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The mechanical weeders used in rice cultivation practices in Tripura, India, and their relation with the system of rice intensification (SRI)

A technographic study of the orchestration between makers and users of a tool

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1 - Introduction

1.1 - Categorical simplicity

What we commonly refer to as a weeder is a farming tool used in secondary tillage practices and designed primarily for use in the production of food and fibre (ASAE standards, 2004). There are several categories of secondary tillage implements, according to: the categorization of tillage practices, the level of mechanization of a particular farming area, and the crop grown. We then have harrows, cultivators, rod weeders, rotary tillers, and rotary hoes, for example. Machines as such can till the soil to a shallower depth than primary tillage ones, in so doing they provide additional soil pulverization, mix pesticides and fertilizers into it, level and firm the soil, close air pockets, and eradicate weeds. They are designed to be moved in straight lines, whether in the phase of land preparation or in between already emerged crop rows. To further define a weeder, a minimal **definition** can go as follows:

> *A weeder is a mechanical implement used in agriculture primarily to suppress and control the amount of pest weeds in cultivated field, which can be operated by one or more operator and it moves in a straight line.*

Such definition determines these machines according to **the reasons why** they have been designed and built in a particular way, regardless of different contextual conditions and different way of using them.

"Primarily to suppress and control" indicates the primary use of the weeder. The simple fact that we call it "weeder" clearly indicates the intention that the designers have put into it. It expresses the desire of counterweighing the amount of pest weeds in favour of the crop, and suggests controlling weeds mechanically rather than with manual weeding or other equally valid agronomic measures.

"In cultivated field" indicates where the weeders operate. The conflict between productive crops and antagonist organisms has been going on since the first settlers decided to abandon the nomad lifestyle and posed the basis for the modern farmers-field interactions. In these interactions, the weeder plays a positive role for crops and negative for the pest weeds.

"Can be operated by one or more operator" indicates a usage scenario or a usage pattern, which the weeder design allows or prevents. There is the flexibility to find in a particular field, with certain defined characteristics and with particular users, a particular weeder design and not others. According to different sizes, weights, or shapes, a weeder needs to be operated by at least one operator, but it is possible to have multi-operator machines to accomplish the same task.

"It moves in a straight line" refers to the set of rules and routines needed in order to make the tool working in the field. The design of the machine is instrumental for how it moves and for the conditions in which it has to operate; it basically defines such conditions. Different designs of the weeders influence their susceptibility in how they are being used.

Acknowledging the fact that it is an impossible quest to completely avoid competition and productivity loss caused by pest weeds in any cultivated fields, it becomes necessary to implement any suitable techniques to control at best their level. Besides, the weeders have secondary usages, such as slightly mulching the soil or incorporating fertilizers or other chemicals into it.

1.2 - Area of study

The area of my study is Tripura, the third smallest state of the country in the northeast. It borders Assam, the biggest state of the northeast, and Mizoram to the east, whereas Bangladesh represents the northern, western and southern border. Tripura can be well considered as a landlocked country for it is bounded for the most part by another country, and its particular land morphology, with a series of parallel hills and valleys that run north-south. It has one single poorly maintained highway road, the NH 44, which cut the country north-south towards Assam, and works as a very (and only) important road connection with the rest of the Indian Union.

More than 50% of its population depends on agriculture and allied activities for living, although the percentage of the primary sector on the total GDP is slowly decreasing and it counts actually around the 20% (Government of Tripura, 2009, 2011). This indicates a declining attraction of farming activities when compared to the higher salaries reachable in other sectors and the better living conditions achievable in urban areas. The actual living conditions of rural communities are indeed much poorer the more one is leaving the main connecting roads and get into the hills, for instance.

In many part of India, the hand weeder, also called rotary weeder or mechanical hand weeder or rotary hoe or cono weeder, is a tool used in agriculture and allied activities to keep control of weeds in rice and other crops cultivation. Rice is a staple crop in the country and Tripura is an area historically devoted to its cultivation. The vast majority of field operations practices are still carried out using manual labour. Nonetheless, different types of weeder exist in the field and are actually used by some of the farmers, who are very skilled in operating them. This shows the history of the weeders and the existence of a system of knowledge sharing.

1.3 - The System of Rice Intensification (SRI)

SRI has attracted the interests of many international research institutes of the like of the International Fund for Agricultural Development (IFAD, 2013), the World Bank (World Bank, 2013), and the International Rice Research Institute (IRRI, 2013), with specific websites for the collection and diffusion of knowledge about it. IRRI has recently launched the Global Rice Science Partnership (GRiSP, 2013), a joint collaborative project of which its director and ex-Wageningen scholar Bas Bouman published a full report (Bouman, 2012) where he places the origin of SRI and the actual development of the rice cultivation research on a global scale.

A good starting point comes from the article of Glover, cited by Bouman himself, about the research on SRI done by Fr Henri De Laulanié (D. Glover, 2011a). In this paper, Glover carefully dissects the origin of the term, supposed to be originated from the French "*Système de Riziculture Intensive*", and argues that the system and its creation rely on elements of invention and adaptation to local contexts, in addition to a certain shared idea that sees SRI as a serendipitous discovery to be placed around the early 1980s in Madagascar, as in the paper of De Laulanié himself (De Laulanié, 1992)[1] and those of other scholars and research centres (Dobermann, 2004; Prasad, 2006; Norman Uphoff & CIIFAD, 2002); this work helps in understanding SRI as a complex, fluid set of principles drawn from a longer history.

The set of practices firstly delineated by De Laulanié (De Laulanié, 2011)[2] underwent a process of elaboration. They were only partly different from the conventional rice cultivation practices known so far in

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[1] This article is an English translation cum comment version based upon the observations from which the 1993 French article has been written, and has been has been published only recently by the CIIFAD.

[*2] This is a commemorative article of Tropicultura about the 30th anniversary of the work of De Laulanié, so the material in it comes from the 80s.

Madagascar, and were considered most successful when applied together. As Glover reports, the first two essential principles for De Laulanié were transplanting very young seedlings between 8 to 15 days after sowing and planting them in single post rather than in clumps. Others, secondary level principles, can be summarized in: intermittent drainage of paddy fields, irrigation with a minimum use of water, the use of a gardenlike seedling nursery, careful soil preparation and levelling of the paddy fields, careful handling and skilful transplanting of seedlings, early and regular weeding, and timely harvesting. Also suggested spacing distances of 25 x 25 cm in between rice seedlings, that could have been modified to adapt to local conditions (D. Glover, 2011a).

Few of these primal principles, later on adapted and validated by further researches in other countries, are partly similar to other previously existing ones, like the single seedling per post practiced since 1965 by Malagasy people (and acknowledged by De Laulanié himself); or the careful soil preparation and levelling typical of any water management plan; or the Japanese Method of Cultivation of row planting and mechanical push-weeders used since 1950's by the Indian Council of Agricultural Research (ICAR, 1956). A synopsis of different sites, and a critical view over the putative benefits of SRI, out of the scope of this thesis, can be found in the article of McDonald et alia. (McDonald, Hobbs, & Riha, 2006) and subsequent replies (Norman Uphoff, Kassam, & Stoop, 2008) (McDonald, Hobbs, & Riha, 2008). Further scientific rows can be found in the view expressed by Glover and his plea of taking seriously the phenomenon SRI not only as *"a function of compelling scientific argument"* but also for the strong support it is receiving from many different stakeholders, especially at field level as the case in Indian agriculture (Dominic Glover, 2011).

After De Laulanié collected his observations in a paper, and even after joining efforts with Tefy Saina, the local Malagasy association of practitioners and farmer's help he co-founded, very few followers were aware of his set of principles. This until a project of the Cornell International Institute for Food, Agriculture and Development, directed by Norman Uphoff, steps into the picture (SRI-Rice & CIIFAD, 2012). As Uphoff grasped the concepts behind SRI (Norman Uphoff, 1999), he made a plea to international research bodies over the agricultural research issues raised by it (Stoop, Uphoff, & Kassam, 2002) and moved towards a further analysis and comparison of SRI, together with other scholar as well , for its peculiar difference with conventional rice cultivation (Thakur, Rath, Roychowdhury, & Uphoff, 2010; Norman Uphoff et al., 2008).

His work has been so far openly in favour of adoption of SRI practices at the farmers' level, and have generated heated controversies (McDonald et al., 2006, 2008) while having the undoubted merit of calling for more and more accurate research on SRI and the underlying agronomic principles (Barah, 2009; Dobermann, 2004; Latif, Ali, Islam, Badshah, & Hasan, 2009; Stoop, Adam, & Kassam, 2009; Stoop & Kassam, 2005). His stances, alone or as a co-author, have then further expanded the discussion on SRI, for example in the comment of Uphoff to Glover (Norman Uphoff, 2012) and successive reply (D. Glover, 2012) or the analysis of discontinuities of labour distribution between researchers and agricultural extension officers as in Maat and Glover (Maat & Glover, 2012).

1.4 - Research objective

Mechanical weeders in Tripura are recommended by the SRI practices as the "most effective" one that farmers can use to weed the paddy fields. These practices are backed by local governmental agencies like the Tripura Department of Agriculture, research institutions like CIIFAD, and even supra-national interest like the ones expressed by the World Bank (Zoellick, 2009). This thesis, being focused on the *technology-in-use* (Jansen & Vellema, 2011), will take the point of view of the weeder to describe: how the making of the weeder is carried out by different actors, what kind of characteristics does a weeder need to have, and how a weeder works.

Many different weeders have been designed, selected, or proposed again with no clear definition of salient characteristics and no "definitive" design. The **research objective** will be to investigate the causal explanations of using such technology among farmers and other actors in Tripura, in order to provide a partial answer to "what weeder is good at" for professionals, farmers, and researchers. This will support the agricultural development from a more tightly focus on the ground level of intervention.

It is relevant to look at the "orchestration" that different actors or group of actors need to express together in order to produce a tool that is useful, i.e. a tool that "fits" in the intended uses or objectives of the actors involved and the need of the rice plants. This orchestration will shed some lights over the process of making the tool and the reasons to devise a weeder in particular ways. Different task-groups, locally situated ways using the weeders, and peculiar task ordering activities will be observed and described.

1.4.1 - Problem statement

The rice weeders used by the farming communities in the paddy fields of Tripura represent a multiform, locally adapted concept. They come in different designs, have different usage patterns and outcomes, and operate according to the local rules and routines. The System of Rice Intensification, a way of producing rice which differs from the local one (D. Glover, 2011a), is becoming part of these rules and routines, and is affecting the way such machines are being selected in the area.

Little is known among farmers about how much diversity exists in terms of the rice weeder designs and models, how such diversity has come about in Tripura, and what role SRI has in defining a weeder design.

1.5 - Research questions

- Why do a profusion of different weeder designs exist in Tripura?
- How do different models end up being distributed in this way?
- What role does SRI have in this profusion of weeders?

1.5.1 - Sub-Questions

- How many different designs and models of rice weeder exist in Tripura?
  - How are these different designs and models being used?
  - What influence do they have on SRI?
- How have weeders changed during time?
  - What influence has SRI had on this?
- What do group of actors need to do in order to arrive at a settled design?
  - What characteristics are considered salient?

1.6 - Review of existing literature

1.6.1 - Indian weeders and SRI

It is hard to carve out a definition of the weeder used for rice cultivation; there are example in literature in which it is called push- weeder (Stoop et al., 2002) (SRI-Rice & CIIFAD, 2012), rotary weeder (De Laulanié, 1992), mechanical hand weeder (Alizadeh, 2011), rotary hoe (Chapagain & Yamaji, 2010), or cono weeder (Ravindra, Ravi Kumar, & Narendranath, 2012); (Prasad, 2006). They all refer to the same type of machines, though they have several way of being used and do slightly different jobs. It is then a multiform concept, which become in-use according to different actors, like the researcher who describes it, the importers who buy and sell it, the farmers who use it and the institutions that support it.

The attempt of the Indian Ministry of Agriculture to list all the possible manual implements for different agriculture systems, SRI included (Ministry of Agriculture India, 2012) is still in a draft phase nowadays.

Specifically for SRI, this naming profusion has been ordered in the publication of Wassan (WASSAN, 2006), in which weeders are showcased in separate sections for each ones with some self-explanatory pictures.

The ratio for publications as such is to provide ideas and a robust though minimal set of choices to start weeding with mechanical aid. It seems intended to be read directly from field level officers, if not farmers. It can be also seen that a "one-size-fits-all" definition of the weeder is not provided, giving credit to the Glover argument that "imprecision reflected in these definitions of SRI has provided fertile ground for critics to attack the system''(D. Glover, 2011b). As he suggested then, "a focus on farmers' practices does tend to dissolve the categorical simplicity that a purely technical definition imposes on rice farming systems that are intrinsically diverse, dynamic and contingent".

A characteristic of the mechanical weeders is the fact that they are used in row crop cultivations, being its inherent shape and size perfectly suited to aid any farming activities which happens to be in rows. For rice cultivation in India, row planting has been first implemented with the Japanese method of rice cultivation (ICAR, 1956) and subsequently SRI. Using a weeder in such cases has been boosting rice yields. As we know from other scholar nowadays, the real boost to productivity that can be inferred from De Laulanié papers and that of other scholars could have come from only a part of the principles proposed as SRI.

For example the acidic soils of Madagascar could have been benefited more from the different water management, which happens to reduce the amount of root-toxic compounds that are usually formed in flooded conditions on such soils in that area (Dobermann, 2004; Horie et al., 2005); furthermore, the wide spacing allowed to the rice plants, when combined to different water management like alternate wetting and drying (AWD) have only synergistic effects over their improved tillering capacity, (Chapagain & Yamaji, 2010), instead of posing them as self-standing aspects (Thakur et al., 2010).

Even though the rice is a plant that can adapt quite well its tillering capacity to different spacing pattern (Horie et al., 2005), a debate is still going on between rice scientist about the necessity or not to adopt larger spacing, and the SRI debate is an example of it, with its principle of adaptable practices (Bouman, 2012) (Thakur et al., 2010). Weeders are being actually treated as an essential principle in SRI in order to actively influence soil aeration (Stoop et al., 2002; N Uphoff, 2006), though the scope of such literature is to provide a line of reasoning supporting SRI. The influence of a weeder is broader and not so focused on aeration, rather on other more important qualities like actual efficacy in weed control (Haden, Duxbury, DiTommaso, & Losey, 2007) or its influence in different water management (Chapagain & Yamaji, 2010).

1.6.2 - Chronology of weeding practices

Rotary tillage implements, locally devised or imported, were already known in India among higher administrative ranks and research stations. They were used in paddy fields since the beginning of 1900. As in the 1956 report issued by the Government of India, already in 1953-54 the Ministry of Agriculture was actively pushing towards the adoption of the so-called "Japanese method of rice cultivation" in many Indian states, which entailed already the use of a push-weeder to manage part of the weeding operations in row-planted rice fields (ICAR, 1956). This publication sheds more lights over the at-the-time situation in Tripura, which was quite poor also in term of space dedicated to it in the publication itself, and the level of intervention not at the same level as in other bigger or more developed states, such as Punjab.

The design of rotating mechanisms was then already known before the advent of SRI in India (Sinha, 1973), even though the context of flooded rice cultivation forced such implements to be used at the stage of land preparation, in order to break the structure of the soil (puddling) and create a hardpan that would help to reduce percolation losses, to increase the availability of nutrients, and to control weeds. More implements were also developed and used for this stage, e.g. rotary implements as in the 1983 article of S. Rami Reddy and S.B Hukkeri, about tillage implements tested in 1974/75 (Reddy & Hukkeri, 1983), hereby reported.

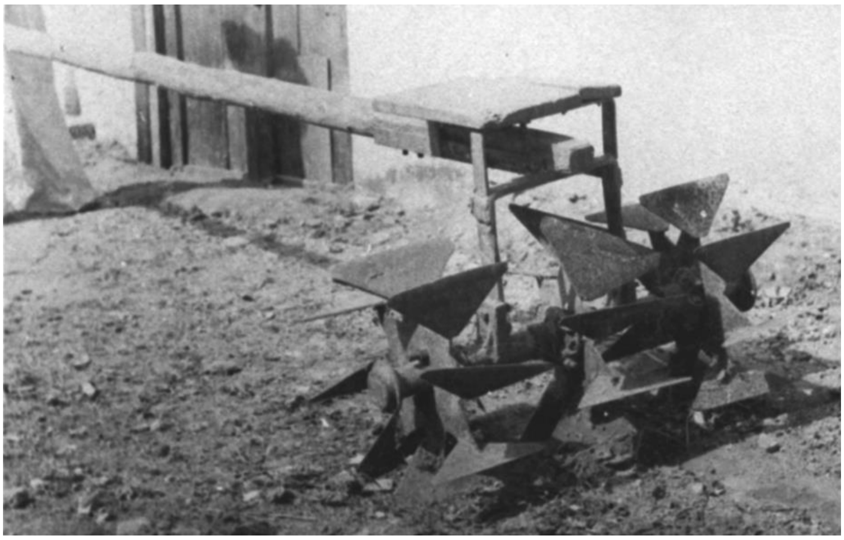

Figure 1 - Wetland rotary puddler used in the 1974/75 tests (Reddy & Hukkeri, 1983)

The introduction of SRI in India is dated in 1998-1999, as reported in the website of the WWF- Icrisat project, thanks to an informal communication held between the PRI in Wageningen and the Tamil Nadu Agricultural University (TNAU) in India. The two institutions joined efforts in testing the different technical aspects of SRI (SRI-India, 2009) and to contextualize its packet of practices in terms of scheduling activities and redefining concepts of weeding a paddy field. What it can be inferred though, at least for the Indian situation, is that SRI could have had the merit of pushing forward the adoption of weeding techniques with the push-weeder during the vegetative phases of rice plants. This was not necessary, if not impossible, in conventional cultivation, due to the submergence of the paddy fields and the historical use of herbicide for the sake of competing pest weeds since last century (F Bray, 1986).

Although being named after the SRI phenomena, the mechanical weeders were existing already in the field before the advent of SRI, an aspect which De Laulanié himself introduces in a paragraph dedicated to weeding, and rotary weeders in particular, of which he acknowledges that they were already imported since 1968 in the Madagascar area where he was experimenting (De Laulanié, 1992, 1993). Considering that the Malagasy is historically a rice producing and consuming area, any previous import stock of the machine means that the use of rotary weeders for tillage practices existed long ago the introduction of SRI, at least for the soil preparation phase of the rice cultivations. This is in accordance with the argument that SRI has precedents in rice cultivation from different times and places as expressed by Glover in his recent conference paper about origins of SRI (Dominic Glover, 2013).

Further attempts of listing mechanical implements has been done in India, but none so far has reached an immediate nor organic synthesis (Ministry of Agriculture India, 2012).

2 - Theoretical framework and methodology

2.1 - Actor-network theory

We can see disconnections between formal agronomic research and field-level technology development and promotion (Maat & Glover, 2012). Research institutions like IRRI and TNAU, and governmental agencies in Tripura like the Department of Agriculture are teaming efforts to spread the use and adoption of mechanical weeders in the fields. This has given me an idea about to what extent the stakes of different agents are important and how these influence the selection of the weeders. Being in a field experiment and looking at how this pressure take place among the farmers, coherent with the view expressed by Latour, has been useful to understand how social context and technical content interact (Latour, 1987).

That has led me to firstly list all of the actors involved (Law, 2003) and then to identify who or what group have enacted that way and for what reasons. This is useful also to directly see what the actors are actually doing, and how that action is then shared among the others, like represented in the media or explained by field officers. It can also identify possible gender polarization in shaping a particular technology in use (Francesca Bray, 2007; MacKenzie & Wajcman, 1999).

2.2 - Technography

This research can be considered as an example of technographic study for being focused on the shaping, use and impact of a technology (the weeders) in concrete social situations (Jansen & Vellema, 2011). As Jansen and Vellema posed in 2011, technography has **three dimensions:** making, distributed cognition, and the construction of rules and routines. Different theoretical tools are used to inform them, as follows.

2.2.1 - Script and situated action

There is an action inscribed in the weeder itself, which is the action that the designer has built into the machine prior manufacturing it. A useful insight comes from the paper of Madeleine Akrich about the in-scription and de-scription of material activities into physical objects; in an argument that is congenial to the perspective I am outlining here, she captures the fact that the **weeder's designer** defines actors with specific tastes, competences, motives, aspirations, and political prejudices, so they assume that "morality, technology, science, and economy will evolve in particular ways" (Akrich, 1992).

A weeder as a material object then, got already a text inscribed in it, which the designer has thought about to put it inside it, and that its users are expected to understand and then operate it in a certain way. Though, the final users are the ones who will use it, so they may or not de-script it according to the designer's text. The argument of SRI as a "new" set of practices should consider the tillage practices long known in the fields. Without being conclusive or definitive about them, constructions of rules and routines are intended to be contextual and situated in local practices and daily use (Suchman, 1987).

2.2.2 - Task ordering and orchestration

In his cycle of ''small group culture'', McFeat argues that a task group can be observed by looking at:

- the capacity of the group to order culture content during time,
- The capacity of the group to task-order their inflow in order to achieve the task,
- The capacity of the group to group-order their inflow in order to generate a model

I picked up the concept of **orchestration** starting from it (McFeat, 1974). Under this lens I can consider as a task group any group (or sub-group) of farmers, labourers, manufacturers, engineers, importers, and governmental institutions, because they all have something to say in the activity of "making use" of the tool. They also need to work together in a coordinated way, as in an orchestra, to define a weeder's shape. The argument here is that this orchestration is played by different grouping configurations divided by tasks. This concept is enlarged with insights from the seminal book of Leeuwis about communication for rural innovation, in particular when he points out that

> *"The process of distributing and/or gaining access to scarce resources often involves making project proposals in fixed formats, tendering procedures, etc. In view of such 'rules of the game', it is inevitable that farmers' organisations, government bodies, etc. form coalitions and strike deals with each other and with funding agencies"* (Leeuwis & Van den Ban (Contributor), 2004).

This excerpt can be almost entirely transferred to the Tripura case, in which different grouping configurations can be observed in the Department of Agriculture, together with their peculiar policies and tendering procedures for adopting new technologies that will then be transferred to the field. In other words, such task groups and the way in which they organize their internal policies can influence the adoption and diffusion of a particular weeder, or hindering such process.

Hence, the most successful, useful, or "the best" weeder for such task-group is the tool "coming out" of these relations. It is hereby proposed, at least for Tripura**,** to look at SRI as a task-ordering activity, enacted by task groups to accomplish their shared common goals.

2.2.3 - Expertise

There is the case, in the fashion of knowledge extension, that so-called "experts" or groups of them are in charge to go and "teach" farmers how to use a weeder, so to show them how to follow the text in-scripted in it. The latter example can be found in literature talking about the "man of knowledge", or the **técnico**, as it is called in Spanish, though this will raise further questions, namely:

- Who is the técnico?
- How does expertise influence the distribution of power over policy and decision making?
- What happens when experts have power? (Grindle, 1977)

In his 1977 article, Merilee Grindle try to answer them, explaining the expertise of the técnicos as a way to administrate power from top hierarchical levels, and she discusses what happens in case that the técnicos blend in some characteristics of the políticos (Spanish for politicians), insofar they help forging policies.

In Tripura the weeder is a tool depicted in the local SRI guidelines as the "most effective" farmers can use to weed the paddy fields. Besides, the approval track of a new machine has a definite course, which creates a small sub-group of professionals inside the Department of Agriculture, who concentrate the very essence of technical expertise and top hierarchy. The choices of the técnicos are also supported by other state level and transnational institutions, which basically endorse their activities or openly link to them.

2.2.4 - Technological evolution and trajectories

There are different codified set of rules and routines attached to the weeders, e.g. a manual, an extension officer who has been instructed about how to use it, or previous local knowledge of farmers and labourers. How they co-exist, i.e. how they "orchestrate" their relations, is based on the joint coordinated desire to fulfil their shared desired objectives (McFeat, 1974), e.g. increasing the rice yield, selecting new sets of crop managements or achieving a better standard of living for the farmers and their families.

From the starting question of *''why so many''* then, I ended up considering the orchestration as the key point to explain why different shapes and different models have evolved in a way instead of another. As Dosi poses, there are certain evolutionary trajectories that work for actors and not for others, and are based over the social, political, economic and cultural discontinuities of that context (Dosi, 1982). E.g. the sub-group of experts inside the Tripura Department of Agriculture, which have direct and indirect power over the approval of specific machines, in so doing influencing the "natural" selection process of the tool.

As Jansen and Vellema pose, technology can be addressed as the use of skills, tools, knowledge and techniques used to accomplish certain ends. (Jansen & Vellema, 2011) Hence I am addressing the rice weeder as a technology inscribed in a socio-cultural environment that performs using a certain set of skills, coded in a certain body of knowledge. Overriding the six assumptions of the traditional concept of technological process as suggested by Basalla (Basalla, 1988), the idea of evolutionary progress of this technology accepts the possibility of limited progress towards a carefully selected goal within a restricted framework. That is exactly what I argue is causing the differentiation in the shape.

As Basalla poses, artifactual diversity is the material manifestation of the various ways men and women throughout history have chosen to define and pursue existence. Thus the choices are consciously made to fulfil immediate goals, although do not constitute human progress.

> *''We should cultivate an appreciation for the diversity of the made world, for the fertility of technological imagination and for the grandeur and antiquity of the network of related artefacts''* (Basalla, 1988)

2.3 - Patterns of causality

I have used the arguments delineated in the paper of Ray Pawson and Nick Tilley about realist evaluation, to describe the weeder and the causality relations in its shape selection environment. Contextual factors in Tripura define the environment in which a weeder is selected. This generates some observable patterns, like favoured weeders, particular ways of using them, and so on. There are then mechanisms that work as enabler or constraints in order to arrive at that outcome. The sum of these three elements generate what Pawson and Tilley define as a ''configuration'' of social and technical interactions (Pawson & Tilley, 2004).

In Tripura SRI has been identified as one of the possible "solutions" that could give a boost to the depressed rice yields, without modifying too much existing equilibriums in term of farming input. The reasons seems to follow the same line of Glover, in considering SRI **not** as a discrete, mutually exclusive and competing system for rice cultivation (D. Glover, 2011b), rather as a method constituted by a fluid set of good agricultural practices (GAP). Such GAPs are parallel to the mainstream one, and have comparable efficacy (D. Glover, 2012; McDonald et al., 2008).

The question would be if farmers apply/practice SRI methods as whole or only elements of it. The weeder in fact can be well inscribed as being part of those GAPs that have an efficacy comparable to the HYVs ones, both in term of more economical effective and of more environmentally sustainable. Given the variability of weeder designs used in Tripura, the sole process of devising a new machine can be considered flexible, hence standardization is a mechanism that generates from the precarious organization that the different actors have when devise the tool (Law, 2003).

2.3.1 - Increased labour requirements

According to the argument developed by Francesca Bray in 1986, labour-saving changes in agriculture can have four possible effects:

1. They may enable the same number of workers to bring larger areas of land under cultivation;
2. They may enable the same area to be cultivated by fewer workers, thus liberating the surplus labour for some other employment;
3. They may allow the same area of land to be more intensively cultivated without increasing the number of workers.
4. In case of land shortage and abundant labour, i.e. where rural populations are dense and opportunities for alternative employment few, they may increase land productivity and labour demands.

The first three increase production output at the cost of reducing the labour force, whereas advances of the fourth type are preferable to absorb labour and reduce agricultural underemployment. The latter type then, while frequently dependent upon highly skilled labour, do not necessarily require mechanical sophistication. (F Bray, 1986) This counter-intuitive argument seems quite fit to be adapted to the Tripura case, in which the percentage of unemployment, especially during peak times of the year in which the labour is particularly scarce, simpler mechanical implement and labour training sessions are preferable to the increase of complexity, and most of the time the increase of costs, in the farm.

2.4 - Methodology

Various methodological tools are used to identify the substantial relations between the three dimensions, as it is always the case with technographic study being methodologically plural (Jansen & Vellema, 2011).

2.4.1 - Recording the diversity

Any group or user expresses different criteria about what they consider useful in a weeder. The definition of **a simple typology** of weeder existing in Tripura is a necessary point to understand them. They have been selected on the base of availability and saliency for rice cultivation. Empirical geometrical measurements of the tools have been taken, together with pictures of the different shapes, and video materials have been recorded on how different shapes are used by farmers or labourers. Also **important to know:** the price of such tools, the amount of eventual subsidies, if and in what occasions this price changes, and a comparison with the other farming aids available to farmers. The typology, presented in a neat and comparable list, has been considered the starting point of the experiment, e.g. to identify what characteristics deserve further investigation with the experiments.

How the surrounding local institutions were framing all the information regarding weeders is part of the contextual reasons for selecting them. How extension materials (pictures, videos or training sessions) look like and what kind of advertisements (or the lack of) that tools' producers and importers make in the farmers' area are all worth investigating. Raw agronomic data about the rice cultivation, like interline width, size of the plots, capacity and timing of irrigation, rice variety used, soil composition, water sources, and chemical input used **have been recorded** to get a better picture of the environmental condition in which weeders are being operated.

2.4.2 - Stakeholder analysis

An important step is to define the composition of the task-groups via a stakeholder analysis and direct observations in the farms, in the markets and in the fields. This will be used to understand the networks of relations among actors, their economic interests in weeders, what kind of competences is required to build such a machine and for which purpose they prefer a shape instead of another. **The composition and heterogeneity of this ''task group'' is responsible of defining the standards** (or the lack of) and is a clear example of how people are coping with different interests and how different competencies relates.

The participation analysis is constituted by qualitative methods like needs and wishes categorization, power-interest grids, standpoints mapping and so on, all based on clearly defined and quantifiable indicators. They are used to describe the members in the task-groups and further divide the task groups according to their intended goals. This analysis has been used to understand how weeders performs as catalysers of different stakes and how are selected or adopted by different actors. E.g. it is useful to understand the relative importance of research institutions and governmental agencies' stakes when it comes to make the weeder appealing for the farmers, or the stakes of welding shops and farmers when it comes to the material with which the weeder has to be produced or fixed.

2.4.3 - Participant observations and interviews

Participant observations were conducted along the daily routine of farmers, labourers, garages, and governmental officers, because what the actors actually do is influencing the process of de-scription (Akrich, 1992), adoption or rejection of a particular type of weeder. I have been asking my informants what characteristics they consider salient when selecting or adopting a weeder and why. What they consider "salient" is related then to the concept of "natural" selection of technology. I have been using this technique during Departmental meetings in Agartala, in order to define which criteria to use in order to select the farmers and how many of them I needed to interview. Considering the important environmental obstacles and the poor infrastructural connections, traveling in a timely manner was very difficult, so I had to carefully select my informants' locations among the choices that were "reasonably" close by.

The local knowledge that farmers already have about conventional SRI weeding practices is the first source of information, hence interviewing them and having a closer look at their daily routines has helped me to shed some lights about their practices. It is important to inform how the weeder has been produced, what manufacturers, welding garages and mechanical engineers consider salient criteria in a weeder, and to what extent; again coming back to them if the case. The interviews range from informal one-to-one to semi-structured, most of the time in open air and with at least few people observing. The semi-structured interview has given me enough data about the experiment, for instance, while a completely free and informal one had enough openness with the interviewee to provide me contextual information, even at time not strictly related with the interview itself.

The participant observations were often followed by interviews, as for optimizing time due to the large amount of stakeholders involved. When the number of people intervening was above my focus limit of one informant per time, I switched to Focus Group Discussion (FGD). The kind of questions posed were most of the time open ended, to increase both the possibility of drawn more contextual data from the informants and the identification of particular stakes that would never come out otherwise. FGD were useful especially in the very common case of weeders being shared among more than one farmer (usually its owner). Farmers might have had a collective understanding of the machine, which would have been otherwise lost in individual interviews.

2.4.4 - Field experiment

A series of comparative test trials has been carried out in order to understand what efficacy in removing weeds means for the farmers and how the hand-made and other models are used; to observe the skills that an operator need in order to properly manage a weeder, and to describe how mechanical weeding can be integrated in already existing practices. They informed the tables about timing of weeding operations, the overview of soil composition in Tripura, the influence of water sources management on the drudgery of weeders and the distribution of cultivation between lowland and upland.

The direct observations in the field and the quantification, where possible, of data regarding ergonomics of operations are crucial to describe weeder operators. The heterogeneity among the labourers, as well as the drudgery related to a particular design, works as a selection mechanisms, because cultural, economic, age and gender differences among operators push the selection of “favoured” weeder models.

Informal interviews with local audience and governmental officer were planned at the beginning of the experiment and during them, in order to create an environment conducive to the FGD done at the end of it with farmers and labourer. This work was possible with a local Bengali translator, in order to get first impression from them, and secondary interviews were conducted with field officers and farmers that were observing around, in order to get contextual information or contrasting accounts.

2.5 - Interpretation and reflexivity

I am aware of the fact that facing a problem of this complexity as an outsider can lead me to wrong interpretations of local accounts. It can lead me to have pre-existing assumptions about it. For example, during the preparatory phase I put more emphasis on understanding of SRI as a phenomenon and how it influences the weeders, rather than the other way around. Conducting the fieldwork has been really valuable in battling my pre-assumptions and teaching me the field. It allowed me to clearly recognize individual agents and to study them in their causal contexts. The fact of spending in Tripura a total of seven months, because the fortuitous combination of my internship in the same place, has given me the time and opportunity to think about the thesis as a process of discovery and learning, rather than mere investigation.

The preparatory phase was indeed extremely important before entering the field. It is crucial to have enough time to prepare oneself with a sound literature grasp and to give oneself enough time for the iterative process of learning to work in the field. I used and earlier version of the weeders typology during my observations. Many times I have found myself discovering something new or noticing a detail by just reading the notes of the day before, and confronting it with the typology. I was hen able to come back in the field and double check, also with different informants.

My daily field notes and observations were my principal source of information, and they have been catalogued and sorted by different logical categories. They have been kept as neat as possible, numbered by date and I included more than a few parts in this thesis directly. Their ordering helped me to describe my problem in a good technographic way when I was in the field.

It is **not so important the kind of strict naming** to owe to the machine, for the machine in this thesis will be de-scripted simply as part of secondary tillage implement family of agricultural tools. I used push-weeder, rotary weeder, mechanical weeder or rotary hoe with quite some freedom, to refer always to the same technology-in-use in the field. I used strict definition only for the technical, tabular description of the single weeders I have found during the fieldwork, instrumental to their description and their interactions with the field, plants, and farmers of Tripura.

3 - Describing Tripura

3.1 - First and foremost: weeding practices

In Tripura there are different options to manage rice weeds. Manual weeding is one, very accurate in removing the majority of weeds from around the plants, though time-consuming and not as economical efficient as the mechanical weeding. Then there is the Japanese weeding method, a row planting scheme which is a decisive step towards the adoption of mechanical weeders. It does not allow crossed passages in the field, so it forces the farmers in doing manual weeding on the line still. Then we have SRI, in which ideally no manual weeding is required, especially if weeding is done by a trained operator. Thus, the choices of what weeder, the training of its operators, and the support of local sodality together have lessened the labour requirements for weeding.

The majority of farmers still rely heavily on manual weeding. It is an accurate practice to carefully remove weeds around the rice plants and to minimize root damages, though more labourers than in mechanical weeding are required to cover the same area unit. On the other hand, mechanical weeding requires a set of skills to master, an initial cost to bear to buy the machine, and a minor efficiency in weeding the surroundings of the rice crowns when compared to manual weeding. Such obstacles are anyway greatly surpassed by the benefits achieved with mechanical weeding in terms of rice yields and time savings.

Weeding practices relates to the size of farming households. They average 1 kani in Tripura (Government of Tripura, 2011). The *kani* is the local measurement area unit equivalent to 1600 square meters. When their size is smaller than this limit, the level of rice produce is so low that the economic gains do not justify continuing working for it, when there is a nice and relatively well paid job with NREGA. The official figures of the Government of Tripura clearly indicate as a success the 100 rupees per 100 days of work guaranteed by the scheme (Government of Tripura, 2011), whereas in the field I have clearly seen the negative impact the lack of valid and skilled labourers during peak times has.

The use of mechanical weeders as a substitute of manual weeding is **strongly supported** by governmental institutions. They are pushing forward a technological path of shifting from ancient, slow and manual practices to relatively new, faster and mechanized ones. This path is having few obstacles on the way, like the absence of follow-up measures to evaluate the performance of rice in the field after introducing the weeders; and of a knowledge sharing mechanism among farmers, from early adopters to the other.

Under SRI the time frame for weeding operations is the main issue; the local rice varieties grow enough to completely cover the field surface after 30 days after transplanting (DAT), hence they physically block any mechanical intervention. Farmers have only this time frame in which they can use the weeders.

3.1.1 - Gender division of labour

An interesting contextual aspect that we can discern is the shifting roles from women to men when it comes to weeding. The weeding operations under conventional rice cultivation have been traditionally made by women in Tripura. Weeding was a female task, and allowed the man to be free to do something else. I have observed that men are now operating the rice weeders instead of women. The former are now doing a historically related feminine task. The weeder itself plays a role instrumental in this shift.

Tripura farming communities were and still are much integrated into the conventional practices. The “advent” of the rice weeder is pushing them towards reconfigurations of gender roles, in order to still be integrated together, though in a different way. In short, the weeder can be seen as **a new way of doing things.** Previously rice weeding was done by men and woman, and now the men are “in charge” of operating the weeder whereas the women continue with manual weeding; it can be considered a good example of re-configuration of gender imbalances (Francesca Bray, 2007; Rustagi, 2005).

3.2 - Weeders

The first distinction to define a mechanical weeder can be about the power source, so we may have **manually or engine powered** weeders. This feature has different implications:

- It can influence the operational speed, i.e. an engine powered is usually much faster than a manual one. The speed has and indirect effect over the pulverization of the soil. Engine powered implements pulverize it more than the manual ones. Though, pulverization of the soil is not the main function, because a weeder works at a shallow depth.
- The engine-powered implements have a strong, direct impact over operational drudgery, saving its operator (or more than one) from an otherwise very tiring process, necessary when manual tools are involved. Even if not faster than the manual counterpart, saving on human labours is one of the critical features in adopting a powered machine.
- It increases the relative importance of skills and competences in using the weeder. Power weeders are one step towards the standardization of practices, e.g. it has a fixed max rotational speed, fixed direction of movement, and it goes from one side of the field to another. Conversely, manual weeders still rely heavily on the characteristics of the operator(s), which cannot obviously be standardized. It is affecting speed, direction of movement, and the movement needed to operate a weeder, e.g. back and forth or constant push.

These mutually interconnected aspects have economic implications on the kind of choice farmers make about the management of their crops. The manually powered weeders are the only ones in Tripura fields. Their cost is relatively low, whereas the operation timing (e.g. man day of labours) increases substantially. In the case of engine-powered, the initial cost to bear is so high that it cut out nearly all the farmers who cannot afford such a machine. The cost of a mechanical weeder is high for Tripura farmers because the majority of them are below poverty line (BPL), thus they can only afford to buy the cheap labour available when they need it the most.

Moreover, BPL people are entitled to buy rice at subsidized rates, which lower their willingness to cultivate paddies. The price of rice produced in farming households is not so competitive to the subsidized rates for rice imported from outside Tripura, so the farmers prefer to grow crops more remunerative than rice, and buy the rice they need at local, subsidized rates. Exceptions to this are made for local rice varieties, considered more pleasant and favoured over the imported ones.

Focusing on manually powered weeders, their soil engaging components can be further divided in:

- manually ground-driven, like the rotary weeders
- manually-dragged, like the Raichur weeder (Wassan, 2006)
- manually pushed, like the indigenous models

The above definitions define both the power source used to move the soil-engaging components, and the direction of movement, towards or opposite to the operators.

A particular subset of soil engaging components is the float system, which can be an addition or integrated into the design of the weeder. This component becomes relatively important when the weeder is thought to operate within particular crops or deep-water agriculture systems. In the case of rice cultivation, a float is needed for the machine not to sink in accordance with the different water levels into the soil. A weeder needs to be thought and designed for it, whether it is engine or manual powered. A float can have different characteristics, shape, size, weight or use (example in fig. 3).

Figure 2 – Example of modified float of Raichur weeder (courtesy of Charlotte Kalkhoeven)

3.2.1 - How they are supposed to work?

One of the reasons why the rice weeder became the symbol of the SRI method is the cheaper implementation cost bore by the farmers when compared to higher input/higher yielding HYVs, as stated by several studies freely accessible on the CIIFAD website (SRI-Rice & CIIFAD, 2012). In Tripura the governmental publications regarding SRI follow this approach, like the Tripura SRI guidelines or the reports about the conditions of agriculture in the state (Majumder, 2006, 2008; Tripura Department of Agriculture, 2011b). These do not take into account local knowledge, or the fact that different levels of knowledge co-exists in the field.

A weeder has been built with interdependent purposes in mind; as to say, the script in it (Akrich, 1992)can have a plethora of different purposes. Such purposes can be seen as mechanisms, which may generate some others in a causal sequence, and/or being connected with others at the same logical level.

A graphical representation of the causality of these mechanisms is reported in figure 2, in vertical order from left to right:

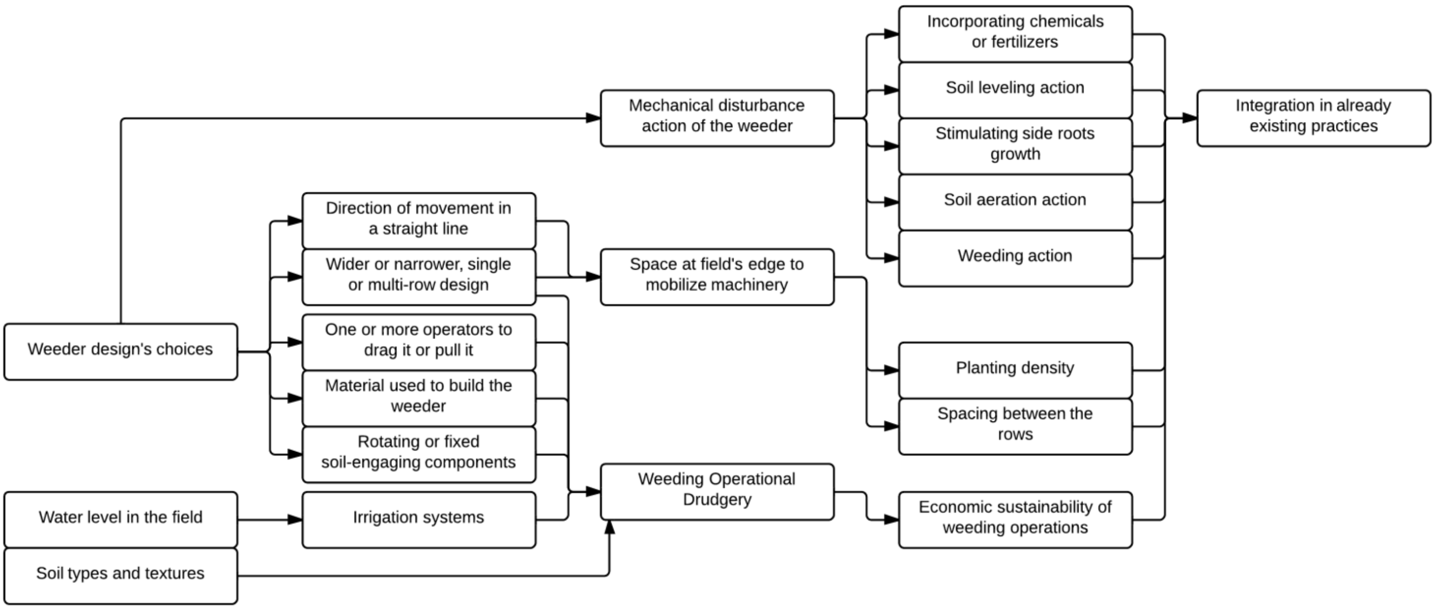

Figure 3 How a weeder is supposed to work

The far left column indicate the principles out of which a weeder is supposed to work. From them, there is a chain of causality of the existing mechanisms. They have been grouped together in the three central columns. This chain ends up at the far right, with the integration of the weeder into the existing weeding practices of Tripura.

3.2.2 - Availability

Tripura does not have the necessary raw materials (like iron) and metal industry sectors to produce weeders with rotating parts internally, so manufacturing companies are from other Indian states like Andhra Pradesh, Maharashtra, and Gujarat. Manufacturers import their stock on trucks via the very poorly maintained National Highway, with consequent price surcharge, time, and availability constraints. They market their products via local distributors.

Tripura lacks the necessary infrastructure to adequately import the machines, because the local rail lines are designed for small gauge trains unsuitable for freight transport, and there is no direct connection with Agartala, so people and goodies need to stop at Dharmanagar (the northernmost city of Tripura) first. The commercialization, thus accessibility, of weeder or a specific design in particular, is strongly related to the official approval that the machine has undergone at the Agriculture Department. It was interesting to observe how marketing strategies or possible subsidies worked in the field. lacking Tripura heavy industries almost completely (Government of Tripura, 2011), thus importing all implements from “abroad”.

Farmers who still practice the conventional method of cultivation do not use a mechanical weeder for weeding operations; the one who adopt some practices of the Japanese method have no direct access to them because they need to be full-SRI compliant. **Compliance** is then suggested as strictly following the Dept. guideline about SRI.

3.3 - Policies

The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS or NREGA) impact very widely on the livelihood of poor rice farmers in Tripura, providing them with 100 days of employment paid by the government (Dev, 2012). Unfortunately this timing impacts heavily on the availability of labours during peak periods of rice cultivation, e.g. weeding. The supposed benefits of this scheme are in reality discouraging farmers in sticking with rice cultivation and pushing them to grow more remunerative crops, if not completely out of farming activities.

Being introduced in 2006, the scheme has undergone several convergence acts with different central government sectors under different Ministry, e.g. (Ministry of Rural Development India, 2009), and is being implemented in every state. The Tripura Agriculture Department is then responsible of an ad-hoc state-level commission in charge of dealing with such convergence, and added an extra scheme that its Sector Officer needs to implement.

A good report of Ravindra and alia, with contribution from Prasad, suggests the need of integration of the SRI principles and the necessity of converging them under the funding provided by the MGNREGS (Ravindra et al., 2012). The SRI methods instead have gained in Tripura the status of a sub-scheme under provision of partly the National Food Security Mission (NFSM) and partly Rashtriya Krishi Vikas Yojana ("development of the farmers" or RKVY) scheme, and the Agriculture Department is responsible for all of them.

On top of that, the Department support SRI for reasons like: the urgent need to reduce water consumption for rice cultivation while enhancing productivity (SRI-India, 2009); the demographic pressure due to the population shift from farming villages to urban centres and the shrinkage of cultivable areas for rice in favour of other more remunerative crops (Majumder, 2006); the increase in rice productivity, as reported in the powerful statement made in the "achievements" section of the Department website (Tripura Department of Agriculture, 2011a)

3.4 - Water sources

In Tripura the irrigation water management is broadly divided in upland and lowland areas. The upland areas follow the monsoonal characteristics of the weather, with a rainy season that floods everything but then run off to the lowland fields followed by a dry season, with random rains scattered through the period between September and May. The winter rice season, Rabi/Boro, is entirely dependent over the (lack of) monsoonal provision of rain water (Norman Uphoff, 2007)(Government of Tripura, 2011). Reducing water consumption is in this case closely interconnected with maintaining a sufficient level of production, hence to farmers' food security.

Farmers in lowland areas rely on two broad groups of sources: rain fed, which includes rainwater harvesting with or without ponds; groundwater, usually with water wells pumps owned collectively. A rain fed plot is usually waterlogged for a longer period of time, due to the poor drainage of the lower horizons of the soils; it is the only viable way of irrigation for really poor farmers. Conversely, groundwater plots have usually the lower horizons allowing for enough drainage, thus less water to set in the field for a shorter time. In such cases though, there is the possibility of correctly dosing water amounts according to the drainage capacity of the soil and the needs of rice plants, minimizing waterlogging of the root zone.

4 - Typology of Tripura weeders

Predictably, weeders have undergone an evolution in terms of designs and materials (Basalla, 1988), and there are now several different types and models available, made of different materials. In Tripura, the vast majority of farmers use manually powered weeders, since engine powered implements are too costly for them. This is especially true for below poverty line (BPL) farmers.

I identified five types of weeder in use by paddy farmers in Tripura. They were locally known as the Cono weeder, the Japanese paddy weeder, the Babulal weeder, the Jute weeder, and the Bidyut weeder (see table 1). These weeders have different characteristics and attributes, summarised in the following sections.

Table 1: Paddy weeders in use in Tripura

Model name	Cono Weeder	Japanese Paddy Weeder	Bidyut model	Babulal model	Jute model
Type	Rotary type with two conical rotating drums, single shafted, commercial manufacture	Rotary type with two rotating cylinders, double shafted, commercial manufacture	Wooden type with no moving parts, single shafted, home-made manufacture	Wooden type with no moving parts, double shafted, home-made manufacture	Wooden type with no moving parts, broom-handle shaft, home-made manufacture
Manufacturers/suppliers	ASPEE, Magnificent Engineers, Banabethi	ASPEE, others	Locally made	Locally made	Locally made
Material	Power coated steel for the frame. Uncoated steel for the rotors.	Power coated steel for the frame. Uncoated steel for the rotors.	Teak wood for the frame. Iron nails as soil-engaging components.	All woods: bamboo for the tines, heavy weight for the head and light weight for the handlebar.	Local woods for the frame. Iron nails as soil engaging components
Weight Kg	5,5	4,50	5	2,2	0,8
Price (INR) and subsidy	**1800 - 2900 full rate, 50% cheaper on subsidy.**	**1190 INR full rate, 50% cheaper on subsidy**	**NA**	**Around 200 rupees**	**NA**
Height of the weeder (vertical from handle to ground)	Cm 110/130 adjustable	cm 85/105 adjustable	80 cm fixed	100 cm fixed	Not fixed height, it's a sort of rake, so the operators choose the working angles
Weeding attachment or head: the part which carries the soil-engaging elements					
Length cm	76 cm	cm 50	48	29	7
Width cm	Screw-Adjustable width	cm 15 (**non-adjustable**)	12,5	15 (6 inches)	20,3 (8 inches)
Length of the float cm	33 cm	cm 18	NA (no float part)	NA (no float part)	NA (no float part)
Blade or soil-engaging components					
Length of the tines (from the surface of the blade)	3 cm both rotors	8 cm both rotors	The nails protrude from the surface for 1 cm or less	The nails protrude from the surface for 1,5 cm or less	The nails protrude from the surface for 5 cm or less
Width of the tines	Every blade is 0,3 mm thick	Front blade 1,2 cm Rear blade 2,1 cm	0,3 cm nails width	0,8 cm.	0,3 cm nails width.
Handle length, description	50 cm length. T-shape handle, circular cross-section, plastic coated ends.	36 cm length. Circular cross-section, plastic coated ends.	28 cm length. T-shape handle, squared cross section	38 cm length. Circular cross-section.	Locally variable length
Handlebar length, description	130/150 cm adjustable length. Single bar, circular cross-section.	1,2 m length. Double T bar with reinforcement in the middle	1,5 m length. Single shaft with squared cross section	1,42 m length. Double bar nailed to the head with reinforcement in the middle. Circular cross section.	Locally variable length. Single bar firmly nailed (several nails) to the head. Squared cross-section.

4.1 - Japanese paddy weeder:

This model has been named after the “Japanese method of rice cultivation”, and its name still resist. Even though being a very old set of practices known since the ‘50s, it failed in Tripura in having a long lasting impact, especially in terms of weeder diffusion and adoption. That said this model is the most commonly found among Tripura farmers because it has been introduced around 1998-99 by the Agriculture Department and its extension officers as part of the SRI recommended guidelines.

This rotary weeder has two cylindrical rotors mounted fore-and-aft on the frame. The rotors have same radius and width, and their axle is perpendicular to the direction of the weeder and horizontal to the ground. They typically have 6 rows of 3-4 tines welded on the surface (fig. 6). A common pattern is that the front rotor has rows of four tines while the rear rotor has three.

The frame is hinged to a double-shafted handlebar, which ends with a flat short rod handle. The hinge mechanism is adjustable on three fixed positions, so the handlebar changes its angle of incidence with the soil; it makes the machine more or less tall and slightly longer or shorter. The height of handling has been regarded as important for manoeuvrability by many informants. The majority of machines I have observed are fixed (in some cases welded) on the lowest position, so the height is the shortest possible.

The weeder has to be operated with a back and forth movement on the line in order to be effective in SRI fields, because its width is around 15 cm, narrower than the 25 cm space as suggested in the Tripura SRI guidelines. The farmers need to move in such a way in order to cover the full width of operation in the line; conversely constantly pushing towards one direction would force them to do a second passage in the same line. This model is still subsidized by the Department for: it is more looked after the farmers, and more suitable than others to carry on the work under certain soil conditions, like clay partially flooded fields. Its compactness allows the operator to stand in a more balanced way during weeding operations.

4.2 - Cono Weeder:

The cono weeder is a machine first developed by the International Rice Research Institute (IRRI) after their research on conical rotors in 1987 (IRRI, 1989). Drawings, design information, and limited technical support are provided free to manufacturers who want to produce IRRI designs on a commercial basis. Their original design (Ampong-Nyarko & De Datta, 1991) has been further modified in India at TNAU, which designed a slightly longer handlebar with a different mechanism to adjust the length and height of operation. Both versions have been since available on the market from different manufacturers, who are independently customizing them to their will. It was first introduced in Tripura in 2002 by the Agriculture Department subsequent to the Japanese model.

The Cono weeder is basically the same as the Japanese weeder but with the following differences: the rotors have a conical shape and are mounted on either side of the sled assembly, oriented inwards so that the two cones rotate in opposite directions on their respective axles. They are furnished with alternating ranks of straight-edged and serrated blades, which are designed to churn the top 3 cm of the soil. Each cone is mounted on an arm inclined downwards towards the soil, so that the lower edge of each cone is flat to the soil surface and the blades engage the soil horizontally. When a bladed cone is rolled along a straight path on the soil surface, the blades displace the soil differentially at points along the axis of the curve, creating a more aggressive tillage action (IRRI, 1989). The arm on which each cone is mounted is adjustable, so that the combined width of the cutting surface can be made wider or narrower.

The shaft is a single bar ending with a larger flat rod handle. A flat rectangular float with a wedge-shaped or semi-circular leading edge is welded to the front of the sled assembly, which helps to prevent the weeder from digging too deeply into the soil during normal operation. The machine is designed to be pushed all along in one direction in between rows of rice plants because its width can be adjusted to the spacing of the crop. Nonetheless, the back and forth movement become necessary again when the width cannot be adjusted, whether for lack of training of a labourer or for design flaws (see **video**)[3].

The Cono weeder is available in Tripura in two basic variants: the so-called "improved long-handled" as developed by TNAU, produced by Aspee group of companies (fig. 5) and Magnificent Engineers (fig. 8), and a more compact model based on the original IRRI design, manufactured by Banabethi (fig. 7). The former models have a longer shaft with a mechanism on it to adjust the length, whereas the Banabethi model has a shorter shaft of fixed length, which is hinged on the weeding sled via a three positions mechanism, similar to the one in the Japanese weeder. Again as in the Japanese model, the handlebar is kept on the lowest height possible. The arms that sustain the cones on the Banabethi model are claimed to have an efficient adjustable mechanism, with a lock nut preventing them from getting loose off the sled.

The Cono weeder is promoted by the Agriculture Department using subsidies to encourage skilled farmers to adopt it, together with the other weeders. Its price is anyway higher than the Japanese weeder, so its diffusion is still quite marginal, and even the farmers who own one already often switch back to a Japanese model, claimed to be more compact and easier to handle. The manufacturer said that the Cono weeder have had always marginal diffusion since its introduction, and has slowly increased till today level of 30% of total rotary weeder sales, the rest is for the Japanese model.

4.3 - Jute model:

This venerable tool is used not exclusively in paddy cultivation but mainly employed for light weeding around horticultural crops, and was formerly in the cultivation of cash crops like jute, which was once a very important source of income for farmers in this part of India before Partition in 1947. This model has been often found in the lowland fields in the south-western part of Tripura, being those previously cultivated with jute and geographically close to the mills downstream the river used to process the jute after harvesting, which are now on Bangladeshi soil or in West Bengal.

It resembles a rudimental rake, comprising a simple block of wood furnished with long thin nails and fixed onto a long handlebar, which works as an handle too (figs. 4, 10). The nails are prone to be bent and get stuck in the mud when used in paddy fields; when this happens, it's very easy for a labourer to crack the handlebar while working on the line, though this model is fabricated locally from available wood, and thus it can be easily replaced.

This model is usually operated with a constant push movement, though its long teeth get easily stuck if pushed non-stop, so there are often pauses and it has to be cleaned up from clogged material (see **video**)[4]. Its width of 20 cm (around 8 inches) is narrower than the suggested spacing for SRI. Its working height is user-dependent: farmers arch their backs over the tool, assuming a prone position which makes weeding operation very tiresome. This weeder is employed only by some of the farmers who get no access to the

[3] http://youtu.be/JiZYh2lku-M
[4] http://youtu.be/Ths3z_PeirU

subsidies, or in case the other weeders owned are being serviced. Skilled farmers are substituting it with other models more suitable for rice cultivation, keeping this one for other crops.

4.4 - Bidyut model:

This model has been found and used in the paddy fields of the Northern districts of Tripura. It has been named after its owner, Bidyut, who is an employee and staff-member of the Department of Agriculture and posted below the Sector Officer level as Village Level Working Officer (VLWO). Bidyut's father devised this machine on his own at the beginning of the '80s, at least 15 years before the Department introduced the Japanese Paddy weeder in the area; he did so to improve onto the features of the Jute model in the Japanese method of rice cultivation.

It's manufactured locally from solid teak wood (*Tectona grandis*) called *Shegun* in Bengali, selected for its durability and water resistance. This particular wood is heavier than the one used in the Jute model, and do not float easily on the surface of paddy fields due to its weight (5 Kg, heavier than the Japanese model). It has no moving parts and its soil-churning components are thin short nails (fig. 13), which get less often stuck in the soil than the Jute model. It is also fitted with a proper handle across the handlebar (fig. 9), so the position is not crunched over the machine while operating it.

This model is employed in hard soils in substitution to the Japanese model, where the latter is claimed to bump over in such conditions and be ineffective. This model is still used by Bidyut's relatives for paddy cultivation, even though they are now using SRI methods for growing their rice. They were using it before SRI with a constant push, when the lines were narrower. They now use to do two passages back and forth in the same line due to the narrow width of this implement (12,5 cm). Bidyut is perfectly aware of the existence of more "modern" machines like the Cono weeder because he is part of the Department, though he prefers to rely on the traditional knowledge, and tools, transmitted by his father. The only "novelty" he introduced in his fields was the Japanese paddy weeder, as his neighbours.

4.5 - Babulal model:

This weeder was designed and built by Babulal Das, a now recognised skilled farmer in Joyshree village, Kanchanpur sub-division, North Tripura district. Babulal started using a Japanese model in 2000 with no training while helping his relatives in Panisagar, North District. His village Panchayat didn't recognize him as a skilled farmer at that time, so in 2005 he built a copy of it. He also created a narrower version with a 12,5 cm (around 5 inches) width, which is used in upland areas for horticultural crops (fig. 12).

After his inventive exploit, neighbouring farmers changed their mind and started recognize him as "skilled", this got him entitled to receive subsidies, to got hold to a Japanese model and in 2007 he received his first "official" training of SRI methods (with a Japanese weeder) in the Farmer's Field School of Joyshree.

This is a village-made wooden weeder without moving parts; it combines the general shape of the Japanese model and the functional parts of the Bidyut model. In place of rotating drums, the Babulal model has a flat wooden sled furnished with conical nails made out of bamboo, which protrude through holes drilled in a regular pattern. The thicker bamboo nails are claimed to be better than thinner metal ones for several reasons: are cheaply replaced with locally available material, do not bend easily, and being blunter are less prone to get stuck in the soil blocking the machine. The form factor and dimensions of this weeder strikingly resemble those of the Japanese weeder (fig. 11); the operational width is 15 cm (around 6 inches), the handlebar is double shafted and the handle has a comparable size. Babulal has tried to make it looks as close as possible to the original he was copying from.

This weeder is used mainly for rice cultivation, and it is operated with a constant push instead of the back and forth movement. The problem is that it only scratches the surface of the soil without churning it, so usually farmers need to pass the second time in the same line to clean it completely from weeds. Its lighter weight and low-density wood is also a problem if the soil is flooded, because it floats very easily. It is mainly employed in upland areas, where this problem is rare.

4.6 - Weeder's prevalence

Scattered areas in Tripura still retain manual implements without moving parts and the knowledge to use them, e.g. in the south west they were previously used for jute and other horticultural crops. The northern districts are the areas where I found more diversity in terms of designs than in the rest of the country. In these remote villages on the hills, mainly inhabited by local tribal communities, farmers rely more on their inventive capacity to create a tool, or peer solidarity to access it instead of buying a new subsidized one. They live in places difficult to reach and difficult to serve for the Department Officials, and the condition of the roads adds to their isolation.

On top of that, farmers need to be selected by their villages Panchayat prior to be recognised as "skilled" and receive a subsidized machine. This poses obstacles in accessing particular machines. The case of Babulal's copy could be considered as the (so far) known attempt of knowledge adaptation and transfer from an existing technology to a more accessible one. Accessibility is defined here as being not scarce. As Babulal told me, he first assisted to an SRI demonstration made by the Department in 2000 in his area. Being excluded by the electoral vote to receive the SRI subsidies at the beginning, he started devising the machine on his own.

Among weeders with rotary part, the Japanese model is the most commonly found in the fields. Farmers know it because they have used it during SRI seminars and Farmers Field School (FFS) sessions organized by the Agriculture Department. It is also positively experienced in the rice fields, as a labour saving machine and as easily adaptable to different soil moisture condition.

The advent of SRI has mutated quite radically the aspect of rice cultivation, especially in lowland areas. The farmers, who were previously producing rice with the conventional method of scattered sowing, need now to employ a machine with moving parts in order to efficiently weed their paddies.

The Japanese model is their first choice as suggested by neighbours and by the Agriculture Department. The Cono weeder is practically unknown except by few farmers because: it has been promoted after the Japanese model; it is rarely used during FFS sessions; and is often experienced as problematic in partially flooded clay soil. The latter happens often in lowland areas due to the partial, if not inconsistent, water regimentation. When farmers do ask for it, the only possible way to obtain one is via the Agriculture Department, due to its higher and not sustainable cost.

4 - Pictures

Figure 6 Japanese Paddy weeder

Figure 5 CONO weeder manufactured by ASPEE

Figure 4 Jute model full view

Figure 8 CONO weeder manufactured by Magnificent Engineers

Figure 7 CONO weeder manufactured by Banabethi

Figure 9 Bidyut model full view

Figure 10 Jute model head

Figure 11 Japanese model and Babulal model

Figure 13 Bidyut model head

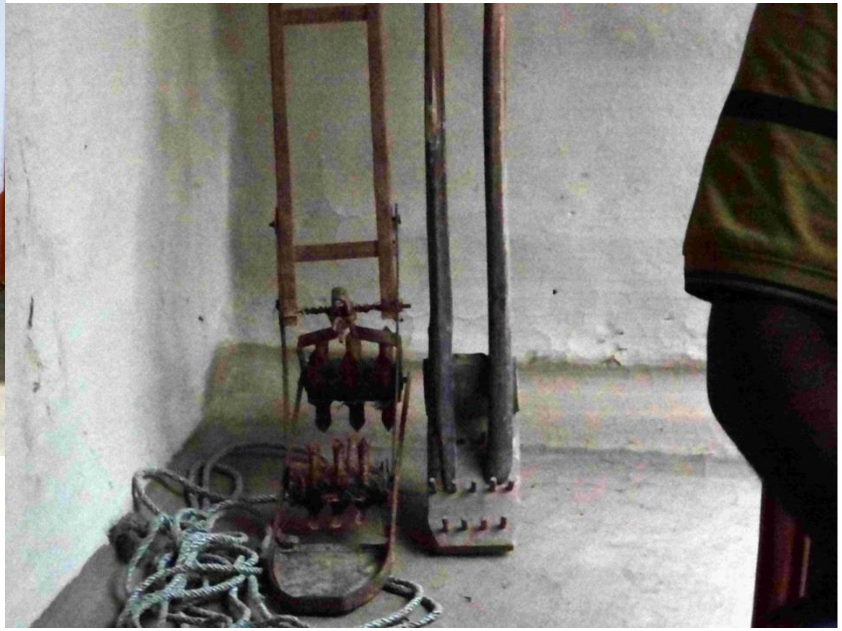

Figure 12 Narrow Babulal model alongside a Japanese Paddy weeder

5 - Selection and adoption

5.1 - For the farmers

The only way for Tripura farmers to get a weeder with rotating parts is via a procedure involving other farmers, their local Panchayat, and the Department of Agriculture. The first step is to being recognised by their neighbours and fellow farmers as very knowledgeable about rice cultivation techniques. They consider things like entrepreneurialism, variety of crop cultivated, visible inventive capacity in crop settings and tool making, and the degree of confidence with Department personnel. Political affiliation is also considered, especially if the farmer actively supports the party voted by the others.

Then the Panchayat need to vote them among a small group of farmers who are effectively defined as “skilled”. This generic term indicates which farmer is “allowed” to receive subsidized rates to purchase farm inputs (and weeders) from the Agriculture Department. The votes are casted once a year autonomously by the single Panchayat. Their only limitation is about the number of farmers they can select, in accordance with the limited subsidies issued every once a year by the Department.

This process of election is mediated by the VLWOs, the village level employees of the Department. They know “their” villages and the farmers who can be considered as skilled. There is a big component of human relation in this mediation, and friendship with the VLWO can make a big difference for a farmer without a subsidy. The Department ratifies the decision of the Panchayat and bestows subsidies and technical support to the selected farmers. Delegating this procedure to the Panchayat comes from the sheer number of farmers to be evaluated and selected and the need for the Department of being perceived as neutral.

The only machines available for the farmers are the ones available for the District. If the District has not made a provision to get a particular model, farmers will be given another one on subsidy. Local markets and welding shop do not sell Japanese models or Cono weeders anyway, being the Department and its Sector Officers the only way for a farmer to get such implements. Exceptions are the **Best Friend Farmers (BFF),** a further selection of skilled farmers endorsed directly by the Sector Officer. They are usually more literate than the rest of their pal and get funded for their role with 1000 Rs a month for ten months. They help the VLWO deciding when to hold the meetings and are the ones who follow more strictly the guidelines of the Dept. about rice cultivation.

> *“The Best Friend Farmer doesn’t have to be the **best** farmer, but a **friend** of the farmers, a sort of big brother of them, and needs to be friend of the field officers, in order to support **our** staff in the field” (**Baharul Islam Majumder**).*

There is a certain degree of respect owned to them by other farmers, who recognize them as the “most skilled”. This allows BFFs to be more closely followed by SOs, most notably to test new mechanical implements from other districts. They know which weeder is the most effective for their soil (fig. 16), though the tenders are fixed every year, and single farmers do not have the same weight as the Panchayat. Other farmers do not even know what is good for their soil, because there is no extension service about agricultural machinery done in the field on a regular basis.

The farmers who have participated in the Department demonstration of mechanical weeding, done with the Japanese model around the 2001/2003 period, have not been subsequently updated nor their actual performance evaluated, even if they wanted to. This left them alone in adapting the practices, so the way they use the machines, to their particular field condition and knowledge. When asked, farmers love to get more training and seminar about weeding. Being aware of this aspect beforehand could be crucial for future implementation, if not improvements, of any Agriculture program in Tripura.

Farmers lament the chronic absence of labourers in the fields during peak periods, like weeding. The NREGA scheme is blamed because the program “subtracts” the human resources required when they are more needed. Weeders are positive for farmers because it allows them to save time. On the other hand, the labourers are quite happy to get a NREGA subsidy in a period of the year in which the rice is abundant, hence less costly, and to maintain their obligations with the farmers in other parts of the year. Labourers do not care much about the type of weeder they use.

5.2 - For the Agriculture Department

The Tripura Department of Agriculture is part and parcel of Tripura Government and provides to it consumptive tables about economic indicators and quantity of agricultural goods produced in a year. It gets yearly state funding according to the thresholds met. The state government delegates to it the appraisal and supervision of the agriculture machinery market, which is basically partially free and state controlled. It represents the local implementing commission of the MGNREGA, RKVY and NFSM schemes. It sets the subsidized rates for seeds, fertilizers, agricultural implement (weeders included), and rice grains for the farmers who apply SRI principles in their fields.

The Dept. is in charge of selecting the weeder to use in Tripura, though it delegates the task to the Tripura State Agriculture Research Station (SARS), the ICAR counterpart for Tripura, providing it with a yearly allowance. SARS performs the task of researching, selecting, and testing of new varieties, crop settings, and weeders for rice cultivation, among others. It does so according to the ICAR directives and boundaries, and can send mandatory suggestions on its core subjects to any member of the Department. As for the weeders, SARS opinions are collected and submitted once a year to the Superintendents of Agriculture (SA). The SAs dispose of the most conspicuous part of the budget from the Department, and they have the authority to put the tenders for agriculture machinery and weeders.

SARS has been on the edge of the SRI spread in Tripura since its first implementation in 1998, and has been pushing the Department to subsidize local seed varieties, bio-fertilizers and weeders with rotary parts. It is the publisher of the Tripura guidelines for SRI practices. Tripura government directly provides an allowance to SARS too, for its programme to enhance food security in the state of which SRI is part. Thus more research activities can be possible for SARS if labelled as SRI.

For SARS professionals, indigenous weeders with no moving parts are objects from the past, and they have no interest in researching them or spreading their use. There is an untapped opportunity here, because the cheap price and the knowledge about how to use hand-made weeders still retained in some areas, would at least partly foster farmers with no access to subsidies to reach self-sufficiency in rice production.

The hierarchy in the Department, as at SARS, is rigid and highly compartmentalized. Only a few key members in it have the possibility, or the weight, to influence the selection of the weeder. A prominent role is played by **Dr Baharul Islam Majumder**, officially Joint Director of Agricultural Research, who held at the same time the positions of chair of SARS, director of National Food Security Mission (NFSM) for Tripura state and head of the approval committee of agricultural machinery.

He is very charismatic and knows how to get attention from his audience (fig. 15). He has been so far the strongest supporter and the material executor of SRI implementation in Tripura. Thanks to this personal interest and the evident gains in terms of rice yields increase (Government of Tripura, 2011), he has been awarded a monetary prize from Tripura Government and an official visit of a delegation from the central Ministry of Agriculture, which constituted de-facto endorsements for his activity on SRI.

5.3 - For the Approval Committee

The Approval committee is a working group of agronomists, field technicians, Department officers and other professionals, headed by Dr Majumder. This group choose what given machine should be subsidized at any given year. It is a good example of técnicos who blend in some characteristics of the politicos (Grindle, 1977). Tripura farmers rely on subsides only to buy a weeder, due to widespread poverty, so the committee deals also with the price of the implements. The committee meetings are held informally at SARS premises throughout the year, and few of them are held together with the representatives of weeder manufacturers. The importers need to showcase their models range and discuss about price for that year at the meetings. They are very interested in keeping a good relationship with the Committee members.

It issues yearly recommendations about mechanical characteristics suitability and effectiveness, and the stock of agricultural machinery to be made available in Tripura. The decision has to be made every year, following the fluctuations of governmental subsidies, to allow ever increasing farmers to access the weeders. The recommendations are sent via the Department to the SAs in every district before the tender. The Department have a budget provision for the machines, and it is up to the SARS committee to suggest every year which machines would be supplied for that year. Dr Majumder has the final words over the recommendations, and he makes extensive use of: his own agronomic expertise, advice from mechanical engineers inside the SARS and members of the committee, and from external members like the heads of the local Krishi Vigyan Kendra (KVK) and members of the Tripura Agriculture Graduate Association (TAGA).

The criteria used to select a weeder rely heavily on agronomic characteristics, like speed of operation, working depth, suitability to different soils, as well as economic consideration (the cheaper the better). Especially the ratio of the amount of weeds removed (output) to the force and time needed to use a weeder (input) is considered the first aspect to keep in mind when designing or "improving" a machine.

5.4 - For the manufacturers

Weeders in Tripura come from other Indian states, through the work of three local importers which act as local distributors as well. Mr Ashish Battacharjee is the Agartala importer for ASPEE and KAMCO brands, distributing rotary implements like the Japanese and CONO weeder, and small power tillers. His model range has been the 2013 choice of the Committee suggestions for the tenders.

According to Ashish experience as importer, the only viable solution to bring weeders with rotary parts to Tripura farmers is via "trade marketing". They are too poor to afford one on their own, and the absence of raw material in Tripura forces this process. The Department decide at the beginning of the year to replenish the stock of machines to be subsidized to the farmers. In this case, the approval committee at SARS is essentially **the filter** through which any middle men have to pass. It is peculiar that the Tripura importers know each other, their respective products, and the Superintendents of Agriculture, whom important roles have always been acknowledged. Very important has been regarded the relationship with members of the Approval Committee, though the mechanism with which the importers manage to "win" the Committee suggestions has not been fully disclosed.

The importers are partially in charge of servicing the weeders as well. The welding shops, posted on the main roads, are not specialized on agriculture machinery and get their income from the local servicing and repairs of all sorts of vehicles, like motorbikes, cars, vans, and trucks. Agricultural implements constitute only a very small fraction of their income, so also their relative interest in weeders is marginal. Often the sub-distributor of the importer acts as spare parts provider, if a weeder needs servicing, and provides such spare parts to welding shops as well. In any case, manufacturers' profits lie in the services and products they provide to the farmers. In Tripura, their profits are on farmers who got subsidy, the only ones who can afford to buy the machines. Such farmers are still a minority, so it makes their scope, and leverage in pushing for the adoption of any weeder, very narrow.

5.5 - For Central government institutions

The Indian Council for Agriculture Research (ICAR), with its Central Institute of Agricultural Engineering (CIAE) and Directorate of Rice Research (DRR) branches are part of the Department of Agricultural Research and Cooperation inside the Ministry of Agriculture of India. CIAE and DRR in particular are issuing every year bonding suggestions about the machinery to be subsidized and the policies to be implemented in paddy fields for the whole India.

These suggestions are somewhat independent from the schemes implemented by other central institutions, like the NREGA from the ministry of Housing and Urban Poverty Alleviation, or the RKVY from the Ministry of Rural Development, or the ones implemented at state level, like NFSM. Such policies have their own independent schedule for approval and their own time horizon, regardless of the people and the crops that will be affected by it. They have been accurately divided about District, Sector, Blocks, Villages an even plots, whereas in real field conditions the boundaries are blurring. They need to be translated by local bodies in order to be effective, e.g. KVK, NFSM commission, and the Department of Agriculture.

The scope of central govt. institutions is broader than local ones because they work not only for food security of Tripura people but for the economic betterment of Indian people as a whole and for the infrastructural development of larger areas of the state; therefore deciding about one particular weeder is not among their priorities. They delegate this task, and its relative power, to the lower, local institutions. Nonetheless, every implement designed and accepted at central level is then deployed in the field with small further comparison and evaluation of its real performances, mostly because there are no other choices. In Tripura there are two manual and one power weeder provided on subsidy, though they are so because "approved", rather than being selected on their effective locally tailored capacity.

Local institutions have very few monitor and evaluation mechanisms in place, apart from the ones provided by KVK that overlap the ones done by the Department. It is an ad-hoc central agency with the authority to evaluate the schemes implemented by the Department, hence SRI and weeder tenders as well. This function could provide useful feedbacks for the Department officials, if there would be more "official" coordination. In reality, KVK has a smaller influence than fully local institutions, and such coordination happens only thanks to the personal ties between officials from different institutions, like Dr Majumder for SARS and Dr Subrata for KVK.

The central government schemes are the ones with the least amount of feedback, mostly they give subsidies in exchange of consumptive tables at the end of the year, with the Department of Agriculture held responsible for the provided data. The local schemes are instead the one more closely followed and managed, also because of their limited funding capacity. It has to be said that the sheer numbers of schemes make the Department personnel at Sector and village level very present in the field and in any operations related to agriculture. On the other hand, it makes their focus very broad, because they have to take care of many schemes at the same time, with the risk of diluting the impact of a single scheme. As an example, they are "obliged" to follow a centrally created scheme such as the MGNREGS, which can be or not coupled exactly on the need of Tripura farmers (Ravindra et al., 2012).

5.6 - Consequences

The Japanese weeder is still considered the best weeder to use notwithstanding the old design, whether for its reliability in any soil or irrigation condition, or for the fact of saving the farmers who "know how to use it" from doing an extra manual weeding passage in the field. Farmers instead choose a weeder according to its subsidized prize first (no subsidy, no buy), and then its height, the lower the better.

Knowledge extension done by the Department during FFS has been claimed to be as important as receiving the subsidies. Farmers are used take what they have been given, even if they do not ask for it. E.g. the ones who receive the subsidies do not automatically receive training. It is planned by the Department, and not after farmers' request. If farmers receive initial training, there usually are no further updates for new implements or techniques done by the Dept. When asked, all the farmers are instead very interested in it. New farmers are given subsidies and getting trained almost every year, so the Department relies on them to update their fellows, but this is the case only in rare occasions. What they do is sharing their newly acquired tools among others, though without proper training they soon lose interest in the "novelty".

Farmers are not self-sufficient about rice produced, even though the majority of them grow rice. They need to cultivate more remunerative crops other than rice, or to buy from the market the rice they cannot grow themselves. Unfortunately the markets in Tripura get heavily subsidized in terms of food products. This outcompetes the farmer's own production, and pushes them towards other forms of income rather than the one provided by agriculture, e.g. NREGA. Thus the use of mechanical implements is truly beneficial for the farmers, both in terms of time spent weeding (or labour days to pay) and quantity of rice produced.

Farmers who got the subsidies give no evaluative feedbacks over the performances of the given subsidy because nobody asks for it. Such feedbacks are also hard to collect, because the only mechanism in place is enacted by KVK, which has a far smaller scope and influence when compared to the Department. KVK directly relates to the central government first, so in a way the communication and coordination with the state level institutions is somehow filtered, if not blocked. Strengthening these ties could be a relatively easy and effective way for the Department to evaluate subsidies and scheme performance.

Ad materials from the weeders producers both in paper (fig. 14) and online, is completely not influent on farmers' decisions to adopt a particular weeder, because they cannot afford to buy one without subsidies from the Department, and if they can, they do not know how to use it. Such material is barely useful for the Approval committee, which is the one to have the final words over the adoption. Farmers rely more on peer solidarity and mutual exchange of experiences over a particular tool.

It is interesting to observe how **agricultural research systems are a selective environment** that helps in shaping particular technological trajectories (Dosi, 1982). In the case of Tripura, this is very much true when one is going to observe how the Agriculture administrative establishment works, i.e. creates and implements policies, about the making, importing, using and adoption of the weeders.

Weeder manufacturers are after the maximisation of their profits while selling their products. In Tripura they have to go after the approval committee and to minimize the advertising cost as much as they can. Tripura farmers/potential buyers are out of the market because their widespread poverty.

Weeding practices as a codified set of rules and operations, is very subtle defined and often locally adapted. In Tripura there is a large variety of techniques used by farmers, and mostly in the village there is a sense of sharing tools, knowledge, seeds and labour. This accounts for a high variability of operations existing in the field. The traditional method is always customized at village level, as well as the Japanese method, and more recently SRI as well. The weeding knowledge as a mechanism of definition of what machine is more suitable, **has been surpassed** by contextual factors like: the level of irrigation, or the existence of pro-active SOs in the area, or the access to necessary funding.

5 - Pictures

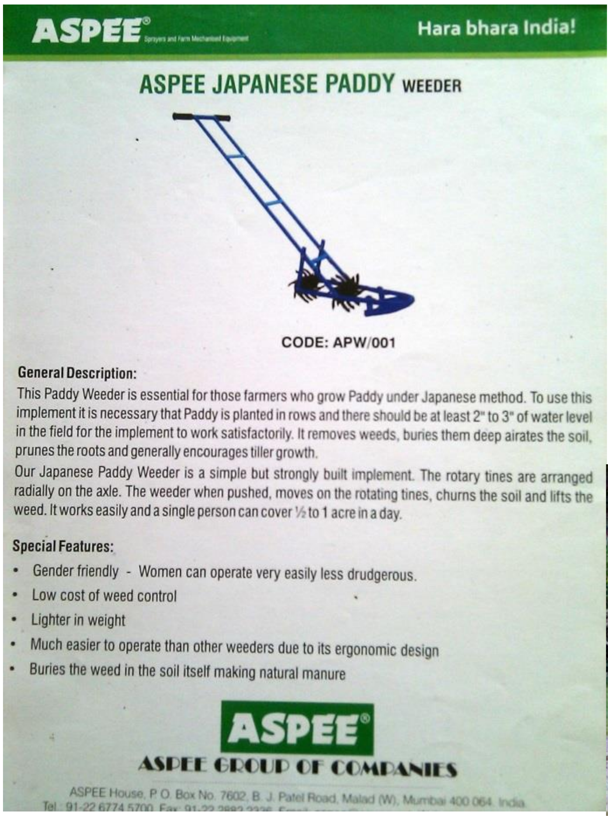

Figure 14 Aspee Japanese model advert

Figure 15 Dr Majumder charisma

Figure 16 Mr Kartik Dey, one of the BFFs, with his favourite Jute model

6 - Experiment

The empirical data sets include: video of weeding operations, with particular emphasis on the movements needed to start the weeding operations, move in the rows while weeding, wash the machine at the end, and so on; pictures of the weed coverage of the selected plot before and after the weeding has been done, in order to visually appreciate the efficacy of a machine in removing weeds; records of time needed to complete one same area with different weeders and operators, to appreciate the influence of skills and the material gains that a "faster" machine can provide.

The same data set has been recorded for: the batch of four different models, two different soils textures, and two different water sources, i.e. rain fed or ground water. The labourers were chosen randomly in order to increase the **internal validity** of my observations, and in all the cases they were known to the owner of the plot. Each of the four selected weeders was operated by more than one labourer to appreciate the differences in skill levels. Semi–structured interviews and focus group discussion has been used afterwards to collect information about drudgery and selection criteria from a user's perspective.

6.1 - Selecting models and plots

The models grouped in the typology are more than the number of weeders tested. The Bidyut and the narrower Babulal models "came out" at the end of the harvesting season, making it impossible to test in the time frame I had. Hence, four models were tried in the fields. The experiment was carried out in levelled, lowland rice paddies in four locations on main connection roads split in two districts, Sipahijala and Gomoti, in the south west of the country (pic. 18).

Full SRI compliant fields were selected with the help of the Dept. Sector Officers and under the supervision of Dr Majumder. The four sites encompass a representative range of relevant soil types and irrigation sources (Table 2). Plots of one *kani* (0,16 ha) were selected. The selected plots were divided into four sub-plots of 400 square meters each, with a fairly regular, roughly rectangular or squared shape. Each sub-plot was weeded using a different weeder. This was sometimes done simultaneously by labourers, which minimized the total time spent in the field.

The experiment took place at around 10 to 15 day after transplanting (DAT) the rice seedlings. It was the first weeding of Boro season. The fields had been planted in lines spaced 10 inches (25 cm) apart according to the Agriculture Department's guidelines for SRI.

Table 2 – Soil characteristics of experiment sites

	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)	Organic carbon content (%)	pH	Textural class	Water source
Shukshagar village Matabari agri-sector Balu Majumder owner	295,68 (medium)	very low	very low	0,70 (medium)	5,5	Sandy	Rain fed
Jowalikhamar village Matabari agri-sector Kartik Dey owner	160,16 (low)	very low	very low	0,75 (medium)	4,7	Sandy Loam	Ground
Bashtali village Bishramganj agri-sector Kamal Debbarma owner	338,69 (medium)	Low	very low	2,8 (high)	4,9	Sandy Loam	Rain fed
Promod Nagar village Bishramganj agri-sector Pradip Debbarma owner	313,6 (medium)	very low	very low	0,85 (high)	5,5	Clay Loam	Ground

6.2 - Plot 1 Shukshagar

Half of the weeders under test were not present for logistical problems, so this plot has been used as a benchmark for the others. With no water catchment systems, the crop relied on local precipitation. The day before had rained, so it was partially flooded. In such cases, Cono weeders can be very tiresome, no matter the soil composition.

A farmer who was using the Cono weeder was not able to complete his task, not even for the first passage in the field. The custom-made design made by Aspee was deemed the reason for these problems. Their modified TNAU design Cono weeder has the rotors attached to the head by mean of an adjustable screw, with no lock nut. After tightening the screws to adjust the blades, one has to tighten them again just after few minutes of work, because they come loose. The reason was that the holes to hold the screw in place were not in line, as showed in **this video** [5], so this leads the rotor to be screwed on the bare metal, ruining the mechanism itself and make the whole attachment loose.

The lack of width adjustability for Cono weeder do not influence drudgery only, but also the efficacy of machine in removing weeds, as shown in **this video** [6]. The fact of being adjustable is then a crucial characteristic for a weeder because it relates to its capacity to remove more weeds with less passages and its drudgery. A lock nut, as in the Banabethi model, could have prevented this.

This plot showed that the timing needed to complete both straight and crossed passage in the field is equal the more the shape of the plot is squared rather than rectangular. The farmers need spending the same amount of time at the end of each field passage to move machinery and start the next new line. This translates in similar time expenditure for both lines, as conversely showed in other plots. When it is not squared, i.e. when a side is shorter than the other, it requires more time for the farmers need to stop, turn the machine, and go again in a new line. The crossed passages take almost always longer than the first lines, and it has been observed in all the plots with such shape.

6.3 - Plot 2 Jowalikhamar

This plot was irrigated two days before the test. The irrigation is based on fortnightly turns, thanks to power pumps owned collectively by the local Panchayat. Its sandy loam composition was favourable to work, though the clay layer beneath it makes the drainage of water a challenge, so the groundwater table was very close to the surface level.

Cono weeder was experienced as very problematic because it was muddling instead of smoothly churn the soil. The operator had a hard time finishing the straight lines, and was unable to complete the crossed passage. As in picture 17, instead of pushing it from the handle, he tried to overcome the excessive operational drudgery he was encountering with a position change, holding it directly from the handlebar. This position, though granting more power, was also more prone to fatigue on his shoulders; hence it was impossible for him to complete the trial.

[5] http://youtu.be/JiZYh2lku-M
[6] http://youtu.be/eISRBArprgI

The Babulal model created a somewhat patchy plot afterwards, though it was experienced smoother than the Cono and slower than Paddy weeder. The Japanese and the Jute models were the most effective in removing the weeds, and the former was faster.

6.4 - Plot 3 Bashtali

The plot is part of a series in between small hillocks, hence the water accumulates in manmade open pond during the rainy season, and used in the dry period. The field had problems with its insufficient drainage capacity, especially after random rains during the summer season. It was irrigated few days before the test, though during the night had rained, so it was still shallowly flooded.

In here I observed how a farmer adapts their knowledge to a machine he never saw or used before. **This video** [7] shows the constant push movement and the moment in which the farmer has to unclog the head of the Jute model from the mud. He "opens up" the following line when is almost at the end of the previous one, to make some space for himself at the edge of the field. In this way, this model was the fastest, with much surprise of the farmers.

This time the Paddy weeder was the slowest of the batch. The plot was incorrectly levelled, so the water accumulated more at one edge of the field, making the paddy weeder sinking into it (fig. 19). The labourer tried pulling it instead of pushing, something which was regarded with laughter from the other farmers. He switched back to pushing as soon as he noticed that the weeder was not doing any work at all. The owner of the plot opened up a small breach in the ditch to let this surface water move to adjacent fields.

The Babulal model have been experienced as smoothly "running" into the lines for its lightweight, but less effective than other implements in removing weeds and easier to clog. Nonetheless, it gave a poor performance about churning (or "aerating") the soil.

The Cono weeder had contrasting feedback about its usage. A farmer complained about its high (for him) handle position, which forced him to push the machine a bit down and lift consequently the front blade up, so vanishing the positive effect on the weeds and making the operations more tiring. Another one instead was immediately at ease, even though he never saw once before. They both were skilled and using Japanese models since years, but one of the two was taller. In this case, the fact that Cono weeder has a higher height compared to the Paddy weeder played a role in the easiness of operation. It works as a mechanism for selection too: the shorter farmer will select another model.

It was interesting to observe that the Banabethi brand of Cono weeder (IRRI design) had a more positive review than the Aspee one (TNAU design). In both the blade's profiles can actually be parallel to the soil, though the former has angled rotors support attached to the sled, rather than angled rotary axles as the latter. All the tubes in which it is built have circular cross sections, stronger than squared ones (fig. 20). The shaft is a bit shorter in length, so it makes the entire machine more compact and easier to handle. It has lock nuts together with the adjustable screws to fix the rotor width.

[7] http://youtu.be/Ths3z_PeirU

6.5 - Plot 4 Promod Nagar

This plot and surrounding areas were selected by the Department of Agriculture to showcase to a Ministry of Agriculture delegation the SRI achievements in Tripura in 2012. The irrigation was on weekly turns with power pumps owned and maintained collectively by the local Panchayat. No problems of poor drainage here. Farmers and labourers were very skilled, and they knew how to use Paddy and Cono weeder. They knew the Jute model as well, though no one saw the Babulal model before. The reason for this is the fact that the Babulal model area is in the north district, quite far from the experiment location.

In here, weeding operations started slowly at first, and then became increasingly faster especially for the two hand-made models. The Babulal model was competitive in terms of time, but the quality of its soil churning effect was very poor. The jute model was the slowest of the batch too. The operators needed to "warm up", i.e. adapt themselves in order to efficiently use them, because they were more accustomed to the commercial weeders. In that area, farmers and the local VLWO "knew" that the Cono weeder was actually faster than the other three used, and the farmer who used it acknowledged it himself.

The Japanese Paddy weeder took less time to complete the crossed passage here, no matter the rectangular shape. Different labourers did the weeding, and the one who did the crossed lines had more experience in weeding than the others. It was a case in which the skills of the operator were surpassing the physical limitation of the tool and an indication that training could improve tools' performances.

It was interesting to observe how SRI could influence the way a machine can be used. The drainage ditches were at regular intervals in the plot, so the operators needed to pay attention during the crossed passage to avoid damaging the ditches, in particularly when they have to turn back, as in **this video** [8]. Maintaining the drainage capacity of the fields is considered more important than fast weeding operations. The SO clearly identified this as important too.

6.6 - Evidences

The collection and weighing of removed weeds was deemed impossible, for the simple fact that the machine hardly "remove" any weeds from the fields, rather they incorporate them into the soil, after uprooting them first and compacting them in afterwards with the action of the labourers themselves, walking in between the lines.

It was relatively difficulty finding levelled areas of regular shape, due to the extreme variability and tiny irregular dimension of Tripura small-holder's plots. Soil levelling was crucial in this experiment, for the water need to be properly managed on the whole surface to avoid build up in between or at the edge of the field. The levelling affects the drudgery of the implements, and indirectly the kind of weeder to use.

Newer designs have better performances only partly because irrigation condition. A good example came from the plot in Bashtali (P3), where the labourers who used it told me about the relative easiness they felt while using the Banabethi Cono weeder, reflected by the fact that it took less time to complete the plot. As for Tripura, we can see that the "improved" long-handled design is not much of an improvement, because the local, contextual factors. The Banabethi brand is experienced as an overall better machine whether for its dimensions and design choices, or for being less problematic to handle during the weeding.

[8] http://youtu.be/Iv8CTpcS4Us

On the other hand, locally devised machine can sometimes be faster and with negligible differences in efficiency, used in the right conditions; if we have a look at the **pictures** from 21 to 32, taken to evaluate weed coverage we will notice they have a comparable effect over the amount of weeds, regardless farmer's age, related drudgery, and the time spent in the field to cover the same area. What makes a difference is the capacity to mulch the weeds inside the soil, and to churn and aerate the soil, a capacity that is lacking in the weeders with no moving parts. In this regard, thicker nails as in the Babulal model, whether made out of wood or metal, have more incisive effects over the surface of the soil; notwithstanding, a rotating mechanism provides a better job.

How come that different brand of the same machine differs so much from each other? A faulty machine is not well accepted by the farmers whatever the subsidy and will not have a longer life, i.e. it will be rejected soon. Between the "improved" long-handled and its compact counterpart the differences are sufficient to admit that the newer models are worse off than the older ones, at least for lowland cultivation in Tripura. What criteria are used to decide which machines and/or brands have to be subsidized? The SO pragmatically said me that any sub-division has the power to announce a tender for the area under its authority, so it is common that any sector can have a different machine.

An incidental observation was that the cono weeder broke down twice during the field experiments, whereas the Japanese Paddy weeder did not. This was seen by farmers as an indicator of poor performance of the Cono weeder.

Table 3 - Time needed to cover the 400 square meters test area in minutes.

	Cono		Paddy		Babulal		Jute	
Fields passages	**Straight**	**Crossed**	**Straight**	**Crossed**	**Straight**	**Crossed**	**Straight**	**Crossed**
P1	Fault	Fault	90	90	-	-	-	-
P2	103,33	Fault	50	76,67	73,33	103,33	90	126,67
P3	59,77	89,66	116,67	138,1	91,95	105,75	47,62	61,9
P4	40	62,86	58,3	49,97	48,14	59,47	50,42	67,23
Sub- Total (P2,P3,P4)	203,1	152,52	224,97	264,74	213,42	268,55	188,04	255,8

6 - Pictures

Figure 17 Liton Das having problem with Cono weeder during the trials

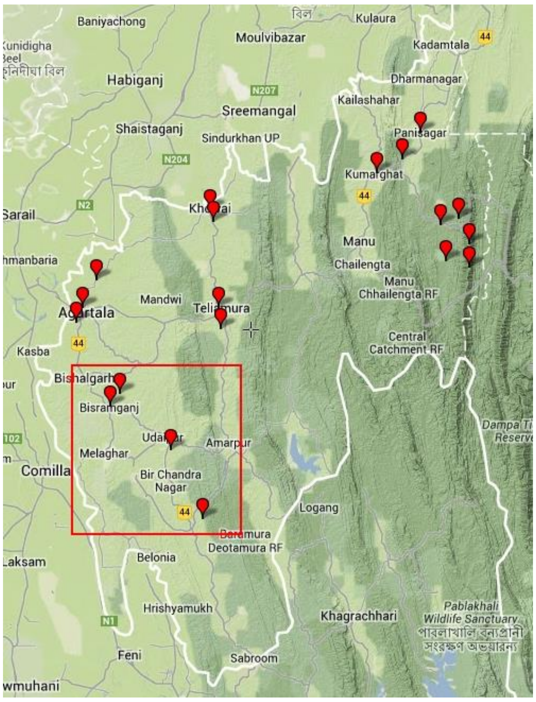

Figure 18 Locations visited. The experiment ones are in the red square.

Figure 19 Paddy weeder sinking

Figure 20 Details of Banabethi Cono weeder head

Jowalikhamar pictures

Figure 22 - Cono weeder weeding

Figure 21 - Paddy weeder comfortable posture

Figure 24 - Patchy Babulal weeding

Figure 23 - Jute model crouched position

Bashtali pictures

Figure 26 - Paddy weeder

Figure 25 - Jute model took much more time than the others

Figure 28 - Babulal model

Figure 27 - Cono weeder

Promod Nagar pictures

Figure 29 - Babulal weeder effect. The right side is unweeded

Figure 30 - Cono weeding effects on soil churning

Figure 31 - Paddy weeding effect on soil churning

Figure 32 – Jute model weeding effect. The right side in unweeded

7 - Experiences from the field and testimony of users

7.1 - The commercial weeders

These weeders are regarded as the “default” official choice for increasing the yields of rice, though only 25% of households, i.e. the percentage of farmers who are actually doing SRI, are aware of their existence. They have weeding attachments furnished with moving parts, their height is adjustable, and are manufactured from steel. They are too costly for the farmers, so they have to be subsidized by the Agriculture Department; else no one would afford to buy them. The subsidized rates were and still are a key factor for its adoption among the farmers.

The Japanese model is common and widely available in Tripura farming households, whereas the Cono weeder is hardly known and mainly in lowland paddies. The Japanese model is operated with a back and forth movement under SRI, being its width narrower than the prescribed space in the guidelines. Cono weeder is instead designed to be constantly pushed, though farmers resolve to use it in the same way they would use a Japanese model, i.e. with a back and forth movement.

Reasons are based on the existing (or lack of) knowledge on how to use it, or physical characteristics, or price; views and opinions of users and farmers about these weeders are different. The Japanese Paddy weeder had positive reviews from the majority of my informants. It was considered:

- light weight and effective in reducing weeds, because it saved labour and was faster when compared to manual weeding;
- more affordable than Cono weeder because even with the subsidy it is cheaper in price;
- cheaper to repair, because every blade could be individually replaced, whereas the failure of a Cono rotor could necessitate the replacement of the entire unit;
- easier to use with the smooth back-and-forth movement when compared to the same action done with the Cono weeder. The reasons are a more compact machine, shorter handle, slightly lighter weight and sharper blades.

Being considered relatively unproblematic, farmers use the Japanese model as a benchmark to compare other models’ performances. Notwithstanding, I observed that farmers often resorted to making their custom adjustments to improve its performances. A typical improvisation is to adjust the pitch of the float at the front of the implement. The angle of the metal plate could be more or less bent to facilitate the skimming over the mud and avoid sinking or clogging during the operations. This has been a very common feature observed in the various paddy fields locations visited. The Department officials are well aware of this farmer’s adaptation, and suggest this modification to other farmers and interested manufacturers.

Among the “skilled” farmers, a very small group, who can have preferential access, the Cono weeder is considered to have a superior capacity in terms of efficiency (time per hectare) and ease of operation. They have participated in various training sessions, received the subsidies to buy the machine, and they actively use it in the field instead of the Japanese model. They are able to adapt the width and to work with it with a constant push. Conversely, all the farmers who got hold with a Cono weeder and have received only an initial training (the majority) complained that they don’t exactly know how to use it and experience it as more difficult to use and “new”, i.e. inherently more complicated than the Japanese model and the traditional tools. They are hardly aware of the adjustable features of the machine because they had no follow-up seminars or update. The Cono weeder perceived as more wearisome than the Japanese model when operated with a back and forth movement, so farmers prefer or completely revert back to use the former.

A peculiar issue with Cono weeder was about the height of it, i.e. the vertical measure from the soil to the handle while operating the machine. A higher position forced shorter labourers in pushing more on the handle and the rear blade, in so doing lifting the front part of the float (fig. 31). Even though the handle was adjusted and the lowest position, its height was still enough to make it more tiring for their shoulders. It was experienced as problematic for other reasons too.

Department officials and farmers complained that it was not properly assembled and adjusted, necessitating frequent stops to tighten bolts:

> *"the bolt and nuts adjustment of this Cono weeder* [Aspee] *were not so tight, so during the operations you have to stop several time to tighten up otherwise the blades got loose and are not performing well"* **Haradon Debnath**, VLWO
>
> *"the "feeding" parts* [the blades attached to the body] *were not very tight together"* **Balu Majumder**, farmer

Labourers experienced a range of problems with the operation and effectiveness of the Cono weeder. According to Balu Debnath, the machine was difficult to control:

> *"the cono weeder goes zigzag and is difficult to keep the balance with"* **Balu Debnath**, labourer

Another labourer found that he had to stop working before completion of his plot.

> *"the blade got stuck in the mud, it was too heavy to operate in this field with this type of soil, and it was also very bad in removing all the weeds"* **Liton Das,** labourer

A VLWO complained that the cono weeder was not the right size for the small-framed people of Tripura, and it could not be adjusted:

> *"this model is good for Punjabi people, not for short Tripura people"* **Haradon Debnath**, VLWO

A farmer compared the Cono weeder unfavourably with the Japanese weeder:

> *"the blades are sharper*[9] *in the Japanese paddy weeder, so it is more useful than the cono weeder because it cut more and better the weeds"* **Balu Majumder**, farmer

I had the impression that the Cono weeder was not doing well during the trials because of the relatively smaller, regular size of the plot. Investigating further, the farmers said that the only problem of the weeder was the fact that the plot was "too long" (related to the size of it) and then it was difficult to operate in crossed passages. The SO confirmed that in plots with larger extension the Cono weeder out-compete any other mechanical implement.

The Department also implement a small feedback system. This is the case of the Aspee branded implements, the more recent supplier of the Agriculture Department. It has recently adapted its Japanese models with a front float already bent by default (fig. 30). Mr Battacharjee, Tripura head distributor for Aspee, has said that he closely follows any suggestions from the Department, to make the machine better

[9] It is intended as "better designed", more effective in cutting weeds.

accepted by farmers. He sends the feedbacks back to the Mumbai headquarters of the company, and they adapt the machines according to it.

This shows that farmers' adaptations are being observed by the Department personnel, and then is translated to the manufacturers via the existing communication channels. In Tripura then, direct interaction between farmers and weeder manufacturer is mediated by the Agriculture Department.

7.2 - The "home-made" models

These weeders are not officially recognised by the Agriculture Department or other institutions. They are instead known by local communities and farmers, and have been much before the advent of SRI. They are cheap to assemble; building your own is the only way to get one of these. They are also cheap to service and to repair in case of breakage, being made out of locally available woods and materials. They are being operated with a constant push movement, though the larger spaces commanded by SRI guidelines are unsuited for an efficient weeding in the line with them; e.g. double passage in the same line.

These models have no moving parts; they are fitted with wooden or metal nails as soil engaging components. A very commonly observable feature while using them is the stop-and-go pause that an operator needs to do to clean the lower "face" of the implement, liberating the nails from clogged mud. They hardly churn the soil; they rather shallowly uproot the weeds that get stuck in between the nails. These make them more easily clogged by mud and weeds during operations, hence less efficient in removing weeds. Farmers are then obliged to supplement the rice weeding done with these models with manual weeding operations, to get out the leftover weeds after the passages. This adds extra costs which are unsustainable for them. The commercial models do not need this extra manual passage. They do not perfectly weed the line in one go, but the operators get very close to the plants. This makes the job done, though inevitably cuts part of the lateral roots.

They have been invented in response to contextual factors. The Jute model needed to aid farmers for the back then widespread jute cultivation, while the Bidyut and Babulal model as a response to the changed practice of line planting and alternate wetting and drying of paddy fields, introduced by the Japanese first and SRI then cultivation methods. They are still used nowadays for a relative difficulty, whether bureaucratic (the selection procedure) or infrastructural (remote badly connected areas), to access the commercial models with rotary parts.

The Jute model can be considered the first in historical terms. It is very lightweight and less tiring to use than other models. It is also more prone to breakage, but being made from any local timber it is easily repaired or replaced. Department officials acknowledge this model too:

> *"the farmers are using it in the vegetable fields and it was used before SRI introduction as well.*
>
> *"the locally made is varying across owner, because the length of the shaft influence the way of using it, so according to farmers' height you can have different shafts' lengths."*
> **Jhutan Miah Kazi,** VLWO, 16 February 2013

The latter comment shows important information related to the flexibility granted to the operator in choosing the right angle of working with the Jute model, and how this flexibility is used to shape the tool itself. This flexibility is inherently related to the adaptation that any technology undergoes when has to be used in a particular context; it has to be situated in place and time (Suchman, 1987).

The Babulal model has been copied from the Japanese Paddy weeder, so it is the most recent one. Babulal Das, its creator, was forced to do so because he was not selected by his Panchayat as "fit" for the subsidies. This innovation itself granted him the possibility to get access to an original Japanese model and the subsidies to improve his conditions. This model gets easily clogged up by mud and removed weeds (fig. 32). The wooden nails are also more prone to wear down quickly, but the cost of repairing them is negligible because of the ready availability of bamboo in Tripura households. Due to its lightweight, it can float over the surface of inundated paddy fields, even if only partially flooded. This undermines its effectiveness because the areas in which it is used are not well drained, as Babulal and his colleagues told me. They use this mainly in upland areas.

Access to the machine, or the lack of it in the case of Babulal, has been instrumental in triggering a different kind of answer which led him to the observation, copy and realization of his own machine. He was basically forced to do that, because he had no access to the economic support from the Department of Agriculture, and he grasped the fact that the tool could have helped him in the farming operations. He even developed a narrower version of it that is used for horticulture crops. Following his inventive capacity, the Department recognized him as a "progressive" farmer, allowing him to get subsidies to get a Paddy weeder. He is now using it together with the models he devised. It has been positive for Babulal to being identified as "skilled", because with the Japanese model he can easily weed his fields even in partly flooded condition. When the model he firstly devised starts to float in the field, whether because of rains, incorrect irrigation or insufficient drainage, Babulal switches to the Japanese Paddy weeder.

I was not lucky to found the Bidyut model before the completion of the trials; hence I have only first-hand data about easiness of operation and comparison with the other models from the interview I got with him and the creator of this machine, his father. Bidyut is a VLWO of the Agriculture Department, hence is perfectly aware of the existence of different machines. He had never used a CONO weeder in his fields. Even if he saw it for few times during his work with the department, he was anyway not keen nor interested in trying, for his father was already using a Japanese weeder together with his own old model. He prefers this "traditional" way, and does not go for "news". Mr Kunal Debbarma, local Sector Officer, suggested the fact that the teak wood is much heavier than bamboo, so it makes it difficult for such heavy implement to float on the surface of shallowly flooded fields, as it was the case with the Babulal model.

7.3 - Mechanisms

The fact that Paddy and CONO weeder are part of the SRI set of rules regarding weeding does not necessarily mean that in Tripura there were no weeding techniques and mechanical implements, accidentally already widely used. In fact, the Japanese Paddy weeder has been introduced only after the Department started its 1998 SRI campaign under the scheme of the National Food Security Mission. Before that, the conventional practice entailed flooded fields that were naturally suppressing weed competition, and the so-called "Japanese" method of row cultivation, while being suited for mechanical weeding and row tillage, was still carried out manually. Weeding with rudimental mechanical aid was already carried out in crops other than rice, and it is quite simple to imagine that, as soon as the fields dried up for drought or for a change in irrigation routines, was maybe easier for a farmer to start weeding also the paddy field, especially if already used to do so in his own fields.

Three factors strongly influence the selection of a weeder: weight, price, and height of the implement. The first two were considered the most important by Dept. officials, and by the importers, who were overlooking the height of the implement, a characteristics to which the farmers were mostly susceptible.

Secondary factors regard other physical characteristics like:

- the length of the handlebar. Farmers prioritize manoeuvrability and stable balance from a weeder, and a longer implement is unstable for them.
- the length of the weeding attachment. A longer one like the Cono weeder was always considered less easy to manoeuvre in the field. The Jute model, being almost a rake, was always getting positive review in terms of usage.
- the width of the tine, the thicker the better, and in the position of the handlebar; mostly farmers were suggesting a bicycle like handle to ease the operation.

Figure 33 - Aspee Japanese model sled assembly

Figure 35 Front part of Cono weeder being lifted because too high for the farmer

Figure 34- Babulal model clogged up

8 - Discussion and Conclusions

This research shows that only a relatively small selection of the universe of rotary weeder designs is actually available in Tripura. It also shows that where farmers have built their own devices, it has been a reflection of their own relative disadvantage in accessing the weeders commercially available in Tripura.

It has been observed that SRI is only one of the existing bodies of knowledge about how to properly use a weeder in Tripura. It is only part of the causal relations to manufacture a “good tool” for rice cultivation purposes. It is undergoing a process of integration in already existing practices. Tripura farmers are involved in situated processes of problem-solving. They are inventive and resourceful enough to devise and adopt locally made weeders in response to the context where they live and work. Such innovations are mutually interacting with the place they originated from.

At this point it seems clear that the weeders are not settled in a definite form and are undergoing further modification. The weeder is **a new way of doing things in Tripura,** enacted by **a lot of different actors**.

8.1 - Why this profusion of weeders? Mechanisms of selection

The **reason why a weeder is designed in certain way** can follow:

- different texts inscribed in it during the design phase (Akrich, 1992)
- different usage pattern envisioned by the actors who practically use the machine

In Tripura there is no inscription phase, being manufacture of the implements external to the context. They get what they have been given. Usage patterns are typically de-scripted by farmers, the final users of the machine, though the availability of the tools strongly limits their choices. Physical characteristics like weight and height of weeders influence their susceptibility in being used in a particular field and not in others. E.g. the height of the implement influences its manoeuvrability.

So to say, the **materiality** of the weeder influences its adoption, rejection or adaptation. This holds true only at field level, being the Tripura weeders strongly influenced by the decision of the approval committee and tender procedures. What it actually drives the tender is not a feedback from farmers’ usage, but other reasons, like special economic arrangements or particular interests. Weeders can be seen as triggers of re-configuration. When environmental conditions are putting the farmers in danger of economic loss, epidemic, displacement, or food insecurity, they resolve not by using a weeder, rather shifting cultivation from rice to other, more remunerative crops. To keep the natural antagonist weeds at an acceptable control level in order to maximize rice productivity holds true for a minority of farmers only. Maximising the productivity is just one of the reasons that farmers have in using the weeder, and comes after selecting which weeder is most suitable for their own field characteristics and socio-economic condition.

It is clear that there are two basic categories of weeders in Tripura:

Commercial weeders, industrially manufactured with rotating parts, locally subsidized, promoted now or in the past by the Agriculture Department. They are made because there is an increasing shift towards different weeding practices. The Japanese paddy weeder is more common than Cono weeder in Tripura because it has been promoted first, is experienced as suitable for all the type of soils, and is cheaper.

This small selection of models reflects Tripura's relative isolation from the rest of India. It reflects the bureaucratic management of an unfree market. In a small scale, what the Department is doing can be seen as a top-down intervention, even though with the best possible intention, for its inherent position of being the one and only filter that a farmer has in getting this machine.

Why is it difficult for farmers to access the commercial machines? For prohibitive costs, the village-made models are easier to produce and have a really low cost of manufacture. For scarcity of subsidies, they are limited and are being set every year by central and state level institutions. For inability to get subsidies, they need to be the "right" type of farmer, or they may lack "salient" social connections.

Home-made or indigenous models, locally fabricated without moving parts, part of already existing knowledge in Tripura. They are made because more accessible than the commercial ones. This has two dimensions. They are cheaper, for being made with locally available raw materials, tools and know-how. They are not scarce; when the people concerned do not have access to the subsidies from the Department or cannot purchase the metal machines, they can improvise.

Farmers' reasons for their inventive capacity seem to be always affine to economic enablers/constraints, like the governmental subsidies and the price of the implements, and to environmental features, like soil characteristics and access (or lack of) to irrigation.

8.1.1 - The influence of shape

In larger plots the Cono weeder out-compete any other mechanical implement in terms of speed, hence area covered per time unit. The reason for this being the fact that cramped size plots, i.e. short distances to cover with a weeder, force the operators in doing the same amount of stop-and-go movement at the end of the line, regardless of the covered length.

So to say, in the same time unit a weeder can cover more area with a longer rather than shorter weeding passage, other conditions being equal. The time spent stopping, exiting a puddled field, positioning the weeder in the next row and continuing the job may appear small, but summed over an extended area can results in crucial time expenditure, which sum up with the drudgery related to the dimension (length and height) of an implement. This holds true for all the fields observed, where larger areas are weeded faster than smaller ones, and the larger they are, the more convenient it is to implement mechanical weeding.

8.2 - How do they end up being distributed in this way? Processes

The weeders are not novelty of invention landed on earth. They have a history, and they have been through a long process of trial and error, with carefully selected goals (Basalla, 1988). This evolutionary process can be recognised also by the amount of different designs in which the mechanical weeder is produced and used. The simple fact that different machine are present at the same time and used for exactly the same cultivation, at time in the same field, is a quite clear indication of frictions, if not problematic interactions, with different ways of conceiving the weeder and its role among farmers. Different weeders are designed to respond to different contextual pressures of selection. The profusion of models indicates evolution.

It is interesting to observe how **agricultural research systems are a selective environment** that helps in shaping particular technological trajectories (Dosi, 1982). In Tripura, the Agriculture Department creates and implements policies about the making, importing, using and adoption of the weeders. It is pushing forward the process of shifting weeding practices from conventional, to Japanese method, to SRI.

Farmers cannot travel to other regions of the state due to economic and infrastructural constraints. Poverty pushes them out of the market. In such a difficult context and with the sheer number of BPL people in the state, having a better chance of survival by only modifying existing practices is easily accepted. They adopt any practices, row-planting, Japanese, SRI or a mix of them, because the increase of yields can afford them economical subsidies, hence a better standard of living, regardless of using a weeder or not.

To overcome these difficulties in accessing the machine, farmers rely more on peer solidarity in exchanging tool and the expertise to use it.

Talking about **materiality**, the machine follows a certain desired pattern of movement, at a certain particular angle, requiring a certain amount of power and particular movements in order to be operated effectively. It has been observed that a peculiar feature is the height of the implement, the shorter the better, at least for Tripura. The Japanese Paddy weeder has been favoured by farmers also because of this.

A weeder, whether commercially available or hand-made, requires a certain set of socio-economic conditions, a knowledge set to be learnt and a degree of skilfulness from the operator's side. The physical characteristics of the operator, like age, height, related health issues and necessary training influence how to use a weeder. The human factor can influence the final outcome over the amount of weeds in the field. In this sense, knowledge extension in a depressed and poorly connected country like Tripura, has been the main vehicle in effectively "extending" knowledge. E.g. training improves performances, as observed in the test. This is true for all the models, even though only the commercial ones are being used in the seminars.

8.2.1 - Irrigation and water levels

The irrigation system in place, whether rain fed or with water pumps or everything else in between, was the most notable feature that influenced the behaviour of the machines during the tests. Access to constant sources of water can positively influence the growth of rice plants, as well as weeds, and it acquires an increasing importance the more the farmers shift from conventional, to Japanese, to SRI methods of cultivation. It is interesting in this regard to note that SRI has been deployed in Tripura paying extra attention to soil levelling and crop patterns, with some small drainage ditches that run into the field.

In poorly drained soil condition, irrigation has a strong influence over the height of the groundwater table. Longer flooded period saturate faster and for longer period the drainage capacity of the field, and subsequently influences what weeder can be chosen to do the job and how tiring the weeding operations will be; e.g. the Babulal model floating on the surface, or the Paddy weeder sinking into it, or the Cono weeder getting stuck. Maintaining the drainage capacity of the fields is then more important, for weeding practices in Tripura, than other characteristics like speed.

8.3 - What role does SRI have?

The adjective "Japanese" is germane to the name that farmers give to the paddy weeder, to the method of row planting, and to SRI. This is historically derived from Japanese breakthrough studies at the beginning of the century about the rice plant capacity to stem in different ways, a capacity called tillering in botany, according to different cultivation practices. This was then combined in the 1920 in an organic set, together with massive use of modern inputs, like fertilizers, chemicals and hybrid seeds (Sinha, 1973).

A mechanical weeder was a machine already used by Tripura farmers' ancestors, in fact they still address the SRI as ''the Japanese method''. They call one of the weeder as Japanese Paddy weeder. They feel at ease with the practice for the strong name familiarity, already used by their forefathers. This process of ''rediscovery'' of practices indicates how the farmers are adapting to it and what evolutionary trajectories the weeder has had (Dosi, 1982). Farmers who are practising SRI see no good reasons to shift from the Paddy weeder to the Cono weeder, considered technologically superior by the Department of Agriculture. It has to be said though, that many farmers are not even aware of this latter model, if not of the differences among brands, so their decisions cannot be informed properly.

Talking about the optimal use of external inputs within an SRI framework, there is a recognized aspect of economic and environmental sustainability which has recently favoured SRI when compared to the conventional methods. The Department is pushing SRI forward for economic reasons. It considers farmers more willing to pay less money and buy one mechanical tool than buying a lot more inputs, like new fertilizers, seeds, pesticides and so on. Environmental sustainability is the fact that SRI can nicely fit into the previously known techniques of row planting, above any other feature. This is not disruptive for farmers' routines; in fact they only need to enlarge the spacing in between the lines, and shifting the use of indigenous weeders to the commercial ones.

The Department is the main force in spreading the adoption of SRI practices in Tripura, though it is the only one because, as a técnico (Grindle, 1977), has the capacity of:

- managing the access and distribution of knowledge, expertise and skills in Tripura on a long term;
- managing and dividing the tasks to "grow more rice" among new farmers;
- Dividing farmers according to their capacity, in order to establish a core-set of people and to replicate them in different part of Tripura.

The importance of SRI methods in Tripura constitutes only a good sales vehicle, especially for the importers of the weeder, because its precise definition of row spacing can be taken up quite nicely by marketing managers who are after profit and nothing else. This gives enough credit to the fact that economic factors are much more important than any physical characteristics of the machine, like the width for instance.

The proposition of SRI being a task-ordering activity provides reasons about why this profusion of designs is undergoing a process of adoption, disadoption, and adaptation by their users. Rice cultivation practices have been always accompanied the Indian population for millennia, and Tripura people are no difference. They grow up in a society in which rice cultivation is deeply embedded into the culture and where traditional methods and tools are preferred over so- called "progressive" improvements. The Japanese method of cultivation was already a novelty long before SRI; though SRI methods have had the benefit of including a more complex and careful soil preparation stage to the practices, which reduced water flooding for the rice fields. Water management was already known as influencing rice yields and weeds population. It was basically a different ordering of tasks. This gave in turn a massive proliferation of weeder models. Such models have being adapted to different context, different task groups and different objectives, and part of them were even revisited or adapted from already existing models.

Weeders are intrinsically flexible in terms of design. They are under a constant evolutionary process, which allows its users to adopt different tools with different body width or different blade shapes according to contextual factors like the irrigation management, or the availability of labourers. They are also selected because of their price, or because they are too high for shorter operators. Saving labours pay day is more important than cutting lateral roots close to the rice seedling. The distance between the rows of rice seedlings, or the tillering capacity that rice plants have according to the allowed space they have to grow within could be considered triggers for selection, though not the most important, nor the only ones. Thus, the SRI "innovation" as a whole **cannot** represent a reason to justify the diversity in weeders forms.

Within SRI, weeders with rotating parts are considered in its synergistic effects on weed removal, soil churning, and soil aeration effect. As in Stoop et alia:

> *"Weeds need to be controlled regularly, starting about 10 days after transplanting. Mechanical rotary weeding, which ensures a churning action and thereby soil aeration, appears to be an important factor."* (Stoop et al., 2002)

In Tripura is openly suggested to use a rotary weeder for manifold reasons:

- speed of operations; the soil **is not** flooded, so the bigger number of emerging weeds will not be blocked by the water layer. In a freshly transplanted fields, tiny and vulnerable seedlings are at risk of being out-competed if weeds are not removed in time;
- mechanical influence over soil structure, aeration, micro flora and nutrients exchange during the vegetative phase of the cultivation, for an overall agronomic rather than chemical input-intensive improvement of soil characteristics;
- the economically sound deploy of a mechanical aid which speed up operations when compared to manual ones, allowing farmer's savings on labour pay-days.

All of these can apply to the hand-made models as well, even if they are not so efficient. Considering their cheap price, and the extreme poverty in which farmers live, there is still space for such models to be used. It is more like an untapped opportunity not to recognise existing knowledge and previously known tools and expertise in the field.

8.3.1 - Societal glue

It is common practice for Tripura farmers to share their weeders among neighbours and friends. The reason is the relative scarcity of these implements among them, so the ones who have it are asked by neighbours to share it. This aspect is often neglected, for it is not considered that in a situation of poor infrastructural links and consequent knowledge and information distance, if not isolation, the farming villages and their Panchayats are the only social and political hubs. Farmers mutually exchanges expertise and friendship ties with it. The weeder is then a social object with a positive effect on agricultural development. My informants told me that the Department itself actively support this sharing mechanism.

This aspect has downside like the timeliness of weeding. If a farmer does not own a machine, needs to ask his neighbours to borrow one. If he follows SRI for example, weeding at defined DAT intervals becomes a crucial aspect for his rice yields. In this case though, the farmer is subjected to other people's timing and schedule, which jeopardise the weeding and will influence such yield. Tool scarcity actively influences timeliness of weeding, so it indirectly affects also which weeding practice to adopt.

8.4 - Further recommendations

More policy-making coordination

Using a tool for weeding, thus replacing the manual input in doing so, can be successfully spread among poor peasant Tripura farmers. This argument is corroborated by the fact that such tools already existed in the past, as pointed out by the discovery of some ancient prototypes still owned by some of the farmers, as a legacy from their predecessors. Though, it has been noted that the high-rank of institutional policy-makers are absent when it comes to let the already existing local institutions building a feedback system.

They former prefers creating ad-hoc commissions and supra-national bodies, like KVK. I am arguing that there is a call for more coordination, like the recognized need of having an update or follow-up seminar to farmers who have been previously introduced with weeders usage. An evaluation methodology adopted on a state level by local institutions will surely have a better grip (and better outcomes) over the environment it insists on when compared to the same methodology adopted by central ones.

More farmers' involvement

The higher degree of human influence over the operations, hence the agency of farmers and labourers, can change quite drastically the way in which the machine is experienced in the field. The weeders, like all of the other mechanical implements for agriculture, have been built **to assist farmers in producing their crops**. Hence, farmers should be involved in the selection procedures of these machines, because they know how to manoeuvre it, what salient characteristics they have, if a particular machine is fit for crops and/or soil types, and how it integrates in their context. **After** their involvement, other reasons like economic feasibility, governmental policy, market availability, and price may be considered. E.g. the small evaluation procedures that other institutions have in place are insufficient to have a full appreciation of the CONO weeder capacities, and even after that, there is no mutual feedback with the farmers.

Making use of feedback

Tripura farmers want to be updated about new implements and new knowledge about how to use them. They are aware of being not well connected, and that they resources are scarce. This should not be considered as a lazy habit; they are instead very active and resourceful. Lacking extensive and focused feedback's system in place at the Department, whether because budget constraints or the excessive amount of scheme to implement, I proposed myself to write a policy recommendation which will strongly endorse the adoption of the Banabethi model over the Aspee one, to be sent to Department of Agriculture officials. This thesis work is part of it.

A final thought is dedicated to further research to be done, at least in India, about the development of local contextual knowledge and adaptation of farming practices, as well as new technology-in-use, with or without SRI. The answers provided here could have not been taken relying only on the existing material in the literature. The fieldwork, and the special position gained by doing an internship inside SARS have been invaluable for this thesis work.

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10 - ANNEXES

10.1 - MANUAL WEEDER COMPARATIVE TEST TRIALS GUIDELINES

Trials setting: Selection of 2 districts in Tripura state:

- Sipahijala – Bishalgarh – Bishramganj sector – Bashtali g/p and Promod Nagar v/c.
    - Sector officer Mr Niladri Dass
- Gomoti – Udaipur – Matabari sector – Jowalikhamar g/p and Fulkumari g/p.
    - Sector officer Ms Debasree Saha

Using textural analysis, fertility indicators and pH test, select 2 different SRI Fields in each identified district which will be used as test plots. The known data for Boro cultivation indicate the existence of at least 2 different textural soil classes for the lowland cultivation: clay soils and clay-loam soils.

The size of 1 test plot has to be large enough to conduct 4 replications in it (1x sub-plot) of equal area size with 4 different weeders. Considering that the average size for a Tripura farmer holding is about 1.600 square metres (Agr. Dept. source), which equal the local measurement unit of 1 Kani, it is given preferential choice to test plot of such area extension or less. Maximum test area size per village will then be 3.200 square meters (0,32 ha).

Selection of 4 mechanical weeders manually powered:

- Cono weeder
- Japanese paddy weeder
- The nailed wooden bat
- Alternative locally designed manual weeder.

Trials protocol: With the help of the local Agr. Dept. sector officers, select the appropriate farmers' paddy field with a square-like shape, if possible, and sufficient coverage of pest weeds. Preferential choice will be made for the farmers who:

- Own already one (or more) of the selected weeders, in order to avoid the transportation of the machinery during the experiments. Otherwise a vehicle will be arranged to do so.
- Follow the SRI guidelines for weeding practices.
- Own enough land to suffice the size requirements.

Considering the large variability of farming holders, all of these aspects will be finalized according to the local possibilities. The selected field officers, the labourers and the farmers have to be fully aware of this protocol and of the information relative to the practical application of these guidelines. Possible other people involved will be senior position of the Dept., village level workers and the machinery supplier.

A visual measurement of the weed coverage will be taken before the start of any trials. Photograph documents from the same standpoint in chronological order and visual appearance will be used after the operations as well.

The farmer, or the labourer, or both will run the weeder as they normally do for SRI guidelines, i.e. crossed interlines. It will be used one model of weeder and one only in a single replication sub-plot to conduct the weeding operation. All the other operations before, during and after the usage of the machine will be conducted as usual, according to the farmer's routine.

In whatever form the pest weeds may come out of the weeder's passage, like uprooted, mulched or pushed back inside the soil, photographic evidence will be taken before, during and after the operation. In case the farmer do so in his field, let them do the subsequent hand weeding and record the appearance of the soil after it. Do incorporate focus group discussions after the weeding session with the local field officer, the farmer/labourer who runs the weeder and the workers/labourers who run the manual weeding operations. The questionnaire-like form can be filled by the sector officer if the case.

Economical arrangements will be covered by Wageningen University on behalf of the Dept. of Agriculture regarding the vehicle used by the researcher to reach the location, possible small refreshments for the farmers and 1 day wage for an extra labourer per identified location, the latter only if strictly necessary.

Data collection: These trials are part of a bigger effort which intends to understand how and why the diversity in weeder designs in Tripura has come about, and the roles of all the people and organisations involved. Main research questions include:

- How these different designs and models relate to how Tripura farmers use them?
    - How does the use of the weeder influence the rice weeding operations?
- How do they have changed during time?
- What are the task-groups of actors involved in the design of the hand weeder?
    - What do they need to do in order to arrive at a settled design?
        - What do they need to do to select a particular design?
    - What characteristics do they consider salient?

In order to answer them, the following aspects are identified as relevant for the trials:

- Impact of the weeding operations conducted via the weeders on the pest weed growing rate and soil coverage
- Relevance of different parts of the weeders, like the float, the blades, the handle to the overall weeding capacity of the weeders.
- Economical sustainability of weeding operations conducted by mechanical weeders

Criteria: The following dataset will be registered for the data collection:

1- Land distribution, type of ownership, size, access and type of irrigation
2- Soil types divided in:
    a. textural composition, i.e. pulverization of the soil and class, to be measured by visual and by hand estimation and textural class tests.
    b. pH, content of organic matter, available nitrogen, phosphate and potash analysis. Sufficient amount of soil sample will be collected from all the test plots in order to be tested in the SARS premises.
3- Efficacy of weeding operations, translated in :
    a. Pest weeds soil coverage, to be measured by visual and photo estimation in percentage.
    b. Time spent by a single weeder to finish the crossed line in 1 replication sub-plot. Timing of the weeding operations will be recorded before and after the 2 series of lines.
4- Salaries and set-up costs to implement mechanical weeding operations in farmers' fields
5- Semi-structured interviews' data collected via a questionnaire to register what characteristics of the weeders are considered salient by the farmers who operate the weeders.

10.2 - Agr. Dept. OFFICERS PROTOCOL FOR THE TRIALS

Name of the sector officer/VLWo:

Posted in:

Telephone number:

Email address:

The following are some guidelines tailored for the sector officer to follow in order to make an environment conducive to the trials.

Preparatory actions:

- Help selecting 2 (or more) farmer's extension of 1.600 square metres with the larger difference in soil characteristics. Ideally every plot should be owned by one single farmer and full SRI compliant.
- In case they don't own them already, provide the selected farmers on the day of the test with the 4 weeders selected: cono weeder, Japanese weeder, wooden nailed bat and the locally devised model.
- In case they never used one of the model before, instruct them to use it as in accordance with the SRI guidelines (crossed interlines).

Executions:

- The farmer and the labourer need to compare their experience with each and every one of the 4 weeders on the 4 replications. Hence any operator will use the weeder which is not familiar with and will execute the weeding on his sub-plot only under time recording.
- Help the researcher to record photographic evidence in the 4 replications before, during and after the weeding operations.
- After the weeding operations, help the researcher in making individual interviews to the operator, possibly one farmers or one labourer at a time. The sector officer can help in recording the answers on his own in order to speed up this phase, if the case.
- In the questionnaire, the descriptions need to be reported as much as possible using the same phrase and definitions that the farmers use, even in Bangla language if the case. They will be then translated at the end of the day.
- After every single interview has been recorded from the 2 (or more) plots, a group meeting will be held between the researcher and the sector officer, the VLW, and the farmer /labourers involved. THIS meeting is very important to share individual accounts of weeders usage, ergonomics and efficiency.
- Help the researcher in acting as a translator for the farmers and labourers.

Conduct:

- Avoid any external interference during the weeding operations.
- Read all the materials and papers provided by the researcher BEFORE going to the field.
- Suggest any possible modifications or addictions to any documents if you feel like. Any suggestions will be heartily appreciated and can be discussed together.
- Sign and then give back to the researcher all the documents provided for the experiment.

10.3 - QUESTIONNAIRE FORM FOR FARMERS' INTERVIEWS

Date: Time: Location:

Area size: Name of the owner of the TEST plot:

1. Name Age
2. Place of birth
3. Residing in
4. Caste Marital status: married – unmarried - widowed
5. Number cum gender of children (if any)
6. Main activity: (farmer, labourer, shared cultivator)
7. Telephone number
8. Languages known (English, Bengali, Hindi, Tribal, other)
9. About YOUR soil:

Location name	Owned/ rented/ loan	Irrigated area size cum type	Rain fed area size	SRI area size	NON-SRI area size

10. How often you irrigate YOUR fields? (date)
    a. Type of irrigation:
11. Type of soil (clay, loamy, sandy)
    a. Texture characteristics
12. How much is your loan or lease? (INR) (if any)
    a. Do you get it from a bank or other source? (define it)
13. When was the first time you heard about SRI? (date)
    a. How did you come to know it? (description)
14. When was the first time you implemented SRI? (date)
    a. How did you implement it? Who helped you? (if any)
    b. Why you delayed the adoption? (if the case) (reasons)
15. What subsidy schemes are you under?
    a. How much is the subsidy? (list all of the items like pesticides, fertilizer, seeds and so on)

16. Do you get subsidy for the weeders?
    i. How much? (percentage or INR)
  b. Do you prefer training or subsidy? (reason)

17. How many rice seasons you do? (Aush, Aman, Boro)
    i. Do you share the production in all the seasons? (if the case)
    ii. Why you do only 2 rice seasons?

    iii. What are you cultivating instead of rice?

18. Quantity of seed purchased x kani

	Variety	Kg of seed in SRI	Kg of seed before SRI	Actual market price x Kg	Actual subsidy price x Kg
Aush					
Aman					
Boro					

19. Quantity of rice produced x kani

	Kg AUSH	Kg AMAN	Kg BORO	Kg before SRI	Actual market price x Kg	Actual subsidized price x Kg
MILLED rice						
PADDY rice						
NON-SRI						

20. Where do you mill your rice? (location)
21. Who buy your rice? (department, customers)
22. Quantity of fertilizer used x kani cum doses (B.D. basal dose T.P. top-dressing) cum price (INR)

	Kg x kani	Basal dose	Top-dressing	Market price x Kg	Subsidized price x Kg
UREA					
Superphosphate					
MOP					
Bio fertilizer					
F.I.M./manure					

23. Same doses for all the rice seasons?

24. Which group are you member of? (g/p, farmer group, self-help group, others)

   a. Position held and location

25. Who is giving you technical support? (name)
26. When was the first time you received training with the weeders? (date)
   a. Was it at the beginning of the training or a separate session?

   b. Was it useful? (reason)

   c. What kind of weeder they have used?

27. Tools and machines:

	Number	Owned/Rented/ Borrowed	Brand name	Market prize	Subsidized price
Power Tiller					
Sprayer					
Tractor					
Irrigation pump					
Other					
Weeders					

28. What weeder do you usually use in YOUR fields?

Type of weeder used	… DAT	… DAT	… DAT	Number of labourer required x kani	Daily wage x labourer	Total days

29. Total days of labourer during other operations (land preparation, seeding, transplanting, harvesting)

30. Is the same scheme for all the rice season?
31. Working hours? (from-to)
   d. At what time you take a break during weeding?
   e. How many break you have during the day?
32. It the weeders broke down, where do you get spare parts? (name and location)

33. What custom modification have you done to the weeder? (if any)

34. Which part of the weeder you want to modify? (if any) (reasons)

35. How do you make the row-to-row distance? (marker, box-rope, bamboo sticks, others)

36. What model have you used during the **TEST**?
37. Last time the test plot was irrigated (date)
38. Time spent to finish the crossed lines (minutes)
    f. Area covered
39. Describe your experience (was it fast? what difficulties have you found?)