) at one end of the marked plot and move forward while transplanting. Women were advised to move forward in transplanting because backward movement makes it more difficult to follow the marked lines or even erase them when stepping back.

Each woman was supposed to cover 3-6 lines depending on arm reach. Each woman would hold a clump of seedlings in one hand, taking out a single seedling with the other and stick it in the mud with a gentle push and then pressing some soil around it. The advised spacing results in a plant density of 16 plants per square metre, much less than the other transplanting practices (Table 5.2).

Table 5.2: Comparing Current Transplanting Practices with Recommended SRI Practices

Method / Parameters	*Bina-Bijwad*	*Saindha*	SRI
Seedling Age (Days)	25*-100	20* - 100	8-12 (having 2 leaves)
Number of Seedlings/Hill	3**-12	2** - 13	1
Plant Spacing (cm)	estimation: 7-27 (15)	estimation: 5-28 (15)	Row: 25 cm; Plant: 25 cm
Hill Density (Hills/sq. m.)	33-72 (~50)	31-76 (~50)	16
Plant Density (Seedlings/sq. m.)	99 – 372 (>132)	99 – 428 (>122)	16

Source: Field Observations and Focus Group Discussions, 2011-2012 (): Average
*According to farmers before inception of SRI, minimum age of seedling was 30 days
** According to farmers before inception of SRI, minimum number of seedlings per hill was 4

PSI's training manual on SRI recommends transplanting within 30 minutes after uprooting at a depth of 1- 2 cm deep, with the roots positioned horizontally (PSI, 2008). The above specifications presumably reduce the transplanting shock, thereby facilitating early growth and establishment of the root system (Stoop, et al., 2002; Toriyama and Ando, 2011). Participant observations during the training workshops from the MVDA revealed that emphasis was put on seedling age (in days), the use of a single seedling and spacing. Further explanation about the two-leaf stage or the need for quick and shallow transplanting received less attention.

Tensions around Recommended Practices: Women in the focus group discussions shared that initially the recommended practices baffled the farmers. Once transplanted, the SRI plot gave a barren appearance and looked less promising even after 15-20 days. Especially elderly farmers considered this problematic. The VLRPs recalled several instances where farmers had returned to the transplanted plots the next day and added seedlings. The timing also created problems in the first years. Transplanting young seedlings at the same time as older seedlings from *Saindha* and *Bina-Bijwad*, resulted in late ripening, especially at higher elevations. This implied additional labour for prolonged crop protection (scaring birds, cattle and monkeys) and late harvesting of the SRI fields. The problem could be resolved to some extent in farms where water was available early in the season for transplanting of young seedlings ahead of the usual transplanting period. This, however, created an additional labour requirement for transplanting in a relatively short period when women farmers were already busy in sowing and weeding *Sathi* and other rainfed plots.

Women of Phalenda shared that rain-fed plots, located away from the irrigated fields, had to be finished first before transplanting SRI plots. In Thayeli rain-fed plots were closer to irrigated plots but there was an acute shortage of bullocks (3 pairs amongst 18 households). Many farm households were therefore dependent on bullocks from neighbouring villages adding more uncertainties in timely transplanting of seedlings under SRI. Since bullocks had to be shared among farm households, those whose plots were prepared last were most affected.

Table 5.3: Number of SRI Plots according to Age of Seedlings (2011 and 2012)

	2011 (205 SRI Plots)				**2012 (259 SRI Plots)**			
Seedling Age / Village	**<15 Days**	**15- 20 Days**	**21- 30 Days**	**>30 Days**	**<15 Days**	**15 - 20 Days**	**21 - 30 Days**	**>30 Days**
Phalenda	53	39	17	2	25	61	9	0
Thayeli	33	25	1	0	45	42	17	0
Dakhwangaon	0	6	2	27	0	3	0	57
TOTAL	**86 (42%)**	**70 (34%)**	**20 (10%)**	**29 (14%)**	**70 (27%)**	**106 (41%)**	**26 (10%)**	**56 (22%)**

Source: VLRP Records, 2011 and 2012

Farmers shared that besides unavailability of bullocks, delayed drying of fields and late arrival of the VLRPs for marking increased seedling age (Table 5.3). One farmer of Thayeli, applying SRI in 11 of his 13 rice plots in 2012, shared:

> We started transplanting our plots from the 10th day of nurseries' establishment but due to bullocks, drying and marking by the time we transplanted our last plot seedling age had gone up to 20 days. Sometimes bullocks were not available, sometimes water did not drain for 2-3 days, and

sometimes marking was delayed. [Personal discussions, Thayeli, 21 August, 2012]

Plot owners of jointly raised RBNs had to wait till others had pulled out their seedlings, and one was assured that there was no need of gap filling then in the main plots already transplanted. These nursery plots then had to be transplanted with older seedlings. Customs and rituals also resulted in older seedling. Delays in the announcement of Din Bar, a common auspicious date announced in the villages for initiating transplanting, was observed in Phalenda in 2012. Likewise, transplanting of seedlings was forbidden on some days like full moon day, no moon day, solar and lunar eclipses. Households were prohibited to transplant when a family member had died recently.

Transplanting in square grids requires cross-marking of the field, which constitutes an additional operation that further delayed transplanting. Cross marking was also reported to be a tiresome activity for the VLRPs. Women had to be reorganized for transplanting once marking was completed. According to the VLRPs, initially many women farmers, especially elderly ones were reluctant, and expressed difficulty in uprooting and transplanting seedlings younger than 20 days' old. Even during the study seasons, some of the beginners said "these seedlings demand lot of care, attention and time to be planted precisely at the proper position. Next time, we would transplant seedlings once they are older" [Focus Group Discussions, Phalenda, 10 September, 2012].

Many women, especially inexperienced and elderly ones, stated that transplanting in square grids takes more time than other forms of transplanting. Time measurements show a different pattern (Table 5.4). Overall time required for grid transplanting, and even line transplanting was less. Women who had transplanted in line or grid more frequently acknowledged it required less time but also stated it needs more attention or greater care.

Table 5.4: Time Required for Transplanting under different methods (in Minutes/100 sq.m./person)

	Transplanting from Bina-Bijwad/ Saindha (eye estimation)	**Line Transplanting with eye estimation**	**Line Transplanting following marking**	**Grid Transplanting following marking**
Range (minutes)	10-74	5-28	4-40	3-15
Average (minutes)	38	14	15	9
Source: Field Observations of rice plots, 2012				

Women, especially beginners shared that selecting one young seedling from a handful was not only tedious but also required attention and time. They found it more convenient to transplant at least two seedlings per hill. We observed that elderly women, even when having experience in SRI transplanting, tend to transplant seedlings inattentively resulting in more seedlings per hill. Women preferred line or denser transplanting as wider spacing of seedlings also resulted in profuse outgrowth of weeds, especially in absence of flooding and timely weeding. Moreover, grid transplanting implied cross weeding with rotary weeder which was considered heavy work, resulting in body ache.

In sum, the grid pattern reduced the time for transplanting but required more attention to get the seedling at the intersection of lines. For several transplanting groups it was observed that the desired forward movement was not followed. Inexperienced and older women in particular were found to move sideways and backwards thereby removing markings and trampling seedlings. A woman of Phalenda recalled:

> In 2010 when we did SRI for the first time, the VLRP marked our plot and left immediately for plots elsewhere. We asked who so ever was available to join for padiyal and we did not ask for experienced women. In spite of the marking, we could not do proper transplanting in lines, and hence we could not run the mechanical weeder through our plot. [Personal Discussions, Phalenda, 15 September, 2012]

The challenges and tensions around transplanting thus proved to be much more complex at field level when the recommendations were put into practice. In the initial years, there was a lot of social pressure, especially from elderly against changing the existing practices.

5.4 Integrating SRI in Rice Farming: Transformations in GroupsandPractices

The tensions seemed to be largely resolved over the seasons by adapting and rescheduling practices, as well as modifying the recommendations, reframing the tasks according to the range of situations, and changing the composition and coordination of task groups.

Rescheduling Tasks for Timely Transplanting: To ensure timely ripening of theSRI crop, the establishment period of RBNs was advanced along with early transplanting of the young seedlings. Once the seedlings at RBNs were ready, to avoid delays due to drying and marking of fields, plots were prepared and left overnight to dry so that they could be marked next morning. Seedlings were preferably uprooted in the morning of the day when transplanting was planned. Transplanting proceeded sequentially as plots were marked by the VLRP. Transplanting was usually initiated as soon as a plot was marked.

Differences were observed across the villages. Changes in early establishment of RBNs and transplanting schedules were largely possible in Phalenda and Thayeli due to the early access of water whereas in Dakhwangaon limited water availability constrained rescheduling of tasks. Similarly, farmers of Thayeli were able to transplant seedlings without much delay after uprooting as compared to Phalenda, since in Thayeli SRI plots were nearer to the habitat and drying of plots was much faster due to higher silt/sand content.

Relaxing SRI Guidelines for Upscaling: In 2010 the MVDA got a new SRI programme funded by Sir Dorabji Tata Trust, Mumbai. This increased the pressure of achieving the set targets of farmers working with SRI. Based on the experienced reluctance about grid transplanting, the MVDA modified its recommendations. After consultations with farmers and local agricultural scientists, it relaxed the norm of adhering to plant to plant spacing of 25 cm and recommended maintaining at least row to row spacing of 25 cm by using the marker in one direction. In Dakhwangon marking was not feasible and farmers transplanted in lines by eye estimation. This was accepted from 2011 by the MVDA.

Women farmers revealed that they were too happy when in 2010 MVDA allowed for line transplanting of seedlings. This saved time for marking and required less attention than grid transplanting. The VLRPs from Phalenda and Thayeli revealed that it was much easier for them too to mobilize farmers to undertake line transplanting than grid transplanting, and later on, transplanting by eye estimation (especially in Dakhwangaon). The Programme Co-ordinator of MVDA further shared "In 2008 and 2009, we closely supervised the transplanting practices limiting deviations. From 2010, as number of farmers increased our field support has decreased in villages affecting quality of SRI. This, however,provided the farmers with opportunities to innovate and adapt according to their situation and insights" [Interview with Programme Co-ordinator, MVDA, Doni, 19 November, 2011].

Reorganizing Labour for Quick Transplanting: Under SRI women members of different farm households, whose plots were already prepared and dried overnight, formed *padiyals.* Instead of shared use of bullocks, drying and marking of fields became more important in forming *padiyals.* Women farmers mentioned that they preferred joining others in transplanting while their plot was being marked as this encouraged others also to join them later. A woman of Thayeli shared:

> I have a pair of bullocks used for preparing plots of three farm households including mine. For SRI we had established individual RBNs but in a common suitable plot belonging to one of us. During transplanting from Saindha, only women from our farm households with additional help of my daughter did transplanting in our plots. While transplanting under SRI, women from other households also joined us in between. These were women whose plots were still being marked. The group size therefore automatically increased. [Personal Discussions, Thayeli, 23 August, 2012]

Under SRI, the number of women per group was generally increasing as transplanting proceeded. It was quite common to see transplanting operations under SRI starting with 3-4 women, peaking up to 7-8 women and then ending with women gradually moving out. Women who joined in the middle were those whose plots had either been transplanted or were waiting for their plots to be marked. Women did not want to stand and waste time while their plots were being marked so they joined those whose fields were already marked. It was observed that older women were usually the first ones to leave besides those women whose plots got marked by the VLRPs. Larger groups facilitated speeding up of transplanting in SRI plots.

Comparisons were made between *padiyals* for rice plots under SRI and other methods (Table 5.5). *Padiyals* for *Bina-Bijwad* and *Saindha* mostly consisted of 1-4 women (average 3) with numbers occasionally going up to a maximum of seven. *Padiyals* for grid transplanting were mostly bigger in size (4 and above). Both in Phalenda and Thayeli group size for *padiyals* in marked fields went up to 12. In Dakhwangaon, there was no significant influence on the size of *padiyal.* As line transplanting by eye estimation was undertaken along the same time as *Saindha*/*Bijwad* and marking was also not done, therefore additional women were unavailable to join *padiyal*.

Table 5.5: Rice Plots Covered by Different Size of Transplanting Groups under Different Methods

Methods / Group Size	Transplanting from *Bina-Bijwad* or *Saindha*	Line Transplanting (by Eye Estimation)	Line Transplanting (After Marking)	Grid Transplanting (After Marking)
1 to 2	22 (39%)	7 (29%)	5 (13%)	0 (0%)
3 to 4	18 (32%)	11 (46%)	13 (34%)	7 (44%)
5 to 6	11 (19%)	6 (25%)	13 (34%)	5 (31%)
7 to 8	6 (10%)	0 (0%)	3 (8%)	4 (25%)
> 8	0 (0%)	0 (0%)	4 (11%)	0 (0%)
Total Plots	57	24	38	16
Source: Field Observations of 135 rice plots, 2012				

Recomposing Groups for Accessing Skills: Most women were of the opinion that younger women and girls learnt line or grid transplanting fast as they found it easier to follow marks, whereas older women took time to find intersection points and did not like being cautious while transplanting. The VLRPs also revealed:

> Young women learn quickly to transplant in lines as compared with older women. They place seedlings exactly where they are told. One who is transplanting for first time, if young, learns quickly whereas elderly and middle aged women habituated to age old practice of inattentive random transplanting were not too keen in SRI type of transplanting. [Focus Group Discussions with VLRPs, Doni, 30 October, 2012]

A group of young girls undertaking line transplanting in Phalenda when asked about their preference, shared “We prefer to stay out from *Saindha* and *Bina* because it requires walking through muddy water and is more time consuming; SRI transplanting however is done under dry conditions and is more systematic just following lines and being attentive" [Focus Group Discussions, Phalenda, 21 June, 2012]. A woman of Dakhwangaon shared "In *Andaza* [line transplanting by eye estimation], we have to pay attention to maintain a line. Young girls and women learn faster how to do transplanting in lines and by eye estimation. Young girls from farm households sharing bullocks therefore participate more in *padiyals* undertaking *Andaza"* [Personal discussions, Dakhwangaon, 15 July, 2012].Thus young girls were invited to join *padiyals* to transplant in lines with or without marking.

Table 5.6: Women of Different Age Categories Transplanting Rice Plots under Different Methods

Method / Age Category	Transplanting under *Bina-Bijwad* or from *Saindha*	Line Transplanting (Eye estimation)	Line Transplanting (After marking)	Grid transplanting (After Marking)
< 19 years	6 (3%)	10 (11%)	31 (17%)	15 (19%)
19 to 35 years	61(30%)	35 (38%)	74 (41%)	39 (49%)
36 to 50 years	88 (44%)	40 (44%)	52 (29%)	16 (20%)
> 50 years	46 (23%)	6 (7%)	24 (13%)	10 (12%)
Total	201	91	181	80
Source: Field Observations of 135 rice plots, 2012				

A comparison of age composition of *padiyals* for different methods (Table 5.6) clearly revealed the higher proportion of younger women and girls in line and grid transplanting as compared to elderly and middle aged women. Field observations showed that many *padiyals* transplanting from *Saindha* and *Bina-Bijwad* entirely consisted of women above 35 years of age. By contrast, *padiyals* for grid and line transplanting consisted almost entirely of young women and girls between age group of 17-35 years.

Results from time measurements on age differentiation show that elderly women, in particular over 50 years, were found to take more time to follow lines, being accustomed to transplant clumps of seedlings, at random and closely spaced. Overall, experienced and older women could transplant relatively faster than young and less experienced women.

Thus, groups for grid and line transplanting transformed in terms of size and age composition due to new requirements of early transplanting time and different set of transplanting skills. According to the VLRPs of Phalenda and Thayeli, SRI had helped in promoting the concept of *padiyals* in the villages which had been decreasing over the years. Women farmers also acknowledged that SRI's introduction enhanced the formation of *padiyals* in the villages.

Redefining Roles of MTs and VLRPs: Women expressed that SRI transplanting required more care and attention compared to existing practices, as it involved holding comparatively young seedlings with attached seeds, counting required number of seedlings and placing seedlings according to marks. They further shared that the required skill came and was improved with years of experience. Discussions revealed that in the initial years, in all the villages, the MT from MVDA and more so the VLRPs tried to be present at the time of the transplanting period guiding the process. They would instruct women to go for wider spacing between seedlings while transplanting in lines and reduce number of seedlings used per hill. In later years, amateur groups often invited experienced women (having at least 2-3 years' experience in line transplanting) to join their *padiyal* and guide the operation.

Beginners in Phalenda, especially invited women from Gabani (a hamlet of Phalenda) to their *padiyal* as most of them had undertaken SRI from the beginning, some even having 3-4 years' experience. In Thayeli most women farmers knew line transplanting. *Padiyal* was therefore done with who so ever was available at that time, except for women having social conflicts. A woman of Thayeli recollected "Initially when we did not know transplanting as per SRI it was a bit difficult. Someone from MVDA was always present during transplanting. Presently farm households whose plots are prepared by the same pair of bullocks form a *padiyal* undertake transplanting independently because we all are trained now" [Personal Discussions, Thayeli, 24 August, 2012].

However, this was not so in Dakhwangaon where very few women had experience with marking, followed by transplanting as it was done mostly be eye estimation. When a beginner wanted to undertake line transplanting even by eye estimation, the MT and/or VLRP would mostly be present till it was completed to ensure that it was done properly.

Redistributing Tasks according to Skills: While uprooting, removing single seedlings from clumps keeping the seed intact was considered tedious, requiring attention and care. Uprooting tasks in RBNs were therefore mostly assigned to older women while younger women participated in transplanting. About 65 per cent of women involved in uprooting of seedlings form RBNs were older than 35 years. In comparison to the above, involvement of children and younger women in carriage of younger and lighter seedlings to main plots was more pronounced in RBNs (42 per cent of women involved in carriage of seedlings were between the age of 16 to 35 years) than in case of transplanting from *Bina-Bijwad* and *Saindha*. A woman from Thayeli remarked "Earlier we had to carry several heavy bundles of seedlings from the nursery (*Saindha*) to a certain plot. It resulted in backache. Now, we are easily able to carry seedlings for several plots in just one basket and move about from one plot to other" [Personal discussions, Thayeli, 24 August, 2012].

Over the seasons there was an additional demand for experienced young women and girls to undertake line transplanting in SRI while the elderly women continued with their skills of transplanting in other methods. A 51 year old woman of Phalenda recollected:

> During transplanting from Saindha, my padiyal consisted of six women aged 43, 42, 40, 40, 38, and 19 years. While undertaking line transplanting under SRI, the padiyal size increased to 10 with the arrival of younger women and girls from the same households. Ages of women in the newly constituted padiyal were 38, 38, 35, 22, 22, 21, 19, 18, 17, 17 years. Some of the older women (aged 43, 42, 40, and 40) were no longer present in the new group. These elderly women joined another padiyal undertaking transplanting from Saindha. I along with another woman aged 50 years opted for uprooting seedlings while younger women transplanted the plot. [Personal discussions, Phalenda, 30 June, 2012]

In padiyals consisting of women of different age and having different years of experience, the elderly inexperienced ones who could not transplant properly were often either sent off or they themselves volunteered, for uprooting seedlings from nurseries. Thus there appeared to be a redistribution of tasks for transplanting amongst and within farm households.

Reframing Tasks and Practices according to Local Conditions: Farmers had to reinterpret the general SRI guidelines to adjust these into practices adapted to the local conditions, as discussed next.

(a) Source of Seedlings (RBNs to Bina-Bijwad/Saindha): Recommendations under SRI required the use of young seedlings from RBNs. Farmers of Dakhwangaon, were constrained to undertake early transplanting of young seedlings from RBNs (unlike Phalenda and Thayeli), due to unavailability of water. Instead they have started to use seedlings from *Saindha* and *Bijwad* since 2010. In such cases 43-77 days' old seedlings from *Saindha* and even 70-80 days' old seedlings from *Bijwad* were used so that the SRI crop could mature along with other rice crops. Farmers preferred transplanting such old seedlings, with or even without marking, while increasing spacing and reducing number of seedlings per hill.

Table 5.7: Source of Seedlings for SRI Plots

	2011 (205 SRI Plots)			**2012 (259 SRI Plots)**		
Seedling source / Village	**RBNs**	***Saindha***	***Bina***	**RBNs**	***Saindha***	***Bina***
Phalenda	88	19	4	63	28	4
Thayeli	53.5	5.5	0	76	18	10
Dakhwangaon	7	28	0	3	32	25
TOTAL	**148.5 (72%)**	**52.5 (26%)**	**4 (2%)**	**142 (55%)**	**78 (30%)**	**39 (15%)**
Source: VLRP Records, 2011 and 2012						

Farmers of Thayeli and especially Phalenda who used seedlings from *Saindha* and *Bina* shared that they mostly did so when they could neither raise RBNs on time nor get seedlings from others. Inability to establish RBNs in time was mainly due to a preoccupancy with the un-irrigated plots, unavailability of water, health problems in the families, absence from village, or various socio-cultural events. Farmers also used seedlings from *Saindha* to complete transplanting in a SRI plot when they fell short of seedlings from RBNs. For gap filling (due to seedling mortality) in SRI plots at a later stage, seedlings from *Saindha* or *Bina-Bijwad* were used. In such cases, the same SRI plot had seedlings from different sources. Farmers of Phalenda and Thayeli mentioned that seedlings used from *Saindha* or *Bina* did not yield as much as young seedlings of RBNs. Slightly more grain yield could still be obtained by taking advantage of widely spaced seedlings. Field observations during the study seasons confirmed usage of seedlings (comparatively young) from *Saindha* and *Bina-Bijwad,* thoughless densely planted in all the villages. Within the two study seasons itself it could be noticed that the use of seedlings from *Saindha* as well as *Bina* was on the rise, and even more so in Dakhwangaon (Table 5.7). But even these seedlings were also younger and more widely spaced than earlier.

(b) Age of Seedlings (Young to Old): Discussions with women revealed that over the years they had gained confidence in transplanting young seedlings from RBNs. Farmers had also become more aware that young seedlings get re-established quickly and produced more tillers. Despite experience of handling and awareness of the benefits, the age ofseedlings transplanted from RBNs was found to be not less than 10 days going up to a maximum of 27 days, even during the study seasons (Table 5.8).

Table 5.8: Range of Seedling Age (in days) for SRI Plots (2011 and 2012)

Seedling Source / Village	RBNs		*Saindha*		*Bina-Bijwad*	
	2011	**2012**	**2011**	**2012**	**2011**	**2012**
Phalenda	11-17	12-27	14-29	12-22	35	14-22
Thayeli	10-18	10-22	16-22	10-20	-	19-22
Dakhwangaon	15-22	15-16	51-66	35-78	-	70-80
TOTAL	**10-22**	**10-27**	**14-66**	**10-78**	**35**	**14-80**

Numbers indicate Minimum and Maximum Age of Seedling in days
Source: VLRP Records, 2011 and 2012

When used from *Bina-Bijwad/Saindha*, the seedling age varied from a minimum of 10 days (in Thayeli) to a maximum of 80 days (in Dakhwangaon). In Dakhwangaon, where most farmers were using seedlings from *Saindha/Bijwad*, seedling age extended beyond 30 days (going up to 80 days) due to shortages of water which interfered with early transplanting of younger seedlings. In Phalenda and Thayeli, however, farmers could even go for early transplanting of seedlings from *Saindha/Bina* when required, as availability of water was not a constraint.

Farmers were thus found to deviate from MVDA's recommendation of using 8-12 days' old seedling. It was observed in RBNs located at higher altitudes that the 2 leaves' stage (recommended by SRI principle) was obtained only in 12-14 days. Even in lower fields, seedlings sometimes took 10 days to reach this stage. Third leaf mostly emerged after 14 days. In certain varieties like *Sarbati* seedling growth was much faster than in other varieties. 45 SRI plots were randomly checked in the 2012 rice season for number of leaves and presence of seed at transplanting. Usage of seedlings having 2, 3, 4 and 5 leaves was found to be 16, 49, 31 and 4 per cent respectively. Thus 65 per cent of plots were still using seedlings within 3 leaves' stage. Similarly, 76 per cent of plots had seed attached to the seedlings at the time of transplanting. Farmers thus took into account elevation/temperature and adapted the recommendation for seedling age to somewhat older plants.

There were other bio-physical reasons for using older seedlings than recommended. Some farmers intentionally transplanted older seedlings in plots having saturated soils otherwise young seedlings tended to rot. Moreover, transplanted young seedlings were susceptible to loss upon early flooding due to seepage or rains. Similarly, farmers of Phalenda and Thayeli in locations at tail end of canals preferred using old seedlings as young seedlings were damaged by water beetle which became more active in dry conditions. Farmers here preferred to use seedlings which were more than 15-20 days' old. A few farmers of Thayeli revealed that they intentionally delayed transplanting as young seedlings could not withstand cold water coming in through canals drawn from the glacier fed river Bhilangana. Another farmer pointed out that at least 12 day' old seedlings were slightly stronger and more resilient to the higher silt content of plots (silt and fine sand came along with the canal water).

(c) Number of Seedlings (Single to Multiple): Farmers preferred to call SRI as "*Ek Dali Ropai*" which meant one seedling transplanting. They were also aware that few seedlings per hill resulted in good root growth as well as tillering. In spite of the awareness about benefits of transplanting young and fewer seedlings, farmers gradually stretched the transplanting age and number of 2 seedlings per hill over the past five years (Table 5.9). Why did they do so?

Table 5.9: Seedling Age and Number of Seedlings per Hill (2008-2012)

Village / Year	Phalenda	Thayeli	Dakhwangaon
2008	8-12 (1)	8-12 (1)	8-12 (1)
2009	10-15 (2-3)	10-12 (1-3)	10-12 (2-3)
2010	10-20 (2-4)	10-15 (1-3)	10-60 (2-5)
2011	11-35 (2-5)	10-22 (1-4)	15-66 (2-5)
2012	12-27 (2-5)	10-22 (1-4)	15-80 (2-6)

Numbers indicate Age of Seedling in days while () indicate Number of Seedlings per Hill
Source: MVDA Records, 2008-2010; VLRP Records, 2011-2012; Field Observations, 2011 – 2012

Farmers shared that their own experience showed tillering capacity of seedlings decrease with increase in age. They therefore preferred increasing the number of seedlings per hill with increase of seedling age (See Figure 5.2). Farmers even had their own thumb rules. A farmer of Thayeli shared "Since most of the time we do not get bullocks at the right time to prepare our plots, the seedling age increases. For increase of every 3-4 days in age we increase one seedling/hill. When we use seedlings from *Saindha* we use more" [Personal Discussions, Thayeli, 25 August, 2012]. Besides increased seedling age, there were other factors and processes prompting transplanting of more seedlings, as discussed below.

Farmers preferred transplanting more than one seedling per hill also as a risk coping strategy against mortality from water beetles and water rot. Even in the study seasons, transplanting was repeated (gap filling) in many plots due to water rot and more often due to infestation by water beetles. Farmers' shared that gap filling not only increased their labour but they also noticed that the later transplanted seedlings yielded less grain. Some farmers even abandoned SRI due to a bad experience with repeated gap filling. Farmers of Phalenda and Thayeli therefore preferred using 4-5 seedlings per hill, especially in locations more prone to water beetles. In plots where water came in from adjoining plots, women planted 2-3seedlings together to cope with water rot.

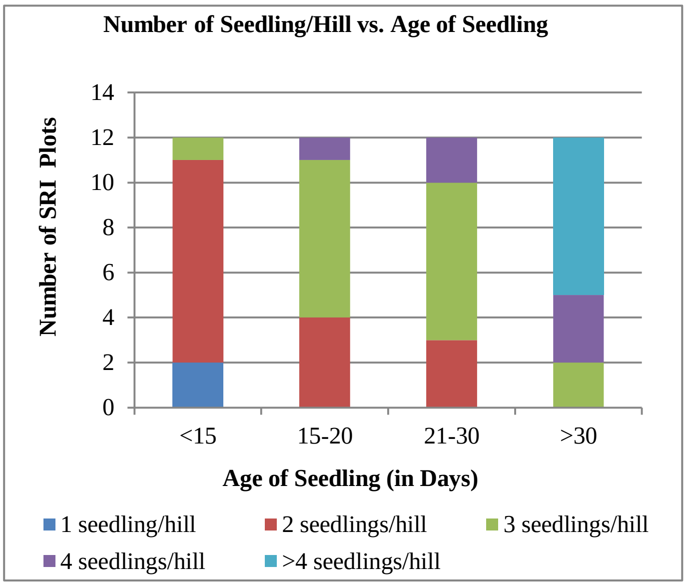


Figure 5.2: No. of Seedlings/Hill uaws doe SRI Plots
Source: Observation from 48 SRI plots, 2012

Table 5.10: SRI Plots with Range of Number of Seedlings per Hill (2011 and 2012)

	2011 (205 SRI Plots)					**2012 (259 SRI Plots)**				
Seedlings/Hill / Village	**1-2**	**2 -3**	**3-4**	**4-5**	**>5**	**1-2**	**2-3**	**3-4**	**4-5**	**>5**
Phalenda	0	64	27	12	8	0	41	42	9	3
Thayeli	19	24	11	5	0	4	70	17	13	0
Dakhwangaon	0	7	9	13	6	0	1	17	15	27
Total	**19 (9%)**	**95 (46%)**	**47 (23%)**	**30 (15%)**	**14 (7%)**	**4 (2%)**	**112 (43%)**	**76 (29%)**	**37 (14%)**	**30 (12%)**
Source: VLRP Records, 2011 and 2012										

The VLRP records of two study seasons confirmed the use of more seedlings per hill than recommended (See Table 5.10). Farmers of Phalenda and Thayeli preferred using 2-3 seedlings (from RBNs) per hill whereas in Dakhwangaon most farmers preferred 3-5 seedlings or even more per hill while using old seedlings from *Saindha/Bina-Bijwad.* Such farmers using more seedlings from Saindha remarked:

> Older seedlings have retarded growth and die frequently. In our (Saindha) method where we use 60-75 days' old seedlings we therefore go for 5-8 seedlings per hill. Under SRI, we use 3-4 seedlings per hill with 25-30 days' old seedlings, and 4-5 per hill for seedlings of 40 to 55 days old. [Focus Group Discussions, Dakhwangaon, 30 August, 2012].

In Dakhwangaon, even those farmers using seedlings from RBNs preferred using 2-3 seedlings to cover the risks of mortality due to prolonged water shortages.

(d) Exploiting Reduced Plant Spacing and Density: In 2010, MVDA relaxed the guidelines from grid to line transplanting recognizing the de facto situation on the ground. In the same year, few farmers from Dakhwangaon (and Phalenda) went ahead trying out transplanting seedlings from *Saindha* in lines through eye estimation. They did not mark their plots and just spaced seedlings according to what they felt were the right distance, even resulting in marginally better grain yields as compared with the random transplanted practice. This motivated more farmers, especially in Dakhwangaon to switch over to line transplanting by eye estimation, as marking delayed transplanting (due to the intermittent drying), which created problems in reorganizing labour but also increasing uncertainties in water availability after transplanting. Moreover, prolonged water shortage after drying enlarged weed and pest problems and thus necessitating greater gap filling efforts. Farmers called line transplanting by eye estimation as '*andaja*' meaning estimate or even '*lining ropai*' ('*ropai*' stands for transplanting).

Table 5.11: Plant Spacing, Hill Density and Plant Density under Different Patterns of Transplanting

	Row to Row and Plant to Plant Spacing (cm)					
	Phalenda		**Thayeli**		**Dakhwangaon**	
Parameters / **Pattern**	R-R	P-P	R-R	P-P	R-R	P-P
Grid Transplanting by Cross Marking	25	23-28 (25)	25	25	-	-
Line Transplanting by One way Marking	25	10-30 (17)	25	10-27 (17)	25	10-25 (17)
Line Transplanting by Eye Estimation	-	-	-	-	15-30 (20)	5-20 (15)
Transplanting from *Saindha*		5-20 (15)		5-28 (16)		5-20 (15)
Transplanting from *Bina-Bijwad*		7-26 (14)		8-27 (16)		7-22 (15)
Figures indicate range; (): Average; R-R: Row to Row Spacing, P-P: Plant to Plant Spacing Source: Field Observations of Rice Plots, 2012						

In 2012 many farmers of Phalenda realized that the grain yields obtained from line transplanting were much less than what they had obtained earlier in initial years 2008 and 2009. Thus they reverted back to grid transplanting. Farmers of Thayeli continued with line transplanting as cross marking would involve greater time gap making it difficult to transplant in the dry sandy/silty soils of that village. Since they had a larger number of SRI plots per farm household than those in Phalenda it would mean more work for the VLRP. One way marking ensured a row to row spacing of 25 cm as prevailed in Phalenda and Thayeli. Where line transplanting was done by eye estimation (mostly in Dakhwangaon), row to row spacing ranged from 15 cm to 30 cm (average 20 cm). The plant to plant spacing ranged from 5 - 30 cm (average 17 cm) in a line transplanted plot to 23 - 28 cm (average 25 cm) in a grid transplanted plot. The plant to plant spacing in a plot line transplanted by eye estimation was still less, especially when old seedlings were used from *Saindha* or *Bina-Bijwad.* See Table 5.11 for plant and row spacing under different patterns of transplanting.

Row to row and plant to plant spacing both under grid as well as line transplanting (both by marking or eye estimation) even within the same plot was not found to be uniform. Sometimes rows were too close and sometimes they were wide as marks vanished. It was observed that elderly women even after having more experience tended to place seedlings more closely than young women and girls. There were also missing hills due to non-attentive transplanting or because of mortality due to drying, flooding or water beetles. Seedlings were usually densely transplanted along bunds as markings were missing or for later replacements. Where the irrigation water entered the plot plant density was reduced by the strong water flow.

Table 5.12: Plant Spacing, Hill Density and Plant Density under Different Patterns of Transplanting

Parameters / Pattern	Hill Density (Hills/sq.m.)			Plant Density (Plants/sq.m.)		
	Phalenda	**Thayeli**	**Dakhwangaon**	**Phalenda**	**Thayeli**	**Dakhwangaon**
Grid Transplanting by Cross Marking	16-20 (18)	16 (16)	-	32-64 (50)	24	-
Line Transplanting by One way Marking	20-32 (24)	20-26 (24)	27-46 (35)	42-84 (67)	24-78 (54)	52-169 (90)
Line Transplanting by Eye Estimation	-	-	27-49 (35)	-	-	202-292 (241)
Transplanting from *Saindha*	31-43 (37)	32-43 (36)	42-76 (52)	99-152 (122)	129-175 (150)	269-428 (360)
Transplanting from *Bina-Bijwad*	33-45 (40)	50 (50)	39-72 (54)	99-205 (132)	250 (250)	263-372 (309)

Figures indicate range; (): Average; R-R: Row to Row Spacing, P-P: Plant to Plant Spacing
Source: Field Observations of Rice Plots, 2012

Wider spacing of seedlings in its varied forms (grid transplanting, line transplanting by one way marking and line transplanting by eye estimation) resulted in varying hill density across SRI rice plots. Hill density in grid as well as line transplanting was far less than for the existing methods (Table 5.12), particularly so in Phalenda and Thayeli villages. With reduced number of seedlings per hill this further implied a much reduced number of plants per sq.m. as well as a greatly reduced seed use per unit area (as also reflected in seeding density in the nurseries). Farm households thus made use of SRI by reducing the hill as well as plant density according to their local conditions. They attributed SRI with having reduced the planting density, an effect locally known as '*Chanti Ropai*' i.e. sparse transplanting having critical effects on yields. The more favourably located villages of Phalenda and Thayeli were more receptive to low density plantings than was Dakhwangaon.

5.5 Emerging Forms of Transplanting

Availability of RBNs along with *Saindha* and *Bina-Bijwad* as alternative sources of seedlings, and the possibility of transplanting in grid or lines either after marking or even by eye estimation opened up various options for farm households. Farm households adopted and adjusted the various elements of SRI while integrating these into their customary practices, in response to their local conditions and circumstances.

With the relaxation of SRI guidelines in 2010, farmers went about trying out various combinations of seedling source and method of spacing (Table 5.13). Over the seasons, this has led to the emergence of new transplanting patterns which varied across farms and seasons. During the study seasons of 2011 and 2012, some transplanting patterns were found to be more prominent in certain villages than others. The prominence was dependent on the adaptability of different SRI elements to the local landscape of the existing farming system.

In Phalenda, more plots were transplanted from RBNs because of the early availability of water. Due to the presence of a reasonable proportion of un-irrigated plots and that too at a distance from the irrigated plots, few farmers still preferred using seedlings from *Saindha* or *Bina* instead of establishing RBNs. Seedlings from *Saindha/Bina* were often preferred for the tail ends of canals, and locations having saturated soils and those infested with water beetles. For seedlings from RBNs, the seedling age varied between 11-15 days whereas older seedlings (up to 27 days old) originated from *Saindha*/Bina; these were transplanted later. In addition several seedlings per hill were planted when using older seedlings. The higher yields under grid transplanting as compared to line transplanting, encouraged farmers to go for grid transplanting though in a limited number of plots to reduce the work load of the VLRP (in marking) as well as women in (additional weeding operations).

As compared with Phalenda, Thayeli had the lower proportion of un-irrigated plots that were also located closer to the irrigated plots. This permitted farmers to establish RBNs timely, as well as to transplant young seedlings early, while using fewer seedlings per hill. Use of seedlings from *Saindha/Bina* was only reported at time of contingencies. For example, the sudden rise of seedling use from *Saindha*/*Bina* in 2012 was due to breaking down of a portion of the main canal which discouraged establishment of RBNs. Grid transplanting was avoided as a larger number of plots had been adapted under SRI, and cross marking would require additional efforts by the concerned VLRP particularly so in soils having high sand and silt content.

Table 5.13 Emergence of New Transplanting Patterns (as number of plots) under influence of SRI

Transplanting Pattern / Year	2008	2009	2010	2011	2012
Phalenda					
RBN + Grid Transplanting (M)	11 (6)	59 (35)	10 (8)	13 (9)	36 (19)
RBN + Line Transplanting (M)	0	0	112 (49)	75 (37)	27 (17)
RBN + Line Transplanting (E)	0	0	0	0	0
Saindha/Bina-Bijwad + Grid Transplanting (M)	0	0	0	0	6 (3)
Saindha/Bina-Bijwad + Line Transplanting (M)	0	0	2 (1)	21 (15)	25 (10)
Saindha/Bina-Bijwad + Line Transplanting (E)	0	0	1 (1)	2 (2)	1 (1)
Thayeli					
RBN + Grid Transplanting (M)	32 (13)	37 (15)	0	0	0.5 (1)
RBN + Line Transplanting (M)	0	0	67 (13)	53.5 (10)	74.5 (16)
RBN + Line Transplanting (E)	0	0	0	0	1 (1)
Saindha/Bina-Bijwad + Grid Transplanting (M)	0	0	0	0	0
Saindha/Bina-Bijwad + Line Transplanting (M)	0	0	0	5.5 (5)	28 (7)
Saindha/Bina-Bijwad + Line Transplanting (E)	0	0	0	0	0
Dakhwangaon					
SRI Type Nursery + Grid Transplanting (M)	9 (6)	7 (4)	0	0	0
SRI Type Nursery + Line Transplanting (M)	0	0	8 (5)	7 (5)	3 (2)
SRI Type Nursery + Line Transplanting (E)	0	0	0	0	0
Saindha/Bina-Bijwad + Grid Transplanting (M)	0	0	0	0	0
Saindha/Bina-Bijwad + Line Transplanting (M)	0	0	0	3 (3)	8 (2)
Saindha/Bina-Bijwad + Line Transplanting (E)	0	0	2 (2)	25 (18)	49 (41)
SRI Like Plots (SRI Like Farmers)	**52 (25)**	**103 (54)**	**202 (79)**	**205 (88)**	**259 (99)**

Figures indicate plots while () indicate Number of Farmers; Some farmers followed more than one method
M: Marked, E: Eye Estimation
Source: MVDA Records, 2008-2010 and VLRP Records, 2011 and 2012

In Dakhwangaon, the absence of an early and reliable source of water along with higher proportion of un-irrigated plots interfered with establishing RBNs at the appropriate time. Instead farmers used seedlings from *Saindha* and *Bijwad.* Farmers found it more sensible to use seedling beyond 30 days' age and with an increased number of seedlings per hill. Uncertainty of water prompted farmers to do line transplanting through eye estimation, which eliminated the marking operation and thus gaining time, while still getting the advantage from the wider spacing. Only few farmers having early access to water went for line transplanting (after marking) by using seedlings from RBNs. Thus in Dakhwangoan, line transplanting of seedlings from *Saindha/Bijwad* through eye estimation prevailed. In Thayeli, line transplanting of RBN seedlings after one way marking was prominent whereas in Phalenda, grid transplanting of RBNs seemed to be on the rise (Figure 5.3).

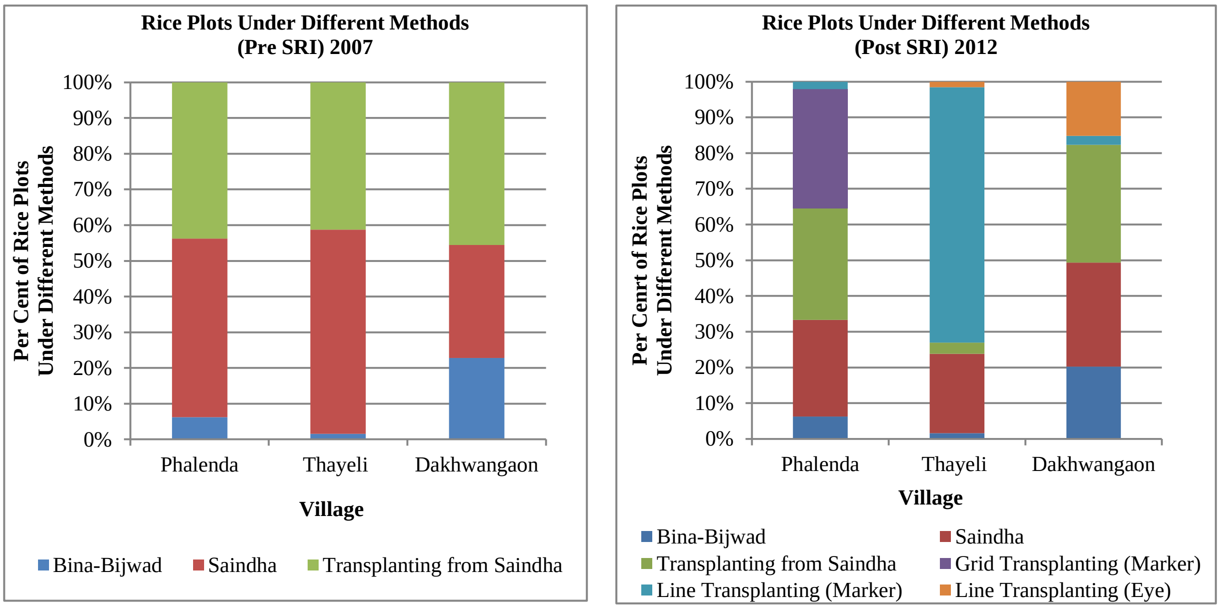


Figure 5.3: Rice Plots under influence of SRI (2011 and 2102)
Source: VLRP Records, 2011 and 2012

In order to understand the extent and type of plots which had been more or less influenced by SRI in the wet rice systems, 18 randomly selected farmers (those applying SRI elements) from the study villages (6 farmers per village) were investigated for seeding and transplanting methods pre (2007) and post SRI's (2012) introduction (Figure 5.3), considering all of their irrigated rice plots (n=190). As much as 40 per cent (77) of the rice plots were found to have been influenced by SRI aspects of transplanting. The influence was most prominent in Thayeli (73 per cent) having early and adequate access to water, in addition there was a high proportion of irrigaqted plots in close proximity to the habitat. Farmers of Thayeli justified the continued practice of *Saindha* as part of contingency planning. A farmer of Thayeli who undertook SRI in 11 out of the 13 plots through 4 RBNs in 2012, revealed "We undertake *Saindha* in two plots just to be sure that if seedlings fall short in SRI plots then replacements could be done from *Saindha* plots" [Personal Discussions, Thayeli, 23 August 2012].

The least influenced was Dakhwangaon (18 per cent) with lack of access to early and reliable water and consequently a higher proportion of rainfed plots. Mostly plots under *Saindha* and those which were earlier transplanted from *Saindha* had been influence by SRI aspects whereas those transplanted from *Bina/Bijwad* were least influenced. Since, transplanting from *Bina/Bijwad* was undertaken in plots where water was available only after the rains; these plots could not be covered under SRI as delayed transplanting would lead to delays in ripening and harvesting of the crop.

The wider spacing and reduced use of seedlings of SRI was also reported to have influenced even the customary transplanting practices resulting in a reduced planting density. According to the Programme Co-ordinator of MVDA "Though the farmers have not adopted all the recommended practices of SRI, they have neither rejected them totally. They have adapted the practices according to their situation and will continue to do so even if we withdraw our support" [Interview with Programme Co-ordinator, MVDA, Doni, 19 November, 2011]. Different forms of adaptations in crop establishment, in terms of source of seedlings, seedling age, number of seedlings per hill, and plant spacing, seems to have emerged according to the local context and experiential learning and skilling of women. The organization and composition of transplanting groups also got transformed and contributed to these adaptations.

5.6 Conclusions, Discussion and Implications

The study illustrates how introduction of SRI in a well-established farming system is influenced by the extant socio-material context across the villages. Agro-ecological variations, varying farm and plot conditions result in diverse transplanting methods. Such diverse methods arise through dynamic processes of adjustments in practices (existing as well as introduced) and reorganization of task groups. Over the seasons, SRI practice seeps through the community and gets integrated into their farming system, based upon interactions of old and new knowledge, experience and skills.

In the mountain farms, alternative ways of growing rice (here we are only talking about transplantation) allowed farmers to cope with differences in elevation, accessibility to water, and diverse cropping pattern besides other off farm activities. Transplanting period in these customary practices was largely set in tune with the above landscape elements. Transplanting characteristics (time, seedling age, number of seedlings per hill and hill spacing) and task organization varied among farm households with rice variety, water, land and labour availability. Staggered transplanting activities, labour exchange amongst households and suitable planting density (for controlling weeds) contributed to stabilizing rice yields in harmony with other farm and off farm activities. This synchronized performance involved complex and coordinated socio-technical interactions between members of individual farm households and their collectives, with other material resources such as seedlings, soil and water. How did the newly introduced SRI practices engaged in the different settings?

SRI practices brought in new dichotomies related to transplanting: young vs old seedlings, few vs more seedlings per hill, and dense vs wide hill spacing. Most of the practices under SRI require special care and impose 'demands' on farmers' labour and skills" (Glover, 2011b). This study highlights ways in which transplanting in SRI demanded more complex and coordinated socio-technical interactions. Having young delicate seedlings transplanted at the right moment with uncertainties about availability of water, bullocks, plough men and VLRPs posed considerable challenges for farmers. The act of marking prior to transplanting interrupted the work rhythm and caused loss of time. Transplanting under SRI, not only demanded new practical skills for working with young seedlings but also managerial skills for arranging the required resources in time as well as in space. The young rice seedlings had to cope with varying farm (labour, cropping pattern, social relationships) and plot conditions (climate, soil, water, insects, and weeds); likewise the already overburdened women had to adapt to a new way of transplanting. Introduction of SRI thus, interfered profoundly with existing practices and the larger farming system. Existing arrangements for transplanting groups, and their coordination with other activities required adjustments to accommodate SRI. How did farmers respond to the situation?

We observed farmers making a range of adjustments in techniques, timing and changing the composition and coordination of task groups. This was facilitated by the SRI promoting agency, which had revised the various guidelines. Decisions pertaining to transplanting variables (time, seedling source, seedling age, seedlings per hill, and spacing), and to organization and working of transplanting groups (size, gender, skills, and task distribution) were adjusted with due consideration of socio-technical elements at landscape, farm and plot level (See Table 5.14). Elevation, canal layout, water availability, cropping pattern, social customs, and relative distance between irrigated and un-irrigated plots were some of the landscape elements that influenced these decisions. Similarly farms and plots with diverse characteristics did influence labour organization around transplanting and choice of specific adaptations. Over the seasons, women and their collectives gradually reorganized labour, learned and redistributed skills, while integrating local and new knowledge; SRI elements were adapted through experience and experimentation.

Table 5.14: Socio-Technical Elements influencing Decisions related to Transplanting Groups and Tasks

Decisions / Level	Transplanting Group	Transplanting Time	Source of Seedling	Seedling Age	Seedlings/ Hill	Seedling Spacing
Landscape	Cropping pattern, Livelihood Opportunities	Elevation, Canal layout, Social customs	Elevation, Water availability	Elevation, Social customs, VLRP, Access to un-irrigated plots	-	-
Farm Household	Labour, Age, Experience, Skills, Relationships, Off-farm activities	Bullocks, Ploughman, Relationship with VLRP, Contingencies	Labour, Cropping pattern, Contingencies	Seedling source, Bullocks, Ploughman, Relationship with VLRP, Contingencies	Seedling Source, Age, Experience, Skills	Number of SRI plots, Relationship with VLRP
Plot			Access, Previous crop		Soil-moisture conditions, Soil-biota, Gap filling	

The study thus exemplifies processes through which ‘performance knowledge’ is recreated and ‘performance skill’ (Richards, P., 1993) modified with the introduction of a new agricultural techniques that usually are not part of the information provided by private sector sales agents interested in selling their costly high-tech products and innovations. SRI seems to have been incorporated into the existing irrigated rice systems in each of the villages more as a socio-technical association than just as a package of technical practices. Different forms of transplanting emerged in accordance with the local bio-physical and socio-economic contexts. Overall, increased usage of young seedlings and reduced planting density (though still more than recommended for SRI) was recorded/observed. Simultaneously transformations occurred in the composition of transplanting groups, and in their coordination for nursery establishment, land preparation and marking operations. Tasks were redistributed, with young girls actively participating in the widely spaced SRI type of transplanting while the elderly women contributed to uprooting of seedlings from raised bed nurseries apart from continuing to transplant the non-SRI plots in the traditional "clump" practice. The extent to which SRI elements get accommodated in the irrigated rice systems also depended upon the local socio-material context of the villages.

Introduction of SRI led to extension and diversification of the repertoire of local methods. New forms of transplanting patterns emerge across the farms through the processes of 'necessity', 'novelty' and 'selection' resulting into technological 'diversity' as described by Basalla (1988). Deviations from recommendations and adjustments in existing practices were done both by intention and as dictated by circumstances. The evolution of the practice of line transplanting through eye estimation in Dakhwangaon demonstrates how farmers' common sense, instinct and embodied skills can outweigh and modify new agricultural advice. The diversity of practices, both customary and adapted SRI practices together helped farmers coping with contingencies, especially at the plot and farm level. This phenomenon of farmers, exploiting and creating farm diversity, by adapting the new technique to the existing diversity reflects their strategy of trying to take advantage of new ideas and techniques but doing so in a more creative and innovative ways, than scientists and development agents usually have recognised. way. It also shows how SRI as a package of practices cannot be a singular solution for rice cultivation across all situations.

The ability of farmers to experiment and innovate is now well recognized (Richards, 1989; Morrison, 1996) and is reemphasized by the present study. The process of incorporation of new practices with customary transplanting practices by women is guided by farmers' previous knowledge (about climate, soil, water, varieties and social coordination), as well as their perceptions and receptiveness to new ideas (about young seedlings and reduced planting densities). Experience was gained through experimentation with rescheduling of transplanting time, spacing by eye estimation, and skill organization in the local context of operational circumstances (landscape, farm and plot conditions). Strategies often changed with varying farm and household level conditions and across seasons, illustrating how the actual practices followed by a farmer are often dictated by 'circumstantial adjustments rather than combinatorial logic' (Suchman, 1987).

The study illustrates the relevance of 'technical' and 'managerial' skills in labour intensive irrigated rice cultivation; especially around organizational improvement of labour and skills (Bray, 1986) at the critical moment of seeding/transplanting. The much debated labour issue in SRI seems to have been better managed in the mountain farms than has been reported for other rice growing regions. This has been primarily possible through redistribution of tasks among the young and elderly while the tradition of labour sharing within and amongst farm households has facilitated the process. Inclusion of younger women and girls also helped in meeting additional labour requirements during the time of transplanting, when there was - at the same time - a peak demand for labour in rainfed plots. The study thus argues for reconfiguration of labour along with task reorganization for bringing about technological changes in labour intensive farming systems.

Past studies measuring labour only in terms of ‘person hours required per unit transplanted area’ have grossly overlooked the critical aspects of labour management and organisation. On the other hand, efforts required to mobilize resources (water, bullocks, ploughman for field preparation; VLRP for marking; and experienced/skilled women for transplanting) for timely transplanting often prove to be quite tedious. The young are found to be more adaptable to the new set of transplanting skills while elderly women resisted the process and require more time to adjust to the new practices. Integration of knowledge about local conditions with new knowledge about the benefits of SRI elements does not happen automatically but is build up over seasons of experimentation and experience. The dynamics of labour management for SRI and other agricultural interventions, in terms of time, knowledge, use of skills and organization, need to be further researched under different forms of labour use.

The study illustrates how agricultural interventions are manipulated technically and socially by farm households and communities according to the needs of the crop, farm household characteristics and local bio-physical conditions. Analysis of changes brought in transplanting under the influence of SRI presented here highlights the need to recognize and build upon embodied human improvisational capacities while designing, introducing and assessing agricultural interventions. The study underscores the need to adapt general principles of rice/crop physiology to suit a particular community at a particular time and location. This in turn requires a long term effort, incorporating flexibility and course corrections by facilitating organizations to help communities adapt new techniques.

Hunt (2000) identifies three dimensions of agricultural labour: time, knowledge and skills, the latter two, he argues often being overlooked. Evaluating the time dimension can be a complex exercise. For example, the time spent in organizing resources is often not counted when measuring labour use in transplanting. Bray (1986) also sees labour primarily as skill, showing how the rice systems of Asia intensified over centuries with skilled labour as the main technological driver of this development. Transplanting among rice communities of Southeast Asia is mostly undertaken through women’s groups. The concept of the task group (McFeat, 1974; Sigaut,

1994) helps to identify the relationship between the composition and working of such transplanting groups. Group formation, McFeat argues, emerges with and around the completion of a commonly defined task. Rather than a certain group of farmers adopting an innovation, it is newly introduced tool or farming method that adopts a group through the task the innovation requires.

The concept of ‘agriculture as performance’ recognizes farmers’ adaptive and improvisational capacity with regard to application of time, knowledge and skills (as labour components) in interactions with materials and artefacts (Richards, 2010). The performance notion in combination with institutional analysis of task groups involved in transplanting can help understand how ‘social change’ is (re)organized collectively to deal with socio-technical constraints, more so with the introduction of SRI under diverse conditions and circumstances Harrington and Fine (2000) encourage to explore ‘links among culture, interaction and structure’ for such groups for understanding the organization and functioning of such groups. Focusing on transplanting, the questions to be answered are how labour groups organise and perform transplanting and what changes in group formation and task performance occurred with the changes introduced in transplanting practices under SRI?

Chapter 6

General discussion

Smallholders' Adaptation Strategies in Rice Farming

6.1 Summary

Smallholders in India (as in other parts of the world), especially in agriculturally marginal regions, have been largely bypassed by the GR. In recent times SRI has been presented as an alternative way of growing rice that is within the realm of smallholders. This study therefore sought to understand smallholders' engagement with SRI in a grossly neglected agro-ecological region of India, the Western Himalayan region. It explored and elucidated the processes of farmers in adopting and adapting SRI in diverse ways.

Past studies on SRI have sought to explain farmers' responses and technological changes in rather simplistic, neat and distinct categories of adoption, non-adoption and disadoption. This study has taken a different approach going beyond the simplistic model of 'adoption' within a binary frame (of yes/no). By studying the activities and motivations of smallholder rice farmers in three particular settings of Uttarakhand, this research suggests how socio-technological changes were accomplished in the wake of the introduction of a new set of recommendations and techniques.

Technologies, whether SRI or the conventional technologies of the GR, put into practice, require coordinated human efforts, besides material requirements, to be made effective. The new technological configuration has social implications. To explain farmers' uptake of an agricultural innovation, it is necessary to understand how farmers exercise practical and managerial skills individually and collectively, taking into account the interplay of material, social, intellectual and agro-ecological elements.

The main objective of this research was to assess and explain the nature, extent and processes of socio-technical adaptations that farmers developed and realised as a consequence of SRI's introduction. The main research question of the thesis was "How was SRI incorporated into the local rice farming systems by farmers in practice?" Specifically, the thesis asked how existing work groups were adjusted to accommodate the new method and, at the same time, how the SRI practices were reinterpreted and adjusted to fit with the local social and agro-ecological arrangements.

The study used a conceptual framework comprising three inter-related concepts: the socio-technical system analytical frame of exploring and investigating the material alongside social interactions; the concept of 'agriculture as performance' highlighting the dynamic interactions in time and space by farmers; and the institutions and culture of 'task groups' responding to changing and changed situations. The rice farming system consists of agricultural work groups that have been considered here as groups of people performing particular farm operations at different stages of the rice-growing cycle. McFeat's (1974) notion of task groups' culture was used in the thesis to understand and explain how the working of such groups is related to their composition and function. More specifically, how reorganizations of such groups take place following the introduction of SRI. These social groups also interact with materials such as canal, water, ploughs, bullocks, rice and soil, while performing specific tasks. Hughes' (1989) concept of socio-technical system helped in analysing how such configurations of social and material elementsare (re)constructed and in turn shape social structure, while Richard's (2000) notion of performance gave due attention to farmers' innovative and adaptive capacities to reconfigure tasks and labour according to the local context and in interaction with the socio-material landscape at the village level.

The empirical research focused on three contrasting villages of Uttarakhand located in the agriculturally marginal Western Himalayan region of India, which had been exposed to SRI since 2008. The three villages were chosen in order to encompass diversity in terms of agro-ecological locations, especially with regard to the irrigation system and elevation. The study followed the smallholders' rice farming communities of these villages mainly across two rice seasons, observing and investigating practices in the farm plots as well as co-ordination among and within different work groups. This made it possible to understand the processes responsible for farm-based technical and institutional adaptations in practices under diverse and dynamic contexts.

The study particularly focused on the crop-establishment phase of the rice crop, covering nursery management, land preparation, transplanting, and water management, in order to explore how farmers cope with attending to rice and other crops at the same time. These operations, which are critical for obtaining a successful crop, are scheduled in the beginning of the rice season, a time when labour demand for other farm activities related to the growing of other crops is also at its peak. Farmers' response to SRI in the wet-rice systems therefore had to be understood in conjunction with activities going on simultaneously in the dry rice systems and other rainfed crops.

The next section (6.2) provides the chapters' overview highlighting key inferences from the different chapters. Section 6.3 provides answers to the research questions analysing the interactions among and within different agricultural work groups and their response to the introduction of SRI. Section 6.4 will discuss findings along with theoretical and methodological contributions, while section 6.5 will deliberate upon implications.

6.2 Overview of Chapters

The sections below summarize the major research findings from the four empirical chapters (2–5) of the thesis. Each of these chapters focussed on a sub-set of the larger rice farming system, addressing a particular operation and probing into different interfaces of interaction. These were those between (a) agricultural work groups and the larger socio-material landscape (for water management), (b) work groups for different related practices (for land preparation and transplanting), (c) different agricultural work groups performing a similar operation (i.e. raising seedling), and (d) members of the same agricultural work group jointly undertaking the same task (i.e. performing transplanting).

The role of landscape in water management (Chapter 2)

Chapter 2 explored how the rice farming communities in the three study villages had to adjust water-related activities and related cultural norm (*Din Bar*) in response to the crop–water management system (AWD) that was introduced as part of the SRI concept. Across the three villages the proportion of land allocated to different customary wet-rice cultivation practices (*Saindha*, transplanting from *Saindha* or *Bina-Bijwad*) varied according to the nature and extent of the canal irrigation infrastructure, local topography and prevailing cropping pattern. Within a village and a farm, the timeliness and adequacy of water availability were primary influences on the choice of wet-rice cultivation method for a particular plot. In addition *Din Bar* is a traditional local practice of declaring a common date to initiate transplanting. The announcement of *Din Bar* under the existing routine was tuned to the likely availability of adequate water for transplanting as well as the release of women labour after land preparation and seed sowing operations in the rainfed plots had been completed. The canal irrigation infrastructure with limited distributaries in a terraced landscape imposed cascade irrigation along with a rotational distribution system, to share water fairly amongst the rice growers. Changing the water regime in a single field, as recommended for SRI, was therefore likely to have a cascade effect too.

Water management involved the whole farming community. The simultaneous need to weed the rainfed plots prompted farmers to flood the rice plots more than the crop required in order to control weeds (and also water beetles), because this facilitated labour allocation across both rice and rainfed crops. This implied labour coordination even extending beyond the irrigation operations. Water distribution and application was therefore closely intertwined with the farming activities at the individual farm and at the landscape levels.

Initial experiences in the villages, especially in Dakhwangaon located at a higher elevation, showed that young seedlings under SRI needed to be transplanted early for timely ripening. Early transplanting, required water and labour, as well as the advancement of the *Din Bar.* The three farming communities studied responded differently to this requirement, influenced by their respective agro-ecological settings.

The response in each location depended on the possibility of obtaining water early, which depended on the perennial or seasonal nature of irrigation; and labour, which was subject to the proportion of rainfed crops in the village.

Thayeli opted for complete abandonment of *Din Bar* as early and sufficient water was available from perennial canals for most of the plots, and the relative proximity of irrigated rice plots, outnumbering the rainfed plots, allowed for easy labour movement around the fields. In Phalenda, for many farms, though water was available, the preponderance of remotely located rainfed plots limited the capacity to adopt early transplanting, mainly because of labour constraints. The community settled for two different *Din Bars*, one for early SRI and the other for the customary practice. In Dakhwangaon, with no access to early water and a much higher proportion of rainfed plots that were located far from the centre of population, no change was made in the timing of *Din Bar*.

AWD was tried for the first two years (2008 and 2009) and then abandoned completely in all the villages. Under the cascade and rotational irrigation system, an SRI farmer would have to allow water through his or her plot for the benefit of downstream users, making the application of AWD an impossible proposition for individuals. It also demanded regular visits to the SRI plot to monitor and control weeds and water beetles (which prefer a drier environment), while excessive flooding might cause mortality of young seedlings that needed to be replaced. This was restricted by concurrent needs to attend to the rainfed plots for other crops. The effectiveness of AWD also depended on a reliable supply of water, even after early transplanting, in order to carry out timely and regular operations of the mechanical weeder to check weed growth. An unreliable water supply, cascade and rotational irrigation systems, and diversified cropping patterns along with scattered landholdings thus interfered with the application of AWD practice in fundamental ways.

The integration of SRI into the crop production system therefore called for major adaptations in the recommended SRI practices. This was achieved in various ways. Rather than AWD or traditional liberal flooding, shallow flooding was introduced by the farmers in SRI plots, especially in the early crop stage. This checked weed and water beetles, while allowing flexibility in labour use between irrigated rice plots and rainfed plots. This was possible in Phalenda and Thayeli, whereas in Dakhwangaon farmers continued with the use of older seedlings and a traditional flooding regime, due to uncertainties in water availability.

The layout of canals, reliability of water supply, location of farms relative to habitats, and plot characteristics (size, shape, soil–moisture conditions, and biota) further guided the allocation of SRI to particular plots. SRI plots were concentrated in the upper and middle reaches of canals, and located relatively close to farmers' homes.

Application of AWD under SRI in the mountain setting demanded simultaneous changes at the community level (rescheduling *Din Bar*), farm level (allocations of time and labour for regular monitoring of SRI plots) and plot level (controlled water application and checking of weeds). The rearrangements in crop–water management practices were made at two connected levels: canals and community (the village level), thus influencing the cultural norm of *Din Bar*, and plots and farmers (the *tok* level), influencing the choice of plots for SRI and water application practices.

Aligning land preparation with transplanting (Chapter 3)

Chapter 3 investigated the social and technical factors and processes that influenced the land preparation practices with SRI's introduction. Transplanting widely spaced, young, single seedlings in un-flooded soils readily encourages abundant weed growth. To prevent this, the plot needs to be thoroughly cleaned of weeds before transplanting, and further weed growth needs to be controlled. Farmers are therefore advised to undertake thorough wet ploughing (to rot the weedy residues), trampling (to break and bury weedy residues), and additional levelling (to avoid water ditches preventing aerobic conditions) and to use mechanical weeders (to economise on labour during weeding). Apart from the requirements of water, bullocks and planks for ploughing and levelling, the plants need to be arranged in regularly spaced rows or grids to allow easy passage of the weeders. To achieve the regular spacing, some kind of marking system is highly desirable.

Under the customary practice, field preparation was scheduled once rainfed plots had been prepared and sown, which freed critical resources for use in irrigated fields. With the announcement of *Din Bar*, labour, and draft power were shifted from rainfed plots to the wet-rice system and water was released sequentially to different *toks*. It was into this tightly interwoven set of activities that SRI had been introduced. Contrary to the expectation that SRI plots will be thoroughly ploughed, levelled and planted in regularly spaced grids, different patterns of transplanting evolved in all three villages. These were: square grid transplanting, line transplanting in rows only, and line transplanting without the use of markers.

The additional tasks of field drying and marking created a hiatus between land preparation and transplanting operations, interfering with existing institutions for smooth labour organization and coordination. Unavailability of water subsequent to drying could result in unwanted weed growth or even crop mortality. Marking, especially cross-marking using the metal marker was considered to be a specialized skill requiring experience. Unfavourable plot characteristics such as small size, irregular shape, and sandy or silty loam soils made marking difficult in some plots and locations. These challenges were dealt with by manipulating various practices. Additional levelling was done (depending upon water and bullock availability); the *Din Bar* custom was changed (depending upon elevation and water availability); water was drained from fields after levelling (depending upon subsequent water availability); and marking was done in different ways (appropriate to the soil, water, plot size and shape, availability of skilled labour, and social relationships).

Adaptations in technical practices were accompanied by changes in social organization, for example new arrangements for supplying bullock power and water to the fields, building relationships with VLRPs, and reconstituting transplanting groups. In Dakhwangaon, uncertainty of water supply and the preponderance of rainfed plots encouraged most of the farmers to skip these additional tasks altogether, while switching to line transplanting by eye estimation alone. Farm households in Phalenda and Thayeli that had access to water, opted to drain SRI plots overnight, thereby reducing the time lag between land preparation and transplanting. Additional levelling was more or less rejected, mainly due to the constraints in obtaining bullock power when required. Responsibility for marking was largely handed over to the VLRPs whose social status in the concerned communities changed. Women whose plots were to be marked on the same day got together to transplant one another's plots. To reduce pressure on the VLRP and to further reduce the time lag between the completion of levelling and the commencement of transplanting, one-way marking was adopted instead of two-way, grid marking. Farm households of Thayeli in particular preferred one-way marking because they had put a larger number of plots under SRI, and the soil conditions were not conducive for cross marking.

These reconfigurations were worked out by the farming communities themselves, creating different options according to the characteristics of landscape, farm and plot. Farm households modified marking practices according to changing farm conditions and circumstances across the seasons. The observation that some farm households of Phalenda later shifted to doing cross-marking in fewer plots, because grid transplanting resulted in higher yields, while doing line marking in others, indicates that marking patterns were adapted with greater experience.

Each marking pattern (including eye estimation without marking) implied a different set of socio-technical configurations. The choice of marking was decided collectively by the plot owners, VLRPs and the concerned transplanting groups taking into account water availability, elevation, farm labour, bullock availability, social affinities and conflicts, and plot characteristics. The goal was to achieve a balance between rice and rainfed crop production (a concern for the plot owner) and the demands of time, skill and effort (for the transplanting group and the VLRPs), while also maintaining social relationships. Adaptations relating to field preparation following the introduction of SRI thus brought about new forms of socio-technical configurations including changes in social status (of VLRPs), according to the local context.

Interactions around nurseries (Chapter 4)

Chapter 4 explored how the introduction of the RBNs under SRI affected the organization of seedling production as a socially coordinated agronomic activity. Rice farmers in the three case study villages were commonly deviating from the recommended nursery management practices and even using seedlings from other sources. Moreover, not all farmers doing SRI transplanting were raising their own RBNs. Farmers made a variety of arrangements to procure seedlings.

Wet-rice cultivation in the villages was undertaken both by direct seeding of sprouted seeds in puddled plots (*Saindha*) and through transplanting from dry bed nurseries (*Bina-Bijwad*). Thinning of *Saindha* plots was an additional source of seedlings for transplanting. Customarily there were two sources of seedlings: the *Bina-Bijwad* nurseries and the *Saindha* beds. Seedling raising under these two practices involved a range of operations. Scheduling and location of these nurseries took into account elevation, irrigation, cropping pattern, accessibility, soil fertility, the layout of the main plots to be transplanted, and the availability of the work force. Agricultural work groups organised for seedling-raising primarily involved women members of the same farm household, except for ploughing (where ploughmen and bullocks were hired) and irrigation (for which water was shared with others). While establishing and raising *Bina-Bijwad* and *Saindha*, farm households also attended to preparation and seeding of rainfed plots. Women got into diverse configurations on a day-to-day basis for the management of different operations of *Saindha*, *Bina-Bijwad,* and rainfed plots. A considerable range of flexibility was allowed in the usage of different seedling sources and seedling ages, enabling distribution of the workforce between seedbeds and rainfed plots; this also helped farm households to cope with uncertainties in farm conditions. The introduction of RBNs under SRI imposed restrictions on farmers with regard to seedling source and age.

Raising young, healthy and vigorous seedlings from RBNs required greater care with respect to bed preparation, fertilization, seedling density, intermittent irrigation, and the elimination of pests and diseases. On one hand, the size and period of RBNs was short compared to existing practices, and required less seed and water. On the other hand, it entailed a new set of activities, requiring additional materials as well as skills: treating seeds with cow urine, preparing raised beds, incorporating manure, sparse seeding density, mulching and aftercare (primarily regular watering). Also, uprooting and transplanting of the young seedlings had to be done in a timely manner, at the proper stage of growth to avoid transplanting shock, encourage tillering and achieve ripening at the desired time moment. This required early establishment of RBNs. The new nurseries also demanded suitable plots that could be checked and watered regularly. All these operations required labour to be available at the time of establishment as well as for aftercare. This created an obstacle for early establishment of RBNs because at that time labour was required to attend to rainfed plots. New institutional arrangements as well as technical modifications were required in order to incorporate RBNs in the wet-rice system.

To most farm households of Dakhwangaon the RBNs made little sense, particularly because water was not available for early transplanting. These households found it more convenient and sensible to use seedlings from *Saindha* plots or *Bijwad* nurseries. In Phalenda and Thayeli, despite having access to water early in the season, not all the farm households were able to or wanted to establish RBNs on their own, due to land and/or labour constraints. The smaller size of the RBNs, however, opened up the possibility of establishing multiple nurseries in a single plot. Many of the farmers therefore preferred to raise multiple nurseries collectively on a common plot. The plot should have access to water and be convenient for close supervision. It also helped if the plot used for nurseries could be transplanted easily once the nurseries had been uprooted. Some farmers, having fewer social affiliations and/or independent access to the required resources, preferred to have private nurseries in order to exercise more control over raising seedlings.

Work groups for jointly raised multiple RBNs were formed taking into account the suitability of locations, kinship, caste, group affinity, and past experiences. Farm households were even willing to raise RBNs on behalf of others, or handing out surplus seedlings at transplanting time, since the RBNs were easier to manage and for a shorter time. Besides sharing the common plot, nursery owners shared material resources (seed, cow urine, manure), labour and skills, depending upon their relationships and circumstances. Farmers in Phalenda relied more on pooling work at the RBNs because they had a higher proportion of rainfed plots than in Thayeli. The close proximity of rainfed and irrigated plots, and a greater number of households having experience in raising RBNs, were factors that discouraged farmers in Thayeli to share labour in the common nursery plots. The jointly raised multiple RBNs provided a platform for beginners to learn how to raise seedlings for SRI, which reduced the role of VLRPs in establishing these nurseries in later years. Tensions around jointly raised RBNs, regarding issues such as delays in transplanting of the nursery plot, losing fertile top soil, the risk of mixing different varieties, and concerns about fair sharing of work, were negotiated and accepted in view of the larger benefits offered by RBNs – healthier seedlings at the right time, and convenience of easy management.

The experience with RBNs over the seasons helped farmers to adapt the technical specifications to suit their conditions. Some of the specifications, such as the use of cow urine, sprouted seeds, and manure, were made optional according to the availability of time and resources. The seeding density was slightly increased, based on experience of gap filling. A spillover effect of RBNs was observed in *Bina-Bijwad* and *Saindha* systems, with a reduction in seeding density as farmers began to apply wider spacing when transplanting from these sources as well, especially in Phalenda and Thayeli. Farmers preferred to have RBNs alongside conventional seedling sources, because it helped them to use and exchange inputs and seedlings. This helped them to manage risks (e.g. delayed rainfall) under varying farm conditions.

The RBN thus triggered processes of technical adaptations and social innovations, bringing about concurrent changes in both the recommended SRI package and customary practices. The socio-technical adaptations were contingent on local agro-ecological factors, leading to differences and variations across and within villages. Farm households made choices for different configurations depending upon their material and social circumstances. The overall goal was to make access to seedlings easier and more convenient and dependable in ways that suited the local situation.

Operationalizing Transplanting Groups and Practices (Chapter 5)

Chapter 5 presented the findings from a detailed analysis of the composition, operations and coordination of transplanting groups on why and how do farmers change their practices in response to SRI's introduction. It explored the changes brought in transplanting and its ramifications for labour and skill organization. MVDA initially advocated transplanting a single 8–12 day-old seedling from RBNs after cross marking, ensuring 25 cm plant spacing in square grids. RBNs needed to be established in time (a challenge in itself, Chapter 4) accompanied by advancement of the *Din Bar* (Chapter 2), in order to establish the seedlings in the field at a time that would permit a synchrony in the harvesting time. The young delicate seedlings had to be carefully uprooted without damaging the roots in contrast to the existing practice of pulling out seedlings which does damage the roots. Marked, muddy and levelled fields had to be ready in time for early transplanting which could be problematic with unavailability of water and bullocks, delayed drying of plots depending on soil conditions, and unavailability of VLRP for marking (Chapter 3). Women labour that were also busy at the rainfed plots, had to be reorganized to undertake transplanting that too as per the new specifications.

The new specifications (single plant in widely spaced hills) demanded care and attention, and therefore was considered tedious especially by the beginners. Women were expected to change over from their habitual backward movement to forward movement while transplanting to follow the marked lines and to avoid the removal of marks. These operations had to be coordinated in a timely manner to avoid delays and minimize transplanting shock. What was observed and frequently mentioned was an overall discomfort with the initial barren look of the SRI plot. This was despite the fact that farm households had previously witnessed fully grown SRI fields. So it was not that they couldn't believe that the canopy will fill. Yet the adjustments required in labour organization and practices were considered too demanding.

Farmers responded to the challenges by rescheduling operations, reorganizing labour and adjusting transplanting practices while reinterpreting the SRI guidelines as per the local context. The local promoting agency relaxed the SRI guidelines after two years, allowing line transplanting as farmers found difficulty in grid transplanting. Grid transplanting implied more time and efforts on the part of the VLRPs while marking, and also more care and attention while transplanting for the women. Most farmers of Dakhwangaon favoured transplanting of older seedlings from *Saindha* and *Bina/Bijwad* as they could not do early transplanting of young seedlings from RBNs due to lack of water and labour (Chapter 4). Even marking was abandoned by them due to uncertainty of availing water after drying (Chapter 3), switching over to line transplanting just by eye estimation. Farmers of Thayeli and Phalenda having better access to water preferred early transplanting of young seedlings from RBNs, and therefore either abandoned or rescheduled *Din Bar* accordingly (Chapter 2).

To avoid delays in transplanting, plots were left for drying overnight after preparation and marked on the following day. Seedlings were preferably uprooted in the morning and women whose plots were likely to be marked on a day formed padiyals and proceeded with transplanting as plots were marked. With more women waiting for marking, *padiyals*got bigger speeding the transplanting activity. Young girls joined line and grid transplanting as they found it easier to follow marks as did the elderly women. Transplanting groups were thus transformed in size as well as age due to new requirements of quick transplanting and different set of transplanting skills. While younger women participated in new transplanting activities, the older women took on the task of uprooting at RBNs and continued transplanting in the non-SRI plots.

Farm households based on their local knowledge (about elevation, soil-moisture conditions, soil biota, crop varieties) and experiences gained over many years and generations, made choices for source, age, number and spacing of seedlings. These decisions were also influenced by farmer's circumstances (availability of bullocks, labour and skills, cropping and livelihood patterns). Different forms of transplanting (grid transplanting, line transplanting after marking, and transplanting by eye estimation) emerged in the villages in combination with usage of seedlings from different sources i.e. RBNs, *Saindha* and *Bina-Bijwad* in accordance with the local bio-physical and socio-institutional contexts. Observations and discussions with farmers also revealed reduction of planting density in the customary practices along with SRI plots, indicating farmers' capacities to integrate local and new knowledge for achieving their goals.

Early experiences of SRI show how the introduction of new practices interfered with existing internal coordination of transplanting groups and coordination with other activities. Over the seasons, women and their collectives reschedule operations, regroup labour, learn and redistribute skills, and reorganize tasks integrating local and new knowledge and building upon experimentation and experience. These processes reflect that SRI seems to have been incorporated within the existing wet rice systems in each of the villages more as a socio-technical movement than just as a package of technical practices.

The thesis illustrates through the example of SRI, how new technologies are often assumed to fit automatically into any farming system overlooking the local complexities, uncertainties and constraints. It shows how an introduced practice such as SRI cannot function as a package guaranteeing a pre-determined outcome; neither do farmers adopt such package without introducing adaptations, which are dynamic and flexible processes. In spite of the challenges introduced by the SRI practices, farmers however do not out-right reject them. They rather try to integrate the practices according to the local context, leading to the extension and diversification of the repertoire of methods. Well-coordinated simultaneous changes are brought about in existing practices as well as in the recommended SRI, along with socio-cultural changes. The study illustrates the unobserved capacities and abilities of farmers to respond to new technological propositions/recommendations. The increased diversity of practices, both customary and adapted SRI practices together, helped farmers coping with contingencies at farm as well as plot level. Farmers thus try to take advantage of new ideas and techniques but in a more creative and innovative way than through simple adoption or rejection. Instead, they search actively to create and exploit the diversity in farming thus improving the bio-diversity and resilience of their farming system.

6.3 Conclusions: Smallholders' Rework SRI in the Mountain Farms

Rice farming involves a number of operations (sets of technical tasks) to be done in sequence from seed-sowing to crop harvesting, undertaken by social actors (primarily members of the farming communities) in interactions with material objects. Thus rice farming operates as a dynamic socio-technical system changing over space and time. The mountain farmers of Uttarakhand, also representing other smallholders of the country, grow rice along with a variety of other crops in a diverse cropping system. The topography of the mountains, with rice and non-rice plots laid across slopes, makes this a complex farming system. It was therefore critical to understand how the rice farmers co-ordinated among themselves to achieve an overall satisfactory performance. The study also examined both risks and opportunities created through the introduction of SRI and the manner in which farmers handle these.

Complex but Harmonious Performance

The complexity of mountain farms is revealed in both its material features based on the topography, and the work organization required to carry out several and often simultaneous operations for handling it. The mountain farming situation is primarily rainfed with annual variability, fragmented small farms with limited irrigation, and diverse crops grown along with forestry and animal husbandry activities. The direct seeded rainfed crops (including unirrigated *Sathi* rice, millets and pulses) are grown at higher elevations and in absence of irrigation. Even where irrigation is available, the variations in water availability in terms of timing and quantities give rise to diverse forms of wet-rice practices, namely *Saindha* and rice transplanted from *Saindha* plots and *Bina* nurseries (See Chapter 2). Work organization around such farms becomes tedious with limited labour availability, especially at the start of the season when there is a peak in labour demand. Conventionally labour during this period has been organized through socio-cultural rituals such as the *Din Bar*.

Smallholders in the mountain farms perform various operations collectively through various agricultural work groups. The very first operation of sowing or nursery-raising was primarily done by members of the same farm household but often also required other individuals including ploughmen and help from the community as a whole. Community involvement was necessary for ensuring fair access to water, which was available in limited quantities for the nursery plots especially in the early part of the season. Sowing or nursery operations involved working with rice seed and seedlings, irrigation infrastructure, bullocks, ploughing implements and water (Chapter 4).

The next operation of field preparation, for transplanting of rice seedlings, required coordination among ploughmen and the farm households concerned, along with timely availability of water and bullock pairs. Both water and bullocks are scarce resources at a stage when many crops are being planted at the same time (Chapter 3). The subsequent act of transplanting was done by women organised in groups known as *padiyals*, sometimes with additional labour (in the guise of relatives even coming from outside the village). The village council, representing the community, consulting the village priests for rituals such as *Din Bar*, were also called into action in a coordinated social performance of agriculture (Chapter 5). The water management aspect cuts across all the different operations covering both rice and non-rice plots, which are distributed according to the topography. Traditionally rice plots, once transplanted, are kept flooded to control weeds and insects, which permit farmers to allocate the limited labour across rice and rainfed crops.

Different agricultural work groups thus emerge from the farm communities across the rice crop's establishment period to carry out specific tasks. This requires coordination because each operation involves a wide range of social actors and material elements in various configurations. Practices within the wet-rice systems vary according to the field conditions and farm households' circumstances and priorities. Labour intensive operations of rice, such as land preparation and seeding/transplanting are staggered between the *Saindha* and *Bina* plots, so that the labour requirements for the other crops grown by rainfed farms can also be met simultaneously. Informal rules and routines related to seeding and transplanting schedule, water distribution and application, seeding and planting density have been evolved to keep the wet rice systems functioning in harmony with the rainfed system.

What does all this imply in terms of how socio-technical configurations emerge and operate under rice farming, especially in the context of mountain farms (first research question)? The study illustrates farmers' ability to collectively organize the labour, skill and materials necessary to perform specific operations, while coping with the limited availability of resources and diversity in mountain farming. Coordinated action within and among a range of agricultural work groups is facilitated through building relationships and establishing informal rules and routines relating to the sequencing and allocation of work activities. The flexible structure and working of such work groups enables farmers to (re)configure them according to the task and the site where the work is to be done (i.e. the agro-ecological and topographical setting), and cope with complex uncertainties associated with weather, water supply and other factors. These mountain farmers' actions are rather like a concert performance involving an agglomeration of individual musicians, organised into functional task groups, who – though playing different instruments – collaborate in generating a symphony. An agency attempting to introduce new crop-management practices into such an intricate system therefore cannot address discrete agricultural tasks and engage with individual work groups in isolation, but must account for and build upon their interlinkages.

Encouraging Adaptation

The introduction of SRI introduced new human actors into rice cultivation in the villages, i.e. the NGO personnel (particularly the MT), and a new role to be performed by an individual farmer, the VLRP. The new method required changes in nursery raising, land preparation, transplanting and water-management aspects of the existing wet-rice farming practices. The requirement of healthy young seedlings demanded the early establishment of RBNs with particular specifications, and required a new set of skills as compared with the traditional nurseries (Chapter 4). Land preparation required drying and marking of plots as additional tasks prior to the transplanting of young seedlings (Chapter 3). This brought in new tools in the form of markers, while also calling upon new skills to manoeuvre them properly under different soil–moisture conditions.

The new way of transplanting – one plant per hill at wide intervals, guided by field markings – demanded new skills (Chapter 5). Early transplanting of young seedling also required water to be delivered at the right time along with the advanced scheduling of *Din Bar*. Uncertainties relating to water, scattered plots, the cascade irrigation system and diversified cropping patterns challenged the timely availability of labour for SRI operations. It also created difficulties for implementing the recommended AWD irrigation method (Chapter 2).

SRI, as a new technological package made up of six agronomic practices, thus posed significant challenges for the farmers. It was very difficult for them to apply the entire package in totality. Farming communities while appreciating the potential of the newly introduced practices also recognised how these could disturb the existing well-embedded institutions.

What then are the implications of the new SRI practices with respect to existing practices (second research question)? The study highlights that incorporating the new set of practices implied not only changes in technical procedures, but also timely, collective and synchronized organization of material resources, along with labour and new skills. The introduction of new actors (Master Trainers and VLRPs) along with artefacts (RBNs and markers) threatened to disrupt the existing social order among the farming communities and their diverse but interactive agricultural work groups. Farmers were confronted and challenged by the mismatched requirements (primarily in terms of time, labour, skill and water) of SRI practices and those of the wider agricultural system. The system thus required to be reconfigured in coordination with the various work groups already involved in rice farming. Not surprisingly, local adaptations were tested and introduced gradually as experience and confidence were gained.

SRI extends farmers' performative repertoire

With the introduction of SRI, farmers in the study villages tried to understand risks and opportunities created by the interaction between the new practices and existing practices, in the context of the larger socio-material landscape. Experiences across farms and over the seasons helped them to integrate established and new knowledge and skills, enabling them to make adjustments in the introduced SRI practices and interestingly in the established practices too. This thesis has identified several examples of this adaptive process. Most farm households preferred to raise multiple RBNs collectively on common plots. Some households relied on others to raise nurseries or share seedlings. Seedlings from conventional nurseries and RBNs were often exchanged between different rice systems when farmers faced a shortfall for some reason (Chapter 4).

We also observed the development of different marking patterns in different rice plots, which evolved over several seasons through interactions among VLRPs, plot owners and transplanting groups. Even seedlings in conventional rice plots were transplanted at much wider spacing, but by eye estimation rather than marking (Chapter 3). This reduced the transplanting density of conventional plots. The new and old systems exchanged practices, became a little less distinct and discrete, and were put to complementary use.

The selection of different SRI components (such as the source, age, number and spacing of seedlings) and the extent to which they were incorporated was influenced by the availability of water and bullocks; soil–moisture conditions; labour availability; the elevation, location and layout of the plot; cropping patterns; and livelihood systems.

Transformations occurred in the composition of work groups for SRI transplanting, with an influx of younger women who quickly learned the new skill and the preference of older women to follow conventional transplanting systems (Chapter 5). The three village communities responded differently to the need to advance *Din Bar,* depending upon whether it was possible to contemplate early transplanting because of the availability of water. Shallow flooding, especially in the early stage of SRI, was preferred over the recommended AWD irrigation, in order to allow flexibility of labour movement between irrigated rice plots and rainfed plots, where weeding was an urgent necessity (Chapter 2).

All these mechanisms resulted in the intermixing and integration of existing rice cultivation practices with newly introduced concepts and techniques under SRI. Initial frictions and contestations between the existing and new systems were eventually resolved by mutual adjustments and accommodations. Though distinctive systems continued to exist, a degree of blending occurred as they influenced one another.

Drawing inspiration from the metaphor of farming as an activity rather like that of a musician (or group of musicians), we interpret SRI as a set of propositions, principles and techniques that has added new elements to the repertoires of rice farmers and rice farming communities in the study villages. In Chapter 1 we discussed how the metaphor of performance emphasises practice and experience as important stepping stones to becoming a skilful and effective musician, or farmer – that is, a craftsperson capable of reacting to the needs and uncertainties of the moment with a suitable and effective set or sequence of responses. These may be drawn from a stock of learned and practised themes and actions – in other words, a repertoire. We add further emphasis here to the observation that the concept of a repertoire has both individual and collective aspects. Individual farmers or households are responsible for particular plots of land, so they require their own repertoire of skills and knowledge; but they also need to adjust their individual performance to accommodate the work of other members of the community. Together, the members of a rice-farming community produce a collective performance that underpins the livelihoods and food security of the community as a whole, including valued social and cultural institutions that support collective action and solidarity.

How rice farming operations and related work groups were adapted and adjusted in conjunction with the introduction of SRI methods under different agro-ecological settings (third research question)? The study illustrates that adjustments and exchanges between the existing practices and the newly introduced SRI practices occurred at different levels of interaction in the rice-farming system across different rice plots, within and between different agricultural work groups, and at community level. The changes were not just technical but were accompanied by social reorganization including the restructuring of work groups, redistribution of tasks, creation of new roles, rescheduling of routines, and revamping of rules. These socio-technical reconfigurations took into account farm households' resource allocations, constraints and priorities; complementarity and operational flexibility amongst work groups; and socio-cultural norms and relationships. Farm households, while incorporating SRI into the existing farming system strove to establish complementarity and synergy between various rice farming methods. This enabled fluidity among task groups and led to the extension and diversification of the repertoire of methods used. The goal was to maximize the exploitation of agro-ecological niches, minimize uncertainty in farm production and rationalize the employment of the available work force.

This study therefore re-emphasizes that technology is thus best understood as a human activity or capacity (the act or capability of making), not a tool that users adopt or reject. Farmers neither adopted SRI nor rejected it, but used it creatively and resourcefully in their own way. It should be noted that SRI in the mountain farms seems to be a socio-technical system still in the making. This research has delivered a snapshot – albeit a dynamic one that evolved over several seasons – of an ongoing and unfolding process that was still undergoing change at the time the fieldwork was concluded.

6.4 Discussion

The study explored smallholders' strategies for rearranging wet-rice farming practices concurrently with the reorganization of work groups, in response to the introduction of SRI in the mountain villages of Uttarakhand. The rice farmers' overarching goal is to produce rice in the quantity and quality they need in an economical and practical way. The study reinforces through the case of SRI's introduction, farmers' ability to respond to whatever opportunities and risks may be associated with any new agricultural intervention, and their skill in exploiting these for the purposes of achieving their own goals in rice cultivation without compromising on overall farm production.

Diverse forms of farmers' groups emerged from the same farming communities across the growing season. This study contributes to scholarly understanding of the notion of 'task group' in the context of agriculture by focusing on the culture of these agricultural work groups. While probing into smallholders' organizational strategies and capabilities for undertaking farming practices especially under diverse settings, it further elaborates upon the social performance of such agricultural work groups, particularly focussing on the organizational and coordination aspects of labour. This further helps in rethinking the ongoing debate on SRI in relation to labour use. Finally, the study illustrates the usefulness of technography as a methodological approach for understanding socio-technical systems and interactions in the context of agricultural production. This section elaborates upon these broader contributions of the study.

Work Groups in Smallholders' Farming: Beyond Formal Organizations and Farms

The study examined the various operations (nursery raising, land preparation, transplanting and water management) in mountain wet rice farming systems. In the process the prevalence of a wide range of informal farmers' groups was recorded. These groups do not fit into the category of farmers' associations that have been of much interest recently in understanding collective action. These associations (later groups) generally aim at reducing input costs or maximizing benefits through collective action (LEISA, 2007; Donovan et al., 2008). Formal farmers' organizations (such as cooperatives, associations, self-help groups, alliances or community enterprises) typically operate through formally agreed rules and routines. However, unlike them, the farmers' groups examined in this study were largely informal, having no such written operational agreements and rules nor formal exchanges.

The farm household is a much-used unit of analysis in the socio-economics of small-scale agriculture. Farm households have generally been assumed to be the smallest and relatively permanent production units of agriculture, more so in smallholders' or peasant farming (Ploeg, 2013). Recognizing the importance of the family as the farm 'unit', the United Nations even declared 2014 as the International Year of Family Farming. The farm household as a unit reflects kinship and family ties as important factors in farming activities. However, the groups that the present study came across very often crossed household boundaries. We do come across such traditional multi-household or community level groups especially in the context of shifting agriculture (Conklin, 1957; Freeman 1970; and Dove, 1985), and water management done through water user associations or village communities as a whole (Coward, 1980; Lansing, 1987; and Mabry, 1996). In mountain rice farming practices it was however seen that for a specific farm operation, diverse organizational forms emerged that cut across commonly used organizational units in agriculture/farming often discussed. The organizational forms noticed were more task-related and differed for various farm operations and over the cropping season.

The study illustrates how smallholders get into different socio-technical configurations of agricultural work groups for performing specific operations under each rice cultivation practice (be it *Saindha*, transplanting from *Saindha*/*Bina*, and SRI) along with activities in the rainfed plots. Smallholders enter into work group formations at different stages of crop growth by drawing members from within or even outside their households for undertaking the different operations within a particular practice of rice cultivation under varying farming situations (See Figure 6.1). The agricultural work group formation processes are guided by the material, labour, and skill requirements

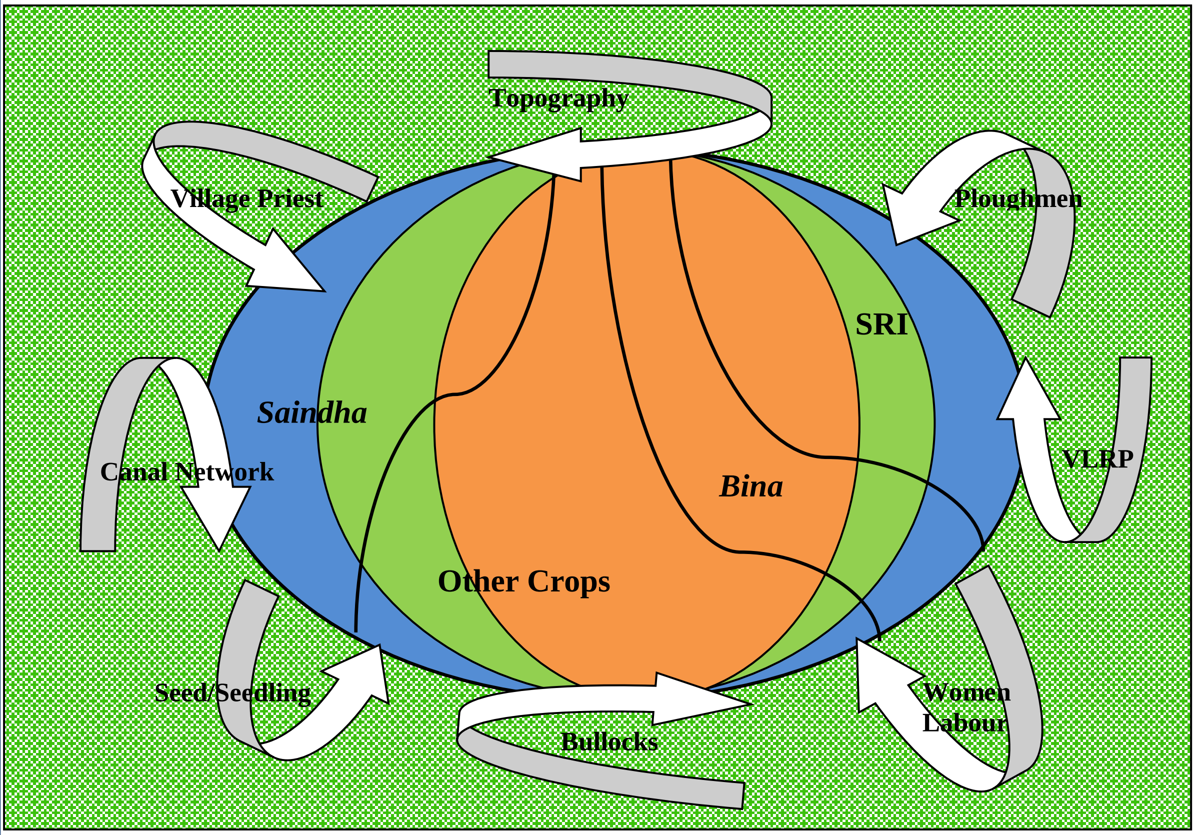


Figure 6.1: A simplified illustration showing a farm having different proportions under *Saindha*, *Bina*, SRI and other crops. The different operations like land preparation, [orange oval] seed sowing/transplanting [green oval], and water management [blue oval] cut across all the plots and undertaken as the season proceeds. These operations done by the farm household interact with the different elements [arrow] of the larger socio- material landscape [green pattern]

of the desired operation, the larger socio-material landscape (particularly labour availability, topography, irrigation infrastructure and cropping pattern), while also being influenced by social affiliations and past experiences of such associations.

Thus a smallholder family when undertaking rice cultivation through transplanting from *Bina* may assign women members from the household itself (for nursery establishment), seek additional help of ploughmen having bullocks (for land preparation), ask the men to join other households (for cleaning of the canal network), consult households of the same *tok* (for water distribution), and exchange women labour with households sharing the bullocks (for transplanting purpose). The same household when trying out SRI, may join other households in raising multiple RBNs on a common plot, take the help of the VLRP for marking the plot following land preparation and consult downstream non-SRI plot owners (for allowing the passage of water into their plots). Among households sharing the bullocks, young girls are asked for grid transplanting, while elderly women uproot the seedlings. Similar work groups for other rice growing practices and other rainfed crops may be formed likewise.

The smallholders' agricultural work groups seem to evolve differentially from the larger communities, quite similarly to the Algonian hunting and migrating groups of McFeat (1974). They differ however from the hunting groups, having more plurality and operating more flexibly across the seasons, in co-ordination with each other. The intrinsic 'fluidity of organization' in agricultural work groups and their ability to respond and 'adapt to environment' help them not only in coping with diverse farm situations and unusual weather events but also in absorbing shocks instigated by new interventions such as SRI. The organizational and operational principles of smallholders' work groups has been insufficiently studied and need to be better understood.

Each small-scale rice farmer may follow several different rice cultivation practices simultaneously, while also participating in other production activities such as growing non-rice crops and pursuing other livelihood activities. These different rice cultivation practices and other production activities occur simultaneously as part of a stream of activities, and therefore affect each other. The different practices of rice cultivation (*Saindha*, *Bina*, SRI and their various combinations) are comparable to what Sigaut (1994) refers to as 'paths' of production, consisting of a 'sequence of operations', which are also 'interwoven into a network'. A work group for a particular operation (say field preparation) communicates with the preceding (nursery raising) and succeeding (transplanting) operational work groups of a concerned agricultural path (e.g. SRI), exchanging information tacitly or explicitly which relate to technical specifications and labour/skill organization, which Sigaut refers to as 'task and social instructions' to put the act together.

The act of reorganization of work groups (both structurally and operationally) as the cropping season proceeds seeks for a best fit between the requirements of different crops to achieve ultimately a satisfactory production given the surrounding socio-material environment (local context). This process can be referred to as recreation of 'social culture' by interacting task groups in a socio-technical system (Harrington and Fine, 2000). Different forms of work groups enter, act and exit along different interconnected paths, from the same set of households at different stages of the cropping season, creating a complex, yet dynamic network of socio-material assemblages (agricultural work groups interacting with material objects). At any particular time in the cropping season, several similar and dissimilaragricultural work groups could thus be seen operating synchronously in the farming system. The notion of interconnected paths and their intricate linkages with the wider socio-material environment encourages us to recognize that rice cultivation is not the only thing the smallholders do, not only in one way, not at all independently and therefore requiring much flexibility.

The existing wet-rice farming practices in the villages have evolved over generations in accordance with the larger socio-material landscape. Informal rules and routines (some even associated with social rituals like the *Din Bar*) related to the practices, keep the different agricultural work groups of various rice farming paths in synchrony with each other as well as with other production paths for an effective system performance overall. One can see some familiarities in the functioning of the smallholders' farming system in the mountain ecosystem with that of the self-organizing and self-contained Balinese water temple networks (Lansing, 1987). In case of the water temple networks, the *subak* system guides social organization related to cropping pattern, planting time, and irrigation schedule. The co-ordination in the *subak* system is more influenced by the irrigation facilities. The *toks* in the mountain villagesare quite similar to the *subaks* of Bali. Farm households owning plots within a particular *tok* prefer to come together and co-ordinate not only for effective water distribution and delivery, but also for raising RBNs, land preparation, transplanting and harvesting. The irrigated *toks* further move to a higher level of co-ordination as they are often connected to the same canal infrastructure. They become interdependent, with their work groups co-ordinating amongst themselves for timely and fair distribution of water. The socio-technical coordination amongst work groups at the village community level is reinforced by the fact that all the *toks* (whether irrigated or not) are believed to belong to the common local deity just as the way *subaks* are connected to the water temple.

The plurality of smallholders' work groups and their diverse strategies, guided by the social norms and rituals are able to cater to the agricultural diversity, time constraints of labour and respond collectively to uncertainties. This is similar to the functioning of the multi-household groups of Kantus in Swidden agriculture of Indonesia (Dove, 1985). With fluctuating farm conditions and circumstances around any concerned practice, the related agricultural work group is able to modulate the task specifications and social organization around its operation by coordinating with other work groups and the larger farming system. Different work groups thus complement each other especially in material and/or labour constrained situations. Such adjustments and exchanges at the practice/task level do happen in everyday agriculture practice. Agricultural work groups of smallholders are thus not fixed entities in terms of their composition and function – they have multiple identities and are dynamic in nature. For the same reason, even with the increasing outmigration of the able bodied men and decreasing interest of the youth in agriculture, the women members of the smallholders in these villages are still able to cope with the agricultural tasks in addition to their household chores, by collaborating and coordinating with others.

The farm households of Asian societies are known for exchanging labour, and working in groups for specific operations in rice cultivation, especially during peak labour requirement periods such as during transplanting, weeding and harvesting (Bray, 1986). Growing rice requires ‘practical and managerial skills’ for applying the right techniques, at the right time/moment through social organization. It was observed however that in the context of the mountain farming system, these groups/organizations play a more significant role throughout the growing season and not just during labour peaks. They do become more prominentlyvisible for field operations that require a lot of labour, but likewise exist for other operations as well. This is because farm households here do much more than just growing rice (that too through different practices) as part of their daily routine, attending to other crops, livestock and collecting fuelwood and fodder besides daily household chores. Social organization exists not only for a specific technical practice, but also for ensuring coordination amongst interconnected work groups. The sequence of farm operations in a cropping season creates a sequence of organizational formats, which is flexible but within limits set by the features of the family (e.g. availability of labour, draft and implements; landholdings – their distribution and water availability; and livelihood opportunities) and larger social and material units (e.g. *tok*, community structure, canal layout and elevation).

The study through the example of SRI thus highlights that agronomists, extension workers and planners need to look at smallholders’ farming as a socio-technical system performed by interconnected agricultural work groups. Understanding practices (across space and time) of such work groups and especially their interactions with material things and the wider agro-ecology is therefore critical while interpreting farmers’ response to new agricultural propositions. The frame of task groups provides a socio-technical unit of analysis for understanding the culture and strategies of small holders undertaking diversified agriculture. Agricultural work groups seem to possess certain flexibility and dynamism in their operations, helping them to adapt introduced practices. Interactions between actors within and across groups are observed and interpreted, reproducing as well as changing technical repertoires and institutional arrangements. Looking at informal farmers’ groups, and not just formal organizational forms, especially in the context of smallholders, would therefore give a more complete interpretation of collective undertaking of farming practices and processes of adaptations.

More or Less Labour: Smallholders' Perspectives on SRI

The notion of agriculture as performance gives due importance to the social and material interactions of actors involved in farming. Social performance emphasizes application of labour and skill, and recognizes farmers' innovative capacity to adapt to changing circumstances using knowledge and experience. The concept of agriculture as performance along with that of task group culture enables a better and more nuanced understanding of smallholders' perceptions and approach to agricultural interventions. The diverse farmers' responses to SRI's introduction in the study villages show how labour (including skills) is organized and managed. These throw light on some of the persisting questions related to labour use in SRI as reflected in much of the SRI literature.

Arguments around the quantum of labour use in SRI compared to existing practices have been going on for over a decade now. Increased labour requirements have been highlighted as one of the major constraints in SRI's adoption (Moser and Barrett, 2003; Namara et al. 2003; Barrett et al., 2004; Senthilkumar et al., 2008; Latif et al., 2009). At the same time, a reduced labour use has also been measured in SRI when compared with best management guidelines or existing practices (Anthofer, 2004; Li et al., 2004; Sinha and Talati, 2007; Sato and Uphoff, 2007). Why do these contradictions co-exist? This study illustrates that for the farmers the labour issue is much more complex than a question of 'more or less'; it extends to when, who, and how to organize the available labour force, rather than simply a question of applying less or more labour, which in past studies has been assessed on exclusively economic grounds.

The study in Uttarakhand villages showed that with the introduction of the small sized RBNs of shorter duration under SRI, women farmers are relieved from the burden of managing larger nurseries and carrying heavier seedlings. At the same time, they find it difficult to establish the RBNs at the proper time. Likewise the intensive care required for RBNs competes with preparing and sowing their rainfed fields. Similarly, the grid transplanting for SRI requires less labour and time per unit of area, but it was difficult to organize labour for the early transplanting (necessary for timely ripening) of the SRI crop. Moreover, the elderly women find it boring and that it requires more concentration and care to transplant single seedlings. Even if the crop is grid transplanted, farmers find it difficult to attend the SRI plots regularly for timely AWD water management and weeding, they would rather prefer flooding. To cope with the latter, flooding is obviously the easiest solution. Though, the quantum of labour use for nursery raising, carriage of seedlings, and transplanting might be less than for existing practices, organizing and managing adequate and skilled labour at the appropriate time was a challenge because it competes with attending to the rainfed crops. This additional element of management influences farmers' decisions or choices more than does the quantum of labour use.

Farmers operating under constrained time and labour availability were therefore mostly unable to put all of their rice plots under SRI, even though it yielded more. The study thus highlights that though SRI might be less labour consuming, it involves higher level of organization and management. For a farm household incorporating it into their diverse crop production system (especially such as that of the mountain smallholders), it demands a more specialized and synchronized effort than the customary system. According to Bray, farmers favour methods and practices that are less labour demanding, especially in a labour scarce situation. They are supposed to prefer methods which allow "more free time for more profitable alternative employment" (Bray, 1986, p.61). She further states that "a subsistence farmer relying on family and exchange labour may not count in man-hours of his rice crop, particularly if he has few opportunities to invest his labour elsewhere" (p.57). If that was the case, one would have expected the smallholders to reject SRI outright. However, that is not what exactly happened, and not with all farm households.

What we found instead was rather that in response to the introduction of SRI, the smallholders of Uttarakhand adapted the recommended practices as to allow more flexibility of operations. They came up with various solutions: 1) jointly raising multiple RBNs in a common plot, 2) taking seedlings from others in case they were not able to raise RBNs individually, 3) encouraging younger girls from the same farm households to learn new skills required for transplanting while also providing additional labour for timely transplanting, 4) flooding the SRI plots at relatively less water depths allowing labour flexibility for weeding the rainfed fields simultaneously.

Learning combined with adjustments in practices (adaptation) and work groups over the seasons helped farmers to figure out how to implement SRI in more labour-efficient and/or practical ways. With more prominent patterns of practices emerging in each village after four years of introduction, there seems to be a learning curve with SRI, making the system easier/less labour-intensive with gained experience. As examples: more experienced farm households preferring to establish RBNs in their own plots; farm households resorting to grid transplanting in fewer and better quality plots, and just line transplanting in other plots. It was found that even some of the experienced older women (besides the young women in general) could transplant relatively faster and efficiently as compared to their counterpart who were transplanting for the first time. To make more definitive statements about increased labour efficiency with gained experience, one would however have to specifically measure per capita hours of labour input and how they may have changed over time, since SRI was first introduced. What one could definitely say at this point, however, is that the collective form of labour and the various configurations that collective labour takes, depending upon the field operations, makes it a difficult task to have a straight forward answer to the question of more or less labour use in SRI.

The notion of agriculture as performance thus helps to probe into labour, skill and knowledge interactions within and across agricultural work groups. The multifaceted agricultural work groups of smallholders (as seen in case of groups raising RBNs and transplanting groups under SRI) functioned as dynamic platforms for knowledge exchange, and allocation of material and labour resources thereby facilitating the integration of the new practices into the existing ones. The sharing of labour resources contributes also to learning of skills, illustrating how such informal groups could be very effective in popularizing innovations and promoting adaptations. The possibilities of reconfiguring agricultural work groups under different circumstances and across seasons provided farmers the scope to experiment. Over the years, farmers collectively probed for best options of socio-technical configurations and labour coordination improved. The study thus illustrates how performance relates to farming as a continuous and collective experimentation looking for opportunities for labour rationalization and risk reduction.

Relevance of Technographic Approach: Understanding socio-technical interactions

The study illustrates the use of technography for understanding socio-technical interactions in agricultural production. In order to appreciate the diversity of practices in the rice fields of SRI exposed villages, it was important to understand the bio-physical and socio-cultural context in which rice farming is situated, and the underlying mechanisms of coordination, negotiations and transformations. Neither natural science nor social science alone could have captured the multiple dimensions of the ongoing phenomenon - farmers' dilemmas, experimentations and performances, necessary to understand farmers' response to agricultural interventions. The ethnographic approach helped us to get inside the complex network of farmers and other actors, making sense of the SRI induced trajectory of rice cultivation practices in the different study villages. The use of technography helped in recognizing the diverse, complex, and interactive social-technical configurations, and realizing the relevance of the material and technical aspects as well as the social conditions and processes at different interfaces of interactions.

Technography helped in approaching the research problem by probing into the three critical dimensions of agricultural production i.e. the making of rice (studying performance and situated action, and experience based experimentation), coordination amongst the relevant actors (studying task groups, knowledge interactions, and collective learning) and construction of rules (studying procedures, routines and negotiations amongst associations). This provided the scope for looking into how farmers play around (especially in the present context of climate change) with the SRI practices and figuring out what different farmers do, where and why. The approach revealed farmers' perceptions about the workability of the system and their strategies to make it work.

This study cautions that considering individual farmers or farm households alone as social units might fail to give complete insights of farming systems in transition. Similarly studies focussing just on conventional G (Genotype) x E (Environment) interactions would miss out the role of human management and socio-cultural factors in such interactions. The importance of social institutions, power and their inter linkages and role in agriculture is often overlooked in such studies. The present study demonstrates how technography as an alternative approach could be effectively used for evaluation and impact studies of agricultural interventions. It provides an in-depth understanding of how technology is embedded within existing livelihood strategies, by exploring the intersections of nature, knowledge, technology, and society.

6.5 Inferences and Implications

There have been few studies that provide insights into the extent to which adaptation processes for the techniques recommended by extension/research do affect the field level implementation processes. This research uncovers the key intentions and critical principles of smallholders' attitudes, skilfulness and tactics for adaptations in agricultural interventions. Finally, through the example of SRI in the mountain rice farming system, the thesis questions the adequacy and applicability of a uniform set of practices under varying/variable farm conditions and circumstances.

Adoption or Adaptation in SRI: Smallholders' Experimentation and Learning

How do small holders contribute to the adoption debate in SRI? Do they offer any suggestions about how to go about introducing new practice or technologies? Initial studies on SRI did not give due importance to farmers' differential strategies in response to SRI exposure. Farmers' responses seem to have been oversimplified by categorising them into adoption, non-adoption, and dis-adoption (Moser and Barrett, 2003; Namara et al. 2003), and not paying sufficient attention to the farmer as a pro-active agent in changing their practices under the influence of the new information and practices embodied in SRI. The proponents of SRI when criticizing studies reporting low yields with SRI, point out that the farmers studied were not doing all the SRI practices (Thakur, 2010). They are perhaps trying to evaluate the potential of 'ideal/proper' SRI, which might not be practical enough for many, perhaps most farmers. This study indicates that attempts to fit farm households into categories such as adopters, dis-adopters, non-adopters, laggards, etc., or to seek uniformity in SRI in practice, would be a futile exercise as decisions relating to the application of practices are subject to spatial and temporal variation. We have seen that in a given season, the response of the same farm household varied across plots with different soil-moisture conditions, size and shape, located at different reaches of the irrigation command area and situated at different elevations. Similarly, changing farm conditions and farmer's circumstances along with cumulative experiences affected farm household's decisions and choices in favour of particular practices across the seasons for the very same set of plots. Clear-cut divisions like adoption, non-adoption, and dis-adoption seem not to exist.

More recently, while trying to explain farmers' decisions and strategies related to application of SRI practices, individual households and plot level characteristics have again been treated as mutually exclusive factors (Moser et al., 2006, Lya et al., 2012; Martin et al., 2012; Doi et al., 2013; Palaniswami et al., 2010; Palaniswami et al., 2013), especially through econometric models. The case study however illustrates that in reality, elements interact with each other at plot and farm level and also at the landscape level, influencing farmers' individual and collective decisions. Approaches based on a reductionist lens will fail to fully explain the diverse adaptation strategies of farmers, especially smallholders who, as we have seen, most often operate in collectives of work groups, that too in diverse agricultural systems prone to uncertainties and risks. Farmers are known for applying common sense, instinct and embodied skills under changing situations to come up with unprompted adaptations - the latter is termed as 'situated action' by Suchman (1987) but more in the context of ICT environments. Richards (1989) and Stone (2010) refer to situated action in agriculture (much less mechanical than the ICT environments) as experimentation and learning. Smallholders are recognized as regular experimenters, having the ability to test, transform and adjust practices or interventions. It would therefore be worthwhile to try and interpret smallholders' response to SRI as outcomes of compounded effects of several social and material factors and processes, and their interactions.

The present study deals with the case of SRI as an agricultural intervention introduced in a set of villages located in the same sub-basin, at the same year and through the same organization following a particular extension strategy. Still the responses across and even within the villages were found to vary, thus offering a good case to explore and understand smallholders' diverse strategies in response to introduction of a new agricultural intervention. We have already observed that the diversity in the agro-ecological setting explains the co-existence of multiplicity of rice practices managed by work groups through different configurations. Further, diversity in human capacities, priorities and circumstances lead to variations even within the practices through modified work group configurations in everyday agriculture. Thus unplanned and unorganized decisions and choices i.e. the 'situated action' seems to be in place. The new intervention in the form of SRI when introduced in a farm household's plot sets off a fresh set of socio-technical interactions at the plot, farm and landscape levels simultaneously, involving a range of agricultural work groups and the farming community as a whole. The introduction of SRI thus creates a new situation demanding further action.

SRI as an introduced innovation invokes the latent experimental capacity of farmers. Farmers face several decision-making challenges. 1) Whether to try SRI or not, 2) How many plots should be under SRI, 3) Where is it be applied, 4) How is it be applied, 5) Whom to cooperate with others, for what operations, and how? The demands of the cropping system (more than just rice) and existing social organizations (more than just a single farm household) characterise the specific local context and shape how farmers act, more so than simply enthusiasm or aversion for SRI itself. What we see eventually in practice is that the local situation (i.e. the situated action in which a plan plays a certain role with a certain effect) guides farmers' responses and not the formal blueprint or plan representing 'proper' or 'uniform' SRI practice. Farmers are quite experimental/ innovative and they respond in the same manner to SRI as to daily changes in their conditions and circumstances and to any other technological interventions. It was also observed that the farmers' decisions related to practices are not just individualistic at farm-level but rather community-level or at least group-level. Not necessarily collective or communal but involving an intricate set of adjustments and exchanges that affect more than one person – work groups, extension agents, even the community as a whole. The questions related to performance and negotiations get repeated over seasons and are dealt through experimentation and learning that offer different answers and performance every time.

Experimentation and learning experiences with new interventions in agriculture have been reported to have positive or negative influences on farmers' and labourers' 'skilling' processes (Stone 2010). Stone's (2010) case of Bt cotton is one where the experimental capacity of farmers is overstretched, making them excessively dependent on external inputs and guidance, while undermining their own management skills, with considerable negative consequences. Similarly, Vasavi (2012) ascribes agrarian crisis and farmers suicides in India to 'knowledge dissonance' and 'agricultural individualization'. How does SRI fare in that respect?SRI comprises a set of crop management techniques rather than relying on a GM seed (in combination with mineral fertilisers and crop protection treatments) and therefore probably has something different to offer, especially for smallholders to experiment with. Unlike Bt cotton, it allows more flexibility for making choices and mixing techniques according to farmers' conditions and circumstances. This is how SRI gets accommodated into the crop production system building and rebuilding farmers' practical and managerial skills. Current processes of 'deskilling' and 'knowledge dissonance' in agriculture can probably be reversed if the focus can be shifted to farmers' collective experimentation and resilience rather than just emphasizing on yields.

Basalla (1988) describes technological evolution as a process, using an organic analogy, by which novel artifacts emerge and are subsequently selected by society for incorporation into its material life without engaging either biological necessity or technological process. The technological evolution of SRI at Madagascar to serve as a 'tool kit' does not end with farmers of Uttarakhand just selecting its elements. Farmers rather play around with the tools and integrate it with their own tool kit. It contributes to the repertoire of practices – a mix of old and new (See Figure 6.2).

Farm households and interacting agricultural work groups collectively negotiate across the seasons, based on experimentation and learning, making trade-offs and adjustments according to existing farm conditions and circumstances. Farmers' creativity and ingenuity, as they incorporate or combine these new and old methods, is something that should be recognized and acknowledged. The 'crop management' focus of SRI creates a space within which farmers may think creatively rather than simply substituting inputs or applying a fixed recipe for rice cultivation. This is to move beyond the argument that SRI itself is a system that stimulates innovative behaviour by farmers (Styger et al., 2011). Over time, the benefits of a certain mixture of practices may be recognized and realized by the wider farming community and take a more settled, local form, as seen in case of the three villages that developed three distinct forms of adaptation emerging amongst various alternative possibilities. Adaptations thus emerged from individual and collective experimentation, learning and negotiation (which are elements of situated actions and therefore dynamic in nature).

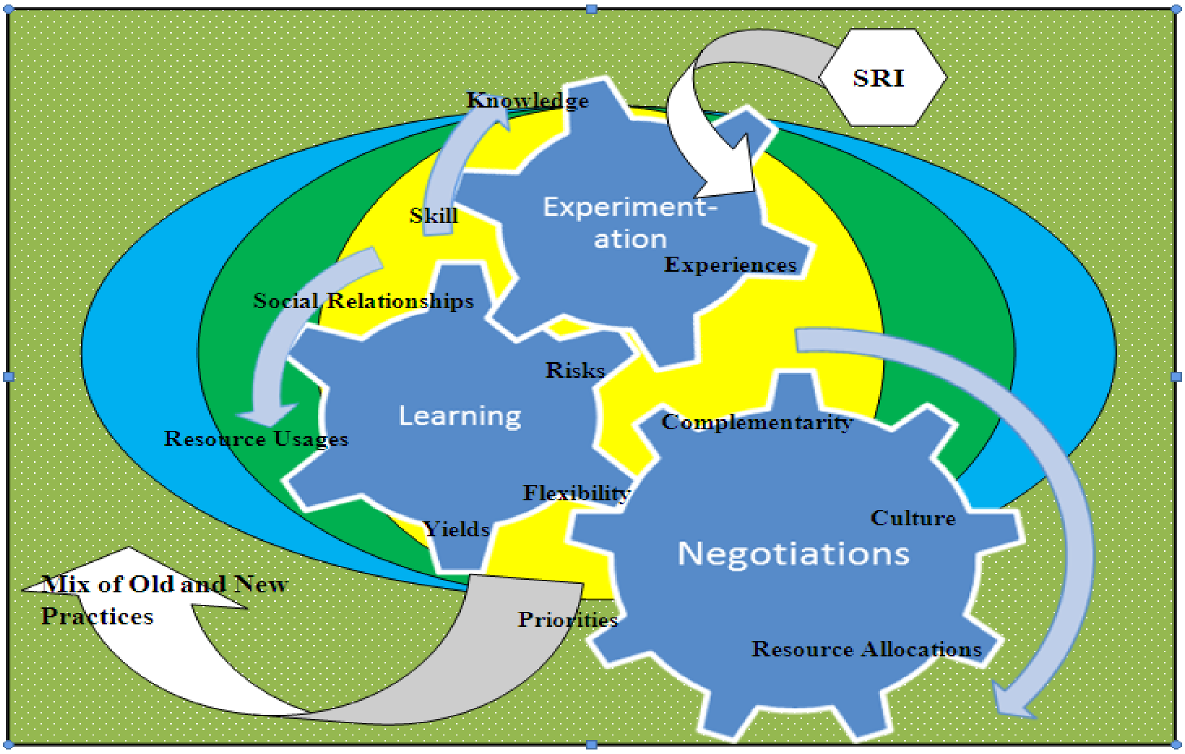


Figure 6.2: A simplified illustration of integration of SRI in farm. The experimentation, learning and negotiation processes cut across the different operations like land preparation , seed sowing/ transplanting , and water management . These processes also take into account the larger socio- material landscape

The study shows, through the example of SRI, that adaptations in agriculture imply changes in socio-technical configurations rather than just modifications in technical elements. It might involve reorganization of work groups, alterations in groups' coordination, rescheduling of routines, and reformulation of norms. Uptake and upscaling of new interventions across farms thus demands a much higher level and scale of adjustments, especially in a diverse cropping system operationalized by interacting agricultural work groups. This complex process is rarely completed in just one or two seasons and may require many seasons of continuous experiments, interpretations, learning and adjustments. A suitable environment should therefore be provided to farmers while introducing new intervention such as SRI, where they can have a free hand to experiment and gradually gain experience and confidence. There is a risk of alienating farmers by not taking this into account and seeking to make them do 'proper' SRI. One has to move away from notion of the 'ideal' SRI itself which has led several researchers astray, as also evident from the discussions in the next section.

Adequacy and Applicability of SRI Practices: Possibilities for Further Research

SRI evolved in the farms of central highlands of Madagascar through a process of participatory research and development (Uphoff, 2005). It comprised of "empirical observation, experimentation, theorizing, practice, and judgment" involving close interactions between a range of actors (Glover, 2011c, p.234). These processes reflect the very core elements of adaptations as discussed in the previous section. According to Glover, the specifics of SRI practices as developed in Madagascar were intended to suit the peasant farmers of that particular agro-ecological setting. According to Uphoff (2001), SRI is more of a set of guiding principles based on synergy among agronomic management practices and their interactions with the crop biophysical environment. Instead of the principles, more often the common recommended management practices are overemphasized, getting converted into more or less standard technocratic practices, as also seen in the case of Uttarakhand villages (and elsewhere) in the initial years of promotion. Farmers' responses in the past also have mostly been assessed by the extent to which farmers followed these standard practices. Are these commonly advocated SRI practices adequately suited to demands of rice crop grown under a wide range of bio-physical conditions? Can the highly co-ordinated labour and new skills' demands of SRI be easily met in any socio-cultural context? How do farmers view these questions of synergy, coordination and skills?

The present study explored SRI's performance in a context that was totally different from the one under which it originated. The experience of SRI in the mountain farms of Uttarakhand, raises a fundamental question in terms of SRI's adequacy and applicability (as developed in Madagascar and commonly advocated) under agro-ecological and socio-institutional conditions that are completely different. The farm households of Uttarakhand have their paddy landholdings predominantly in the form of small, irregularly shaped terraces scattered across the village, located at much higher elevations and fed through a cascade system of irrigation. These paddy terraces have to be prepared through limitedly available animal draft power, and primarily managed by women farmers in a highly diversified agricultural setting, mostly through family and exchange labour. In the study villages, the agro-ecological setting along with the tuned in work organization of existing practices, raised serious and practical problems on the suitability of the commonly recommended SRI practices when trying to apply these to the local crop production system.

a) **Nurseries:** SRI advocates the use of young seedlings for transplanting, without referring to the additional need to establish the nurseries for supplying such seedlings early on in the crop season. The initial experience in the study villages was that the young seedlings matured too late, especially at higher elevations, when transplanted along with the other rice crops. The local practice was to transplant old seedlings at later dates and when the work on the other rainfed crops had been completed. Such a delay in the SRI transplanting created additional problems of protecting the isolated SRI plots and arranging labour for an additional round of harvesting. Hence, the early establishment of nurseries to supply young seedlings proved to be a critical missing element, especially for farms located in higher and cooler elevations. In water scarce situations, farmers had additional difficulty of establishing nurseries early, especially at the beginning of the growing season when labour was scarce.

Farmers were also found to apply excessive seed rates in RBNs than advocated so as to permit post transplanting gap filling, which was quite common due to mortality of young seedlings caused by water beetles and cold water from the glacier fed river. When should nurseries be established for timely maturity of SRI crop? Practitioners would need to work out optimum time for establishment of nurseries for timely maturity of SRI crop under given situation. How can early nurseries be established in labour constrained and water scarce situations? In such situations collective nurseries through formation of farmers' groups in favourable locations could offer a solution. What should be the optimum seed rate in nursery establishment so as to take into account of post transplanting mortality? The seed rate in nursery establishment should take into account mortality based on farmers' past experiences.

b) **Young Seedlings:** The use of young seedlings is commonly defined in days (8-12 days) rather than the 2 leaves' stage which is more suitable. The 2 leaves' stage might be achieved sooner or later depending on the agro-climatic conditions. For the study villages it even took 15 days, especially at higher elevations. The duration of 2 leaves' stage also varied according to the rice variety. Many farm households across the villages also shared that the 2-leaf seedlings were not able to cope with extremely cold water conditions, saturated soils, sandy loam soils or soils infested with pests/insects. Besides, in a diversified agricultural setting with limited draft and labour availability, one is seldom sure when all the social and material conditions will be congenial for transplanting. Therefore, a set of different options is required instead of sacrosanct principles/practices. What should be done if the age of seedlings increases due to a delay in transplanting for whatever reason? Should one reduce the hill spacing or increase the number of seedlings per hill or can other approaches be developed. Researchers should attend to the above question in consultation with farmers.

c) **Number of Seedlings:** Even if one is able to raise or access 2-leaf seedlings, the recommendation of placing one seedling per hill is often questioned by the because of the inherent uncertainties and risks involved in farming. Uncertainties and risks related to survival of young seedlings due to saturated soil conditions, unexpected flooding/water scarcity and pest/insect attack prompted farmers to transplant more than one seedling per hill. Farmers through their experiences are well aware of the decreased tillering potential when using old seedlings. To make up for the yield loss, under delayed transplanting and adverse soil conditions, they therefore preferred to use a larger number of seedlings as the available seedlings were older. In case of delayed transplanting, what crop geometry would be more effective in a given farm situation? How would the crop geometry change with different rice varieties? These are all questions that farmers (and researchers) should together find location specific answers for, instead of (blindly) following uniform solutions.

d) **Wider Spacing:** Commonly recommended hill spacing for SRI is 25 cms by 25 cms. Some studies suggest scope of increasing this spacing further in fertile soils while reducing it for poor soils. What is the dividing line between rich, medium and poor soils? Again, there could not be standardized divisions. The same optimum spacing does not work out for all farm and farm households. Location-/farmer-specific adaptation or fine tuning needs to be worked out by farmers with guidelines from the promoting agency. Wide spacing, that too under dry conditions invites weed growth. Farmers unable to undertake regular and timely weeding (because of the diversified agriculture) preferred closer spacing, irrespective of the soils. Since cross weeding is labour intensive, farmers favour row spacing, rather than the grid spacing. Spacing again has to be maintained by certain means – eye estimation, rope or marker. The application of marker frequently poses problems, as it requires skills and efforts, especially in small irregular terraces and sandy loam soils. Moreover, it also necessitates drying plots, thereby delaying transplanting and creating uncertainties in labour organization and subsequent irrigation. On the other hand we see that eye estimation restricts subsequent weeder use. How proper spacing can then be ensured under varying farm conditions? Farmers of the study villages have also applied the principle of wider spacing to the wheat crop. The experiences need to be further researched. It is but obvious by now that extension agents should not try to provide ‘silver bullets’, farmers are innovative enough to organize labour and skills for timely and efficient transplanting given a few seasons to resolve various practical problems.

e) **Water Management:** Apart from the widespread rainfed situation, many irrigation systems operate under a centralised command structure through which water is delivered periodically to different reaches. The commonly recommendedAWD practice under SRI is therefore difficult to adhere in many locations, as it requires full control over irrigation water. Water application norms for AWD have to be closely tied with efficient water delivery and distribution systems to be successful. In mountain irrigation systems where water supply is unreliable and water has to be usually shared with others, strictly following AWD regimes therefore becomes sheer impossible. Even in case of an assured water supply, preoccupancy of labour in rainfed crops and other livelihood activities, encourage farmers to flood their fields as the easiest and cheapest way to control weeds. How should the water be managed under a cascade type irrigation system? And especially when landholdings are scattered while a rotational system of water distribution is prescribed? Uttarakhand farmers have shown an alternative by starting with shallow depths of water and gradually increasing it as the plant grows. How can farm households having landholdings in different reaches of the irrigation command be organized? How can labour requirement for water management of SRI crop be tuned with simultaneous labour requirements for attending other crops in a diversified agricultural setting? It is through farmers' groups, rather than through individual farm households that such problems might be resolved. In the context of Uttarakhand where there is higher proportion of rainfed areas, it might also be worth exploring application of the SRI principles for rainfed farming through farmers.

What does it imply in terms of further promotion of SRI? A practical insight of this research is that a new agricultural intervention like SRI needs to learn from farmers' existing practices rather than being rigid in its approach. Processes that facilitate co-production of new knowledge and practices, through collaboration between work groups, therefore should be encouraged.

The present study thus explores how a technological intervention is incorporated in small-scale farming, considering SRI as a case in the mountain farms of Uttarakhand. Smallholders while farming operate through work groups which have multiple identities and are dynamic. These work groups coordinate to cope with challenges created by an intervention under varying situations. They use their knowledge, experience and skills striving towards minimizing risks, while making use of the available resources and opportunities (both material and social) to maintain if not improve yields. Their considerable innovative and adaptive capacity i.e. ability to apply, select/reject and modify technologies in whole or in parts is illustrated by this study. Against the current background of a decreasing agricultural workforce (due to modernization) and the uncertainties of a changing climate, it is such work groups that take on greater significance in developing innovative adjustments/alternatives.

The study illustrates through the example of SRI that the introduction of a new set of practices involves many technical as well as social adaptation processes that are generally highly location and farmer specific. As elaborated by Harwood (2012) the complexity of these processes has generally been inadequately appreciated or even bypassed by policymakers, development agents and scientists. This explains readily the often disappointing impacts of many agricultural development initiatives and projects. A more comprehensive approach is therefore required to understand farmers' response to agricultural interventions, accounting for socio-technical interactions and multiple processes at the plot, farm and landscape level. The study demonstrates how 'Agriculture as Performance' helps to probe and explain these interactions while "technography" proves to be an effective way to study farmers' response to agricultural interventions. Why and how do solutions/patterns emerge in different villages, farms and fields; even in villages that are geographically close together? This is for reasons of both agro-ecology and social factors. Under the conditions of mountain farming based on relatively small terraced plots and large differences over short differences these features are particularly obvious. However, by no means, this would indicate that under different forms of agriculture such effects would be absent and negligible. Participatory technology development approaches would have to take into account such multiple processes at different levels while evolving agricultural interventions.

The study further shows that the synergistic effect of the SRI practices also require synergistic social and material arrangements. However, these are not explicitly recognized through the relatively standardised, recommended practices. The most common set of SRI practices, often offered universally to guarantee increased yields was formulated irrespective of farm characteristics. Hence, it might have limitations in terms of practical applications and might be insufficient to ensure good returns for all farm conditions. The present study highlights some of the conditions and factors that enable and/or might constrain the adoption of specific SRI practices under different types of situations. It confirms that they cannot and should not be uniform across different settings. Farmers need space and time to collectively experiment, learn and develop a pool of optional practices incorporating the new principles rather than a rigid package of practices (Styger, 2014). The study thus provides insights on how smallholders of Uttarakhand engage in rice farming though work groups, and how SRI should be viewed as an opportunity for famers to build up their skills. It also shows how agricultural interventions can/need to be promoted in rather flexible ways and needs to be studied as socio-technical systems.

In spite of certain limitations, SRI has brought in new concepts and new options to the farmers of Uttarakhand, helping them to extend and diversify their repertoire or portfolio of technical practices. The various elements of SRI have introduced a new set of ideas, practices and tools that have widened the resources (including ideas) that the farmers can draw upon. It reinforces that technology is best understood as a human activity or capacity, not a 'thing' that they adopt or reject. Application of practices has to be done with due care of the immediate context and linkages with the wider socio-material environment. Farmers understand this and therefore make a whole range of technical and organizational adjustments, both in the existing practices and in the recommended set of SRI practices in order to meet the location-specific conditions of farming systems. Since the study of SRI involved a combination of material and theoretical/ conceptual components, that are equally relevant for other types of interventions/systems, one might assume that the conclusions are not merely relevant to SRI but equally to the whole concept of technology development (including adaptation and adoption) in agriculture and how to study it.

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Summary

How Smallholder Farmers in Uttarakhand Reworked the System of Rice Intensification: Innovations from Sociotechnical Interactions in Fields and Villages

The System of Rice Intensification (SRI) is presented in Asia and other parts of the world as an alternative ‘agro-ecological’ and ‘farm-based’ innovation in rice production. SRI calls for modifications in crop-management practices without relying on external inputs, which makes it different from innovations based on new rice varieties, which became dominant since the Green Revolution. SRI practices are therefore said to be appropriate for resource-poor smallholder farmers.

Previous studies on SRI have focused on recording adherence to or deviations from its recommended practices, or gauging whether or not SRI yields more grain with less dependence on external inputs. These studies have largely neglected to investigate farmers’ underlying strategies, which could lead to a better understanding of whether and how SRI can be called a ‘farm-based’ innovation. This thesis, rather than returning to earlier debates about SRI's adoption and performance, attempts to understand how farm households and their communities have responded to the introduction of SRI in an agro-ecological region dominated by smallholders and lightly impacted by the GR.

The main objective of this research was to understand how farmers respond to an intervention like SRI and what this tells us about SRI as a socio-technical system. The main research question addressed by this thesis is how SRI, conceived as a set of practices introduced from outside the communities, was incorporated into the local rice farming system. Specifically, the thesis examines how existing work groups were adjusted to accommodate the new method, how the SRI practices were interpreted and adjusted to fit with the local social and agro-ecological arrangements, and how the new method influenced existing rice farming practices in the locality.

The research was carried out in three contrasting villages of Uttarakhand, located in the Bhilangana sub-basin of the Western Himalayan region of India. SRI was introduced in this area in 2008. The villages were purposively selected in order to encompass diversity in terms of agro-ecological and socio-institutional settings. A technographic approach was adopted, using both qualitative and quantitative methods of data collection to provide descriptions and interpretations of various socio-technical interactions. Technography is a method inspired by ethnography to understand the use and change of technical tools and procedures. It offers an integrated methodology that encompasses material and technical aspects as well as social conditions and processes. Fieldwork in the three villages was conducted throughout two rice seasons, using participant observation of farming activities combined with initial rapid rural appraisal exercises, focus group discussions, and semi-structured interviews with farmers and other key informants.

Chapter 1 introduces the thesis by elaborating the problem formulation, overall objective and main research question with the use of relevant theories. The theories relevant to this work need to conceptualise the social and material side of technical change as well as the role and activities of farmers, labourers and communities in shaping agricultural technologies. The theoretical resources drawn upon for this research include the concept of "socio-technical system", metaphor of "agriculture as performance", and the culture of "task groups". Together these concepts help to understand rice farming as a collective and mutually shaping social and technical performance rather than the activity of an individual farmer. The theoretical framework built from these three bases was used to focus on the modification of rice farming performance that resulted from the integration of SRI into the whole farm production system.

Chapter 1 further provides relevant details about the mountain communities and farming systems in the studied villages, highlighting differences in contextual conditions. The chapter also provides a brief account of the introduction of SRI in the villages and describes the extension approach followed by the SRI-promoting agency.

The overarching research questions addressed by this thesis were as follows: What is the socio-technical (labour, skill, material) configuration of existing rice farming practices? What are the implications of the new SRI practices with respect to existing practices? How are rice farming operations and tasks adapted and adjusted following the introduction of SRI methods in the local agro-ecological setting? And how do the patterns of adaptation and reconfiguration vary across locations and seasons?

Chapter 2 explores how landscapes and farming communities interact around water management in response to SRI. The irrigation systems in the studied villages are a structuring element in the distribution and coordination of tasks at community level. Under SRI, early transplanting of young seedlings is recommended, resulting in a changed connection between water delivery and timing of transplanting. The vital importance of this connection is expressed in the advancement of *Din Bar*, a date designated by an established local custom as an auspicious day for rice transplanting to be initiated. The chapter shows how the three farming communities responded differently to SRI as a proposition, reorganizing rituals, routines and norms in ways that were related to the landscape, social structures, field characteristics and crop requirements. The scattered distribution of plots, cascade irrigation systems, uncertainties in water supply and diversified cropping patterns all affected the irrigation regime adopted for particular plots. Shallow flooding was generally preferred over the recommended alternate wetting and drying (AWD) method, especially in the early crop stage of SRI. This adjustment fitted with a liberal irrigation regime that helped to control weeds and insects, and also facilitated the distribution of labour between rice and other plots with rainfed crops.

Chapter 3 investigates the changes in land preparation practices and organisation under the influence of SRI. The chapter analyses changes that took place incoordination between two main task groups: ploughing teams and transplanting teams. The decision to plough a particular field at a certain time is based on plot characteristics (location, size, shape, soil-moisture conditions, and biota), plot situation in the landscape (elevation, slope, and water availability), and the anticipated method of rice crop establishment (direct seeding or transplanting). SRI creates a new requirement for drying and marking of plots as additional tasks prior to transplanting. Through Village Level Resource Persons (VLRPS), field-marking tools (markers) were introduced in the villages, which made the marking operation a central issue and their responsibility. The VLRPs emerged as the key specialists who undertook field marking on behalf of SRI farmers in the villages. This additional task of land preparation led to a new set of interactions between the ploughing task group and the transplanting task group, resulting in different marking patterns that were adapted over several seasons jointly by the VLRPs, plot owners and transplanting groups.

Chapter 4 probes into how the task groups that undertake management of nurseries and seed beds are formed and how they function. Before the introduction of SRI, nurseries and seed beds were owned and managed by farm households individually. SRI demands the raising of young seedlings through early establishment of raised bed nurseries (RBNs that have new specifications and require new skills. Not all farm households were able or wanted to establish RBNs on their own plots due to land, water or labour constraints. Farm households preferred to join forces to raise multiple RBNs on common plots. Some farm households used seedlings from conventional flatbed nurseries or from direct-seeded rice plots. Some simply relied on others to raise nurseries. A variety of different types of nursery task groups thus emerged that exchanged seedlings when congenial and convenient. Thus, RBNs and flatbed nurseries complemented each other.

Chapter 5 explores changes that occurred in the composition of transplanting task groups. It demonstrates the linkages that existed between the structure, function and operations of a specific task group. A diverse range of existing diverse transplanting methods catered to the agro-ecological variations within the villages, and task groups and practices were established around them. Transplanting under SRI requires timely labour operations and new skills. However the implementation of various SRI requirements (the source, age, number and spacing of seedlings) is affected by the availability of water, bullocks and labour; soil-moisture conditions and biota; the elevation, layout and location of plot; and cropping and livelihood patterns. A mingling of existing and newly introduced practices was observed. Transformations in transplanting units were brought about, with groups getting relatively bigger in size and younger in age, and an increase in girls' participation under SRI. The chapter argues that task reorganization and reorganization of labour groups is critical in order to bring about technological changes in labour-intensive farming systems.

Chapter 6 reflects and summarizes findings from chapters 2 to 5, providing a synthesis. The research findings illustrate how existing and new rice farming practices and task groups are reconfigured through socio-technical innovations within a given agro-ecological setting. The introduction of SRI acted as a catalyst, initiating a process of readjustment in the socio-technical configurations of rice farming, varying according to the local context. The study improves our understanding of the different interfaces of interaction between social and material factors, where farm households and their collectives apply, observe, interpret, learn, negotiate, and adapt practices while also reconfiguring task groups for different operations. It draws out the fact that farm households, while incorporating SRI into the existing farming system, try to seek complementarity and synergy between various rice farming methods. This allows fluidity among task groups and leads to the extension and diversification of the repertoire of methods used,taking into account the dynamics of the larger socio-technical assemblage. The research highlights farmers' adaptive capacities to reconfigure practices, reorganize social formations, and reschedule routines in response to farming interventions, in order to maximize the exploitation of agro-ecological niches, minimize uncertainty in farm production and rationalize the employment of the available work force.

The thesis illustrates that blueprints for agricultural technology are unlikely to be applicable in the same way across diverse agro-ecological settings. Participatory research in SRI and other farming interventions should be a priority area to determine the extent of flexibility which can and need to be accommodated for recommendations under varying agro-ecological conditions. The study also indicates a potential for task groups as units for effectively promoting new agricultural interventions. It raises questions about the relevance of past SRI studies that got preoccupied with adoption and dis-adoption phenomena or that labelled SRI as merely being labour-intensive. These studies did not give due importance to the location-specific adaptations and failed to recognize farmers' managerial skills to cater to the needs of the rice crop while also adjusting to the local environment. For instance, elements of the set of SRI practices, like the use of younger seedlings, fewer seedlings per hill and wider spacing of hills were shown to have influenced practices in nominally 'non-SRI' plots. This thesis thus highlights the role and importance of the human management component in farming activities and agricultural development. This provided insights into the integration of social and technical dimensions of crop cultivation, particularly the dynamics of rice farming using SRI but also for agronomy as a whole.

Biography

Debashish Sen was born in Kharagpur, Midnapore, West Bengal in India. He holds a Bachelor of Technology Degree (1988) in Agricultural Engineering from Allahabad Agricultural Institute (now Sam Higginbottom Institute of Agriculture, Technology & Sciences), India. After his graduation, he started his career as a research assistant at the People's Science Institute (PSI), a non-profit research and development organization based at Dehradun, India. He took over the responsibility of heading the Centre for Participatory Watershed Development (CPWD) at PSI in 1996.

Since 2006, he has been actively involved in promotion of System of Rice Intensification (SRI), a sustainable technique of farming in the mountain states of India. This further inspired him to enroll for a doctorate programme in 2010 at the Wageningen University, The Netherlands, to research farmer–SRI interactions. He is presently the Director of PSI. He has research interests in sustainable livelihoods, natural resources management and environmental impact assessments. He has authored more than 50 papers and articles on issues related to natural resources management, participatory watershed development, mountain appropriate technologies, traditional water sources and drought management.

PAPERS (Relevant to SRI)

- Sen, D., Adusumilli, R., and Sabarmatee (Forthcoming):"What does SRI bring? Improved yields or increased agronomic-bandwidth?", Contested Agronomy, Institute of Development Studies, Brighton, UK, 23-25 February, 2016

- SRI-Rice (2014): The System of Crop Intensification: Agroecological Innovations for Improving Agricultural Production, Food Security, and Resilience to Climate Change. SRI International Network and Resources Center (SRI-Rice), Cornell University, Ithaca, New York, and the Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen, Netherlands, p.76.

- Shambu Prasad, C. and Sen, D. (2014): "Exploring Diversity, Networks and Knowledge Regimes: Transitions and System Building in SRI in India", paper presented at International Workshop on System Innovation towards Sustainable Agriculture (SISA-2), Paris, 19-21 May, 2014, p.26.

- Sen, D., Maat, H. and Glover, D. (2014): "The farm field as the source of social formation: Seeds, seeding and seed nurseries of rice farms in Uttarakhand, India", paper presented at WASS PhD day, Wageningen University, 8 May, 2014

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- Sen, D (2012): "The shaping and reshaping of farming practices: The case study of System of Rice Intensification in Uttarakhand" paper presented at Altering Rural Landscapes: Structures, Institutions and Households, Annamalai University, Chidambaram, Tamil Nadu Workshop, July 12-13, 2012.

- Adhikari, P., Uphoff, N. and Sen, D. (2010): "System of Rice Intensification as a Resource- Conserving Methodology: Contributing to Food Security in an Era of Climate Change", satsawb.org.,2010.

- Prasad, C. S. and Sen, D. (2010): "The new commons in Agriculture: Lessons from the margins and SRI in India", Innovation and Sustainable Development in Agriculture and Food, Montpellier, France, 2010.

- Sen, D. and Goswami, S.N. (2010): "System of Crop Intensification in Himachal Pradesh and Uttarakhand – A note on PSI's experience during the 2009 Drought", SRI WWF Newsletter, Vol. II, Issue 1, pp. 10-14.

- Sen, D., Tomar, S. K., Bharti, H. and Sharma, R. (2008): "Upscaling System of Rice Intensification in Mountain States of Uttarakhand", paper presented at 3rd National Symposium on System of Rice Intensification, organized by Tamil Nadu Agricultural University" Coimbatore, December 2008.

- Sen, D., Chaturvedi, S. P., Bharti, H. and Bansal, R. (2007): "Promoting System of Rice Intensification (SRI) among Marginal Farmers of Uttarakhand and Himachal Pradesh", paper presented at 2rd National Symposium on System of Rice Intensification, organized by Tripura Agriculture Department, Agartala, November 2007.

TALKS (Relevant to SRI)

- Sen, D. and Maat, H. (2014): "Water Management in Rice Farms of Uttarakhand: Landscape, Culture and Plot Level Interactions and Negotiations", talk at 4th International Rice Congress, Bangkok, Thailand, 27-31 October 2014.

- Sen, D. and Maat, H. (2014): "Reorganizing Padiyals and Din Bar under System of Rice Intensification: Insights from Mountain Farms of Uttarakhand, India", talk at 14th General Conference on Responsible Development in a Polycentric World, Bonn, 23-26 June 2014.

- Sen, D. (2014):"User Adaptations in Rice Farms of Uttarakhand: Landscape and Farm Level Interactions", talk at International SRI research seminar on recent changes in rice production and rural livelihoods: New insights on the System of Rice Intensification (SRI) as a socio-technical movement in India, New Delhi, 19-21 June 2014.

- Sen, D. (2013):“Re-innovating of System of Rice Intensification (SRI): A Technographic study of rice farming in Uttarakhand, India”, talk at Knowing, Making, Governing, Asia-Pacific Science, Technology and Society Network, Biennial Conference, National University of Singapore, 15-17 July 2013.

POSTERS (Relevant to SRI)

- Adusumilli, R., Sen, D., Sabarmatee (2014):SRI- a Driver for Irrigation System Reforms: Policy Opportunities with System of Rice Intensification” at 4th International Rice Congress, Bangkok, Thailand, 27-31 October 2014.

- Adusumilli, R., Sen, D., Sabarmatee, Shambu Prasad, C., Rob Schipper and Raj Kumar Kumawat (2013): “New paradigms in sustainable intensification for food security: Differentiated agronomies in the System of Rice Intensification in India” poster presented at First International Conference on Global Food Security, Noordwijkerhout, The Netherlands, 29 September -2 October 2013.

- Sen, D. and Shambu Prasad, C. (2013): “Adapting agronomic management practices for enhancing rice yields: The spread of SRI practices in mountain farms of Uttarakhand, India”, poster presented at First International Conference on Global Food Security, Noordwijkerhout, The Netherlands, 29 September -2 October 2013.

- Sen, D. and Shambu Prasad, C. (2013): “Role of Management in Rice Farming: Recent evidence from the Mountain Farms of Uttarakhand” poster presented at Association of Rice Research Workers (ARRW) Golden Jubilee International Symposium, Central Rice Research Institute, Cuttack, Odisha, India, 02-05, March 2013.

Debashish Sen
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

Wageningen School of Social Sciences

Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
Technography, Researching Technology and Development (TAD 30806)	WUR	2011	6
Writing of the PhD Research Proposal	WUR	2010 - 11	6
Attending PhD discussion groups (Subject: The System of Rice Intensification (SRI) as a socio-economic and technical movement in India)	NWO-WOTRO Project, WUR	2010	3
Project Workshops : Training, Planning, Progress Review Workshops	NWO-WOTRO Project, WUR	2010-14	4
B) General research related competences			
Research Methodology I : From Topic to Proposal	WUR	2010	4
Information Literacy including Endnote Introduction (ILP)	WGS	2010	0.6
Workshop – Research for Development	WTMC	2010	3
Presentation related to PhD (Research Proposal, Preliminary Findings, Chapters of Dissertation)	TAD/KTI, WUR	2011-14	2
"The shaping and reshaping of farming practices: The case study of System of Rice Intensification in Uttarakhand"	Workshop on Altering Rural Landscapes: Structures, Institutions and Households, Annamalai Nagar, Tamil Nadu, India	2012	0.5
"Role of Management in Rice farming: Recent Evidence from the Mountain Farms of Uttarakhand, India"	ARRW Golden Jubilee International Symposium, Sustainable Rice Production and Livelihoods Security: Challenges and Opportunities	2013	0.5

”Re-Innovating the System of Rice Intensification (SRI): A Technographic Study of Rice Farming in Uttarakhand, India”	Asia-Pacific Science, Technology & Society Network – Biennial Conference 2013, Singapore	2013	0.5
“Adapting Agronomic Management Practices for Enhancing Rice Yields: The Spread of SRI Practices in Mountain farms of Uttarakhand, India”	First International Conference on Global Food Security, Noordwijkerhout, The Netherlands	2013	0.5
“Exploring Diversity, Networks and Knowledge Regimes: Transitions and System Building in SRI in India”	International Workshop on System Innovation towards Sustainable Agriculture, Paris, France	2014	0.3
”*Padiyals* and *Din Bar* under System of Rice Intensification: Insights from Mountain Farms of Uttarakhand, India”	14th EADI General Conference Responsible Development in a Polycentric World: Inequity, Citizenship and the Middle Classes, EADI, Bonn	2014	0.5
”Water Management in Rice Farms of Uttarakhand: Landscape, Culture and Plot Level Interactions and Negotiations”	4th International Rice Congress, Bangkok, Thailand	2014	0.5
“SRI- a Driver for Irrigation System Reforms: Policy Opportunities with System of Rice Intensification”	4th International Rice Congress, Bangkok, Thailand	2014	0.3
C) Career related competences/personal development			
Course – Techniques for Writing and Presenting a Scientific Paper	WUR	2013	1.2
Course – Scientific Publishing	WUR	2013	0.3
Organizing Workshops on SRI	People’s Science Institute, Dehradun, India	2011-13	3
Supervising three MSc Students	XIMB, Bhubaneswar and WUR, The Netherlands	2011-12	2
Training and Supervising Enumerators (Village Survey, Household Surveys, Social Network Survey)	WUR	2012-13	2
“Seeding Social Transformations: Raised Bed Nurseries of Rice Farms in Uttarakhand”	WASS PhD day	2014	1
PhD Workshop Carousel	WGS	2014	O.3
Total			**42**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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