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Abstract

This paper is motivated by two broad questions: how is technology transferred from academia to non-academic domains, and how well do facts within these technologies travel? These questions are explored in the context of a particular extension education program in Tamil Nadu, south India. The paper explores the extent to which fertigation technologies (drip irrigation) and other farm and post-harvest technologies travelled from the Tamil Nadu Agricultural University to the farming community in two districts of north Tamil Nadu. The extension effort, involving direct scientist to farmer interaction, sought to push facts about such technologies – termed 'precision farming' – to the larger community through demonstration effects. We conclude that although facts about precision farming travelled well, the technologies themselves travelled once certain institutional barriers were overcome. This involved not only overcoming the farmers financial inability to invest in a relatively expensive technology, but also fostering cooperative behaviour and improving individual bargaining power through the formation of local farmers associations. This model of an extension education had an strong demonstration effect that encouraged the travel of critical facts about precision farming.

1. Introduction

This study arose out of a larger project which is investigating the nature of evidence and, in particular, how 'facts' are used in the construction, and communication of evidence. In this context, the project team is investigating 'How *well* do facts travel?'[1] This travel of facts can occur across various domains and disciplinary boundaries, as well as through time. From our perspective, technologies constitute facts or embody facts (technical, procedural, scientific, etc.) and therefore the travel of technologies was one of the several instances of travelling facts that came to be studied.

[1] The project is known as "The Nature of Evidence: How Well Do 'Facts' Travel?" and is based in the Economic History Department at the London School of Economics; the project is funded by the Leverhulme Trust and the ESRC (grant number: F/07004/Z).

Technologies emerging from biological or agricultural sciences offer a rich source of study material as they often transcend disciplinary, social and temporal boundaries. In this context, extension education in developing markets promises to offer some particularly interesting instances of travel, addressing not only the ‘how’ of travel, but also the ‘wellness’ of travel: the assumption here being that the ‘how’ and ‘well’ of travel determines the effectiveness of extension efforts.

Two broad questions motivate this study: how is technology transferred from academia to non-academic spheres and how *well* do facts within technologies travel? To assess these questions we have studied a particular extension education programme in Tamil Nadu, south India. The Tamil Nadu Precision Farming Project (TNPFP) was sponsored by the state Government of Tamil Nadu and the Tamil Nadu Agricultural University (TNAU) and operated between 2004 and 2007.[2] The programme involved scientists from TNAU providing 400 farmers, from two impoverished districts, with drip-irrigation and associated technologies, plus instruction on how best to use the technology and monitoring of its use by the farmers in the scheme. The technologies revolved around water- and labour-saving drip-irrigation methods, but crucially also involved fertigation methods (using water soluble fertilizers), community nurseries and a reduction in pesticide use, and were complimented by the formation of farmer associations, the grading and classification of produce, etc.

Our focus is on establishing how well and to what extent the agri-technologies travelled and in particular evaluating the effectiveness of travel; we do not evaluate the PFP technologies *per se*, only their travel. The empirical base of the study involved a large primary data collection component involving over 50 in-depth face-to-face interviews. These were conducted among both participating farmers, who were beneficiaries of this extension effort, as well as non-participating farmers, who rapidly became

[2] The TNPFP is part of the state promotion of modern technology in agriculture that intensified from the mid-1960s in India and which is often referred to as the Green Revolution (Farmer 1977; Byres 1983).

aware of these technologies once they were introduced. Some of the non-participating farmers have since adopted these technologies, either entirely or selectively.

From this material we want to try and address our two broad questions. First how and to what extent did specific facts such as fertigation techniques, water and labour saving methods, etc., travel from university scientists to the agricultural community? Second, if the wellness of travel is reflected by the adoption of various precision farming technologies, did the facts embodied within TNPFP travel well? We conclude that facts about precision farming, and about TNPFP, travelled widely within the target audience, and beyond. We further conclude that facts that were ‘new’ to the audience travelled well; newness in this case was the lack of expert knowledge or prior experience with a particular technology, technique or practice. We also conclude that facts travelled well when certain institutional barriers were overcome, such as financial ability, expert supervision, cooperative behaviour, demonstration effects, etc. In order to put the questions and the main conclusions of the study in perspective, it is helpful to consider the TNPFP in some detail and specifically what we perceive to be the different facts travelling within this project.

2. Tamil Nadu Precision Farming Project

Figure 1: Map showing location of TNPFP project districts

The TNPFP was implemented over three years, 2004-2007, in the districts of Dharmapuri and Krishnagiri in the northern part of Tamil Nadu (see map). The rationale for selection of these two districts was primarily the socio-economic status of both districts, which were considered to be backward, impoverished and water-scarce areas dominated by traditional agricultural

practices. Further, Dharmapuri district is considered to be the 'Horticultural district of Tamil Nadu': the largest producer of tropical, sub-tropical and arid zone fruit crops like mangoes, banana, papaya, sapota, guava and grapes, and vegetables such as, tomato, brinjal, chillies, cabbage, etc. About 10% of the floriculture industry in the state is concentrated in Hosur area of Krishnagiri district.

The stated objectives of the TNPFP can be classed into two broad types. First, promoting hi-tech horticulture through the use of precision technology that involved transferring the latest cultivation and post-harvest technologies to the farmers. Second, promoting market-led horticulture by encouraging farmers' forums and associations and increasing the overall value accruing to the farmers.[3] The project was concentrated around clusters with 200 farmers being selected in each of the two districts to make a total of about 400 farmers. The absorption of farmers into the scheme happened progressively in three stages: by the end of the first stage 100 farmers were recruited, by the second 200 farmers were part of the scheme, and by the third 100 additional farmers were part of the scheme (table 1).

Table 1: Applications and selection of TNPFP farmers by district

	Received	**Rejected**	**Selected**	**Cumulative no. in District Scheme**
Dharmapuri District				
1st Year	170	120	50	50
2nd Year	411	311	100	150
3rd Year	170	120	50	200
Krishnagiri District				
1st Year	90	40	50	50
2nd Year	296	196	100	150
3rd Year	167	117	50	200

[3] Vadivel (2006) p. 1.

There were several criteria used for the selection of farmers, including the minimum area, ability to provide for a minimum quantity of water, nature of the soil, location of the farm in relation to the cluster, etc., as well as other 'soft' criteria such as willingness to participate in associations, willingness to conform to practices recommended by TNAU, etc.[4] It is noteworthy that the number of applications received by the TNAU for participation in the project improved considerably after the first year of operation, suggesting a general increasing interest in the precision farming technologies after the perceived success of the first year beneficiary farmers. This is also mirrored in the number and profile of visitors to the PFP farms over the years, based on the information that TNAU shared with us.

The precision farming technologies were structured in a package that had to be internally consistent and were transferable *as a package* to beneficiary farmers. The technologies within the package can be divided into the *fertigation technology* and *other farm technologies*. The fertigation technology used Class 3 drip irrigation systems and fertigation units along with water soluble fertilizers, and fertigation schedules recommended for each soil and crop type.[5] Other farm technologies that formed part of the precision farming package included cultivation techniques, pest-management techniques, grading and sorting of produce and several others that guide cultivation and post-harvest activities.[6] One of the issues we study is whether there were any changes introduced by the farmers either to the fertigation technology or to the associated technologies, with or without consultation with TNAU scientists.

The precision farming technologies were made available to the beneficiary farmers financial assistance that included the cost of the fertigation equipment and the cost of installation (including the installation of laterals) and the cost of cultivation (including the cost of WSF). This entire

[4] Vadivel (2006) pp. 3-4 for details
[5] TNAU scientists used remote sensing technologies to develop fertigation schedules according to crop and soil type.
[6] Details of the individual precision farming technologies can be found in Vadivel (2006).

cost package was estimated to range between Rs. 75,000 and Rs. 150,000.[7] TNPFP assumed a total ‘conversion’ cost of Rs. 115,000 and the level of financial assistance was based on this estimate. The subsidy to Beneficiary farmers was provided on a progressively reducing scale over the years as follows: Year 1 100%, Year 2 90%, Year 3 80%. Beneficiary farmers recruited in year 2 and 3 of the project were expected to bridge the cost difference themselves.[8] It is important to note that each farmer received financial assistance only for the first year in which they joined the project. Cultivation expenses for the subsequent years (including the cost of the WSF) was to be the responsibility of the farmer.

Historically, most modes of technology transfer in India follow the researcher-to-development officials-to-farmer mode, a process that might be mediated by state officials, or by an NGO, or by a private body. However, the TNPFP followed a simpler and more direct mode, that of researcher-to-farmer. This is potentially one of its most important innovations and played an important part in TNPFP’s success. In terms of the organization, a Nodal Officer (appointed from TNAU) was overall in charge of the project, who in turn was further assisted by two project officers based at the district level. About 17 field scientists were based in the districts, reporting to the two project officers. The field scientists had regular contact with the farmers and provided direct assistance to the farmers and association in technical and farm management issues. Thus, the level of resources dedicated to the project in terms of manpower was considerable. The project has grown in profile over the years, primarily as a result of its effectiveness in transferring a package of technologies as well as in the demonstrable benefits that the

[7] The cost of fertigation equipment excluding the installation of laterals was estimated to be about Rs. 32,750. The installation of laterals was highly sensitive to the type of crop (perennial or annual) and whether the laterals were widely or closely spaced – it ranged from as little as Rs. 8,000 to as much as Rs. 67,000. The cultivation costs could range from Rs. 40,000 (perennial crops) to Rs. 50,000 (annual crops); based on estimates by DEE, TNAU in personal correspondence with the authors.

[8] This comprised of Rs. 40,000 towards cultivation expenses and Rs. 75,000 towards drip and fertigation equipment and installation, Vadivel (2006) p. 2.

participating farmers have experienced from a transition to hi-tech farm management.

3. What is travelling?

There were many different facts travelling within the TNPFP and for functional reasons we classify them into four types: technological facts which were embodied in physical objects, technical facts that reflected expert (i.e. scientific) advice, facts about claims which we term as experiential facts, and institutional facts.[9] Some facts were combinations of two or more of these. In terms of agency, we will differentiate between the expert knowledge of the TNAU scientist and the experiential knowledge of the farmers.[10] Finally, we will also differentiate the travelling process in terms of three spaces or domains: the core technology domain, the secondary technology domain, and the enabling institutions. These domains are overlapping and interactive. The *core technology domain* encompasses *fertigation technologies* that include the drip irrigation and fertigation equipment, WSF, and the fertigation schedule. The first two are technological facts (in economic terms one is a fixed cost and the other a variable cost) whilst the latter is a technical fact (it provides a procedural schedule that embodies the research and recommendation of the scientific experts). All three of these elements were non-negotiable, and monitored carefully by the scientists, in the first year that a farmer was part of the project. The financial subsidy ensured that the drip irrigation and fertigation equipment did travel and it is highly unlikely that a farmer would abandon this technology after the first year as, at a most basic level, it ensured a better delivery of water and fertiliser than had previously been possible. However, the other two elements can only be judged to have travelled successfully if farmers continued to use them after the first year. This, in turn, would be dependent on another element of the core technology

[9] For an example of physical objects as important vehicles and embodiments of travelling facts see Valeriani (2006).
[10] For a discussion of experiential knowledge see Epstein (2005, pp.3-4); for an Indian agricultural technology context see Foster and Rosenzweig (1995).

space – the claims made by the experts about what their use would deliver. Given the water and income constraints faced by the farmers, the two most important claims were that the precision farming technology would deliver significant water savings and significant improvements in income whilst other important claims were that it would deliver labour savings and lead to improved crop yield and health. The farmers would only believe these claims if their own experience of using the core technology matched the claims. In many ways, the experiential facts were the most important for the TNAU scientists – that precision farming could provide significant benefits in terms of water saving and income even for small scale farmers. TNAU wanted to ensure that *these* facts travelled widely across various audiences, not just to the participating farmers. They wanted the experience of the participating farmers to demonstrate to others that precision farming should be embraced. The *secondary technology domain* encompasses *other farm technologies* and expert advice provided by the scientists regarding such other cultivation and farm management techniques excluding fertigation. At times, some of the technology in this domain involved only technical facts travelling, for example crop spacing, much of it involved combinations of facts travelling. For example, the use of pesticides involved both the travelling of a technological fact (the technology embodied in the pesticide itself) and a technical fact (the advice the scientists gave to the farmer about how to use the pesticide). In this space the expert advice, whilst part of the TNPFP package, was offered as part of the general extension education effort and its implementation by farmers was not monitored by the scientists. Furthermore, whereas the core technology (especially the fertigation tank and WSF) was new to the farmers and therefore they were more likely to accept expert advice about this, the secondary technology was less of a black box. Farmers had many years of experience about crop spacing and crop protection and thus in this space the expert advice had to compete with the experiential knowledge of the farmers - the claims of the experts were likely to encounter more resistance in this space.

The enabling institutions space is less clear cut than the other two spaces but we believe that in terms of travelling facts it is important to discuss this as a separate entity – in particular we believe it can help to explain the 'wellness' or travel. This space encompasses the subsidy, post harvest management, and the farmer associations. It may be obvious that the financial subsidy was necessary for these relatively poor farmers to adopt the core technology, and hence it was a key enabler. But less obviously the most important fact travelling in this case was an institutional and experiential fact (as will be shown below) – would the subsidy be delivered? We have classified post harvest management as an enabling institution because the facts that TNAU were encouraging to travel in this instance were about the way modern commodity markets operated – if the farmer had a better understanding of these processes they would be able to exploit them more successfully and hence earn a better income. Even issues that in some sense represented technical facts (sorting and grading) were in fact institutional facts (the sorting and grading for example reflected the norms expected by modern terminal commodity markets or buyers). Finally, agreeing to belong to a farmer association was a pre-requisite of joining the project. The institutional fact that TNAU wanted to travel was that cooperation and coordination through the farmer association would bring significant benefits to the individual farmer. In the case of both post harvest management and farmer associations, expert knowledge would again be competing with experiential knowledge and hence the travelling facts would face obstacles.

4. Methodology

The main evidence for this study is derived from a series of in-depth interviews with a sample of 52 farmers, including both farmers who were in the TNPFP (beneficiary farmers) and some farmers who were not in the project (non-beneficiary farmers). The interviews were conducted between 16th and 21st August 2007 in the districts of Dharmapuri (21 farmers) and

Krishnagiri (31 farmers). Of the interviewees, 34 were beneficiary farmers and 18 were non-beneficiary farmers. Altogether 17 clusters were covered as shown in table 2.

Table 2.

Profile of Farmers Interviewed

Cluster	Beneficiary Farmer	Non-beneficiary Farmer		Total
		Applied for TNPFP but not selected	Did Not Apply for TNPFP	
Dharmapuri District				
Jarugu	3	1		4
Moolaiyanur	2	1		3
Morappur	1	1	1	3
Pallacode	2	1		3
Paperetipatti	2	1	1	4
Somanahalli	3	1		4
Krishnagiri District				
Baglur	2			2
Berigai	3		2	5
C R Palayam	2			2
Jakkeri	3	1	1	5
Kupatti	1			1
Mallasundaram			1	1
Royakottai	2		2	4
Sarakapalli	2			2
S Kurubatti	1	1	2	4
Thirichipalli	3			3
Thorapalli	2			2
Total *(nos.)*	**34**	**8**	**10**	**52**

The beneficiary farmers interviewed were spread over all the three years of joining, although the bulk of them were 2nd year farmers: 9 joined the TNPFP in the first year, 17 in the second year, and 8 in the third year. The non-beneficiary farmers included both those who had applied to part of the TNPFP but had been rejected (8 interviewees) and those who had not applied (10). The interviews were based on a set of common questions, however, the discussion was essentially free-flowing and conversational. All interviews were conducted by one of the authors, accompanied by a TNAU scientist who kindly acted as a translator. All interviews were one-on-one and essentially reflect the opinions of individual farmers, rather than a collective group. Data from the fieldwork are supplemented by additional information from published statistics and other primary sources such as harvest records maintained by the beneficiary farmers.

5. Prior knowledge about precision farming and TNPFP

The primary fact about precision farming (PF) technologies that TNAU sought to communicate was that its adoption would result in better and more consistent quality of produce and an overall increase in profit margins. However, before the benefits of PF could accrue, several deficits needed to be overcome: a knowledge deficit (how do farmers find out about precision farming and its benefits), a skills deficit (how do farmers learn how to apply precision farming techniques successfully), and a financial deficit (how do farmers raise the money necessary to buy the core technology?). Another particular and important aspect of the TNPFP was concerned with post-harvest and marketing issues and here the knowledge and skills deficit to be overcome related to farmers' knowledge about how value chains operated in respect to modern terminal markets and associated with that issues about marketing, branding, and the power of group negotiation with input suppliers and produce buyers.

Consequently, it is pertinent to understand how and to what extent farmers obtained facts about PF, what were the information sources. We

define this as prior knowledge i.e. knowledge about precision farming prior to its adoption. Altogether, there are two possibilities. Farmers were either aware of precision farming before they heard of TNPFP, or they heard of precision farming at the same time that they heard of TNPFP. In the latter case, a pertinent issue is whether they hear of TNPFP before contact with TNAU or Horticulture Department extension workers from other sources. These different possibilities constitute different types of prior knowledge – in essence, whether knowledge about precision farming travelled before contact from scientists/extension workers.

About one-third of the farmers interviewed had prior knowledge of precision farming before they heard about the TNPFP. Just over half of these gained their knowledge from existing demonstration schemes in other states. Newspapers and the television were another important source of knowledge for these farmers.[11] In our sample, there were also three farmers who were using drip irrigation before the arrival of the TNPFP. One of the latter was a farmer who grew mulberry and had heard about drip irrigation from the Silk Board. He had adopted drip irrigation (without the use of WSF) because of a subsidy provided by the Silk Board.

In addition to these farmers, if we also include farmers who heard about precision farming at the same time as they heard about TNPFP, then the proportion of farmers with prior knowledge in our sample increases from one-third to 75%.[12] All of these additional farmers gained their knowledge about precision farming from other farmers. Therefore, an overwhelming proportion of our sample had gained their knowledge about precision farming by observing demonstration schemes, including the TNPFP.[13] Demonstration schemes are predicated on the belief that if farmers actually see precision

[11] According to a 2003 national survey, 29.3% of farmer households in India accessed information on modern agricultural technology via media sources (Birner and Anderson 2007, p.7).
[12] This is a proportion of all the farmers interviewed i.e. those that were part of the TNPFP as well as those who were not.
[13] This seems to contradict the 2003 national survey which reported that only 2% of farmer households gained their knowledge about modern agricultural technology from government demonstration schemes, although another 16.7% gained their knowledge from 'other progressive farmers' and 5.7% from extension workers (Birner and Anderson 2007, p.7).

farming in operation and see the benefits it brings then they are more likely to adopt those techniques. Whilst the evidence that farmers independently adopted precision farming is very weak, there is support for the notion that the demonstration schemes help the fact that precision farming can be beneficial to travel to a wider community (see below) – the demonstration schemes may not have aided the travel of the technological or technical facts associated with precision farming but they did aid the travelling of the experiential facts, i.e. the benefit of precision farming.

How did farmers gain their knowledge about the TNPFP? Half of the 52 farmers interviewed gained their knowledge from existing beneficiary farmers[14] whilst more than a third first heard about the scheme at meetings organised by TNAU; only one farmer cited the Horticulture Department as their source of knowledge. There was, however, a significant difference between the beneficiary and non-beneficiary farmers in the sample: 16 of the 18 non-beneficiary farmers gained their knowledge about TNPFP from neighbours who were beneficiary farmers whilst half of the beneficiary farmers learnt about the project by attending a TNAU meeting.

What about the precision farming or TNPFP was travelling prior to contact or adoption? This could be gauged from the reasons given by farmers for adopting precision farming techniques. It was clear from the general tenor of the interviews that most, if not all, beneficiary farmers would not have joined the project without the generous subsidy. This is discussed in some detail in a following section. The important issue here is that the fact that precision farming techniques from TNAU came bundled with a generous subsidy was an important fact that reached the farmers. Two-thirds of the beneficiary farmers also explicitly mentioned other factors that influenced their reason to join the TNPFP and by far the most important of these were water saving (mentioned by 16 farmers) and labour saving (11 farmers). Other reasons cited included increased yield or crop growth (six farmers), using advanced or hi-tech technology (2 farmers), and the fact that the

[14] On the importance of social learning more generally see Munshi (2004).

technology seemed to be convenient and easy to use. One farmer said that it would allow him to watch television whilst it irrigated! In terms of successful travelling this latter reason should not be under-estimated. We observe that simple facts will find it easier to travel in this sort of environment than more complex facts, although with the fertigation tanks it probably needed an expert to explain just how easy the technology was to operate to allow ease of travel.

6. Core technology space and adoption of fertigation techniques

In trying to assess the extent to which beneficiary farmers adopted, or adapted, the core drip irrigation and fertigation technology interviews with farmers was supplemented by inspection of detailed farm records. These were records that were kept by the TNPFP office and which contained detailed information for the first year of the operation of any beneficiary farmer; unfortunately detailed records were not maintained after a farmer had completed one year in the scheme. As far as the core technology is concerned, inspection of these farm records suggests that in the first year of participation the beneficiary farmers closely followed the fertigation schedule recommended by the TNAU scientists, although of course they cannot tell us what happened in subsequent years. For subsequent years we have to rely on the sample interviews. In the interviews all but two of the beneficiary farmers claimed that they continued to apply the core technology, following the schedule as recommended by the scientists, without any deviation. However, the technology was not static as the TNAU scientists themselves made some changes based on their increased experience of the region. Overall, therefore there does not appear to be any significant deviation by the farmers to the TNAU recommendations of the core technology.

The only exception to this case was a farmer who was also the secretary of the local farmers association. He claimed to have made ‘mini changes’ to the fertigation schedule according to the nutrient content of the soil. He had had his land tested for soil quality and based upon his

experience and judgement he would adjust the amount of fertilizer that he applied to various parts of his land. The changes to the fertigation schedule recommended by TNAU were quite minor according to him. Another farmer claimed that he used both soluble and non-soluble fertiliser to save on cost (water soluble fertiliser, which is recommended, is more expensive). He said that this was his own idea and that he had not discussed it with university scientists. He also claimed that he had discussed with some other farmers and that some of them were also following this method. If this was true then in terms of the use of water soluble fertilisers the deviation from the core technology may be more widespread than the interviews implied. However, evidence from other interviews contradicted these claims. Other farmers stated that although WSF were more expensive, following the fertigation schedule meant that they used *less* fertiliser than previously and that the result was that their overall fertiliser costs had declined. One of the major reasons why there was little or no deviation in the fertigation practices in the first year a farmer was part of the TNPFP appears to be the fact that TNAU scientists would be present during the mixing of water soluble fertilizers. This ensured that the correct dose was applied during fertigation, which also had a demonstration effect on the beneficiary farmers who could observe and learn the proper methods of mixing and applying the water soluble fertilizers.

An important aspect for the successful travelling of the core technology was that in the first year of being in the project, farmers could see that it delivered on the claims made by the scientists. Almost all the farmers interviewed reported a significant labour and water savings as a result of adopting precision farming techniques. Often, this was cited as one of the most important aspects or benefit of precision farming technology. Although the extent of labour and water saved on individual farms was not assessed quantitatively most farmers agreed that they were using at least half of both water and labour than previously. These savings are manifested not only in the reduced quantum of labour or water used, but also the reduced effort applied for irrigation, weeding and other soil preparation activities. In terms of

labour savings one farmer stated that ‘a single labourer, who could previously only work on three acres, can now work on eight acres’ and another farmer said that he was able to reduce the number of labourers that he had to employ from fifty to twenty five. Yet another claimed that he could irrigate his crops himself and did not require any additional labour whilst others cited the labour savings either in monetary terms (‘120 rupees per day’; ‘10,000 rupees per crop’) or percentage terms (ranging from 50% to 80%). Reasons given for labour saving effects were fairly unanimous: drip irrigation reduced labour needs both for irrigation itself and for weeding whilst the more porous soil engendered by drip irrigation made it easier to work and to plough, again reducing labour needs. Similar savings were experienced in the case of water requirements: ‘for the same amount of water I needed previously to irrigate 1 acre, I can now irrigate 3 acres’. The signals on fertiliser costs were mixed: as mentioned above, some farmers had taken steps to reduce the costs associated with using the recommended water soluble fertilisers but several farmers said that although water soluble fertilisers were more expensive the fertigation system meant that they used less fertiliser than previously and that the result was that overall their fertiliser costs had declined. Another aspect of the core technology that impressed several farmers was its impact on soil aeration: this was put best by a farmer from Moolayinur who explained how older methods, such as channel and flood irrigation, left the soil hard while fertigation left the soil loose which in turn promoted growth through better root condition and better yield.

In terms of the impact of precision farming on yield the quantitative evidence that is available is unambiguous: precision farming increased output obtained by the farmers by several fold and the average yield obtained by the beneficiary farmers was also several times that of the national average.[15] For example a preliminary study of nine of the crops grown by samples of TNPFP farmers (tomato, brinjal, banana, chilli, bhendi,

[15] The sample of farmers used varied by crop and these samples are not the same as the interview samples. We do not report the data in detail here but it is available upon request.

watermelon, muskmelon, cassava and cabbage) showed that, apart from cassava, all crops yielded multiple harvests which implied a lengthened crop duration and increased harvest period using precision farming techniques. In addition to the increased harvest period, the average tonnage obtained in one season was also considerable: for example, the average TNPFP yield for tomato, brinjal and banana were at least 3 to 12 times higher than the national average. Such findings were corroborated through conversations with individual farmers, the majority of whom were willing to testify to the positive impact that precision farming had upon the yield and quality of their crop and the income they derived from this. Some of the increases reported by individual farmers were more modest than some of the numbers reported above but were still significant. The smallest increase reported in the interviews was a 20% increase in yield. Other relatively low increases reported included: a cabbage farmer who said that he had 1 hectare under precision farming and 1 hectare using non-precision farming techniques and that the precision farming land gets 50% more output; a farmer who grew a mixture of cabbage, cauliflower and tomato and who said that he got 35 tons per acre with drip irrigation compared to 15-20 tons without drip irrigation. Generally, however, the reported increases (for a greater proportion of the beneficiary farmers interviewed) were much higher.

Apart from yield, the quality and consistency of produce obtained was also reported to be high. For example, one farmer claimed that his tomatoes had ‘good personality and were very attractive’, another said he now produced ‘shiny tomatoes’, whilst a cabbage farmer reported that the average size of cabbage produced had increased from 2.5kg to 3.5kg. Consistency was seen to be linked directly with fertigation: one farmer reported that due to fertigation the ‘quality and size of the product was maintained, and there was uniformity in yield.’ This farmer also compared the results of the precision farming techniques to older methods: he said that for tomato, in precision farming, every 4-5 days there is equal application of fertilizers, leading to even growth through the life of the crop; he also claimed

that this resulted in an extended shelf life of the product, ‘sometimes up to 15 days, where ordinary products would be 4-5 days.’ One result of better quality was that farmers received a better price. Examples quoted by different farmers included: Rs. 20/- extra per crate of tomato for same weight/volume; about Rs. 5/- more per kg on tomato due to improved quality and the sugarcane crop similarly received about twice the income compared to earlier periods; non- precision farming received 180/crate whereas precision farming produce received 200-210/crate (this is for same crop + hybrids). Consistency also had a price benefit: according to one farmer (15) the uniformity of water and fertiliser delivery meant that even on the last harvest he received the same price, whereas previously later harvests would get a lower price. Perhaps the excitement that precision farming has given farmers is best captured by the farmer who told us that before he adopted precision farming he found it difficult to sell but now buyers fight among themselves to get his product!

The impact of savings on inputs, higher yields, better and more consistent quality was that the income of the beneficiary farmers increased, often quite considerably so. The impact on income is captured by the following comments from farmers: ‘income has doubled’; ‘for cabbage I get twice as much income as before’; ‘before I was earning Rs. 1 lakh but now I am earning 2-3 lakhs’; ‘from the first precision farming crop on 1.25 acres I made 3.5 lakhs, which was 80,000 rupees more than I made before precision farming, and my precision farming expenses are 20% less than previous farming techniques’.[16] In some cases the impact on the life of the farmer and his family has been extraordinary: one farmer told us that before being part of the TNPFP he was finding it difficult to educate his children but now because of his increased income he can now fund them at college and his son is studying for an MBA in Indiana, USA.

On the whole, the interviews suggest that the farmers had a strong incentive not to stray from the fertigation techniques recommended by TNAU

[16] Rs 1 lakh = Rs. 100,000

as the improvements in yield and market value were directly attributable to the precision farming practices and fertigation. This vindication of claims made by the scientists ensured that the farmers believed in the science behind the project and in turn enhanced the reputations of the scientists and TNAU generally. This can be illustrated with statements from two farmers. The first farmer stated that when the project ended he wanted the '[university] people to continue to stay with us' as new diseases and pests would be encountered and he also said that 'we will find it difficult if the university people leave us [because] department people [i.e. state extension education officials] do not give such good advice compared to university people.' The second farmer illustrated the importance of the overall package provided by TNAU when he stated that 'from sowing to market, the university guided me.'

The experiential facts therefore helped in the travel of other technological and technical facts associated with the core fertigation technology. The importance of expert claims being transformed into experiential facts and knowledge for the beneficiary farmers was important for the success of the project. One way that this can be seen is in the increase in the number of applications to join the project over its lifetime. Table 1 shows that the number of applications received for participation in the project improved considerably after the first year of operation, suggesting a general increasing interest in the precision farming technologies after the perceived success of the first year beneficiary farmers. Furthermore, there was also a significant increase in the ratio of applicants to available places after the first year of operation – this was true of each district separately and overall.

Overall, therefore, as far as the core technology of drip irrigation and fertigation is concerned, it appeared that the beneficiary farmers adopted these without making any modification, or if any then making only minor adjustments. There was no case of any of the farmers abandoning the fertigation technology from the sample of farmers, nor did we hear of any

such case during our conversations with both beneficiary farmers and non-beneficiary farmers.

7. Secondary space and adoption of other farm technologies

Our initial assumption was that because the secondary technologies operated in a space in which scientific expert knowledge had to compete with practitioners experiential knowledge there would be more resistance to facts travelling and this was what was found. The farmers were keen to experiment and innovate with the *associated* technologies. For instance, several farmers mentioned that they experimented with the spacing between the crops to ascertain the 'optimal' distance and crop density. This was a deviation from the 'standard' distance recommended by the scientists for each crop. This was often done without consultation with the TNAU scientists. For instance, a farmer from the Somanhalli cluster experimented with 6ft and 3ft spacing for sugarcane instead following the 5ft recommended by TNAU. He told us that he discovered that 3ft was a more optimal distance than 5ft. for sugarcane. Similarly a farmer from Paperetipatti thought that the spacing for his banana should be 4 ft instead of recommended 5 ft. In this manner, he could use a single row system rather than the double row system and consequently was thinking of changing the existing system. He told us that he heard about this when some farmers in Krishnagiri district made this modification. Another example of deviation was provided the farmer who wanted to extend the 'trailing' system he was using for tomatoes to bitter gourd after consultation with two other farmers both following precision farming techniques. On the other hand, we had testimony from another beneficiary farmer who had extended precision farming techniques to land he owned which was not in the project and on this land he had changed the spacing from the 5 feet recommended by TNAU to 4 feet (his own idea) but although he thought 4 feet spacing would give more yield this was not the case – his experience was that 5 feet spacing gave more yield than 4 feet

spacing. He also told us that before adopting precision farming techniques, when he had used flood irrigation, he used 1 feet spacing.

Thus, beneficiary farmers were far more willing to deviate from the recommendations of the TNAU scientist when it came to the associated technologies than they were with the core technologies. As far as the associated technologies were concerned, the farmers did use their initiative and introduced changes that they felt were either necessary to their particular situation or improved it. Despite what farmers said we cannot be certain that the changes they made, or the advice they ignored, did lead to a more optimal outcome but this is perhaps not the important aspect of what happened in the secondary technology space. Given the strong control of the experts of the core technology space it was perhaps important that the project included another space in which the farmers could exercise their own judgement, a space where their expertise was allowed the same, if not more, validity as that of the scientists.

8. The Enabling Institutions Space

In discussing the enabling institutions it is worth noting that the mode of delivery in this project was relatively unusual for state sponsored projects in India. Most modes of technology transfer in India follow the researcher to development officials to farmer mode, a three-step process that might be mediated by state officials, or by an NGO, or by a private body. However, the TNPFP followed a simpler and more direct mode, that of researcher-to-farmer. This reduced the chance for error in the transmission of facts or knowledge as it ensured that scientist talked directly to farmers; it also ensured that scientists could quickly respond to queries from farmers and helped to foster a cooperative dialogue in that farmers felt that their concerns and input were relevant to the project.[17] Such a close relationship obviously

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[17] In listening to farmers, and taking their local knowledge seriously, the attitude of the TNAU scientists was a marked improvement on what Barabara Harriss (1977) had observed had observed in North Arcot, another Tamil Nadu district, more than three decades before. See, also, Bonny *et al* (2005).

has high costs for the scientist but it is potentially one of its most important innovations of the TNPFP and undoubtedly played an important part in its success.

It was mentioned before that many farmers had prior knowledge of precision farming techniques from observing other demonstration schemes but this raises the question of why these farmers did not adopt precision farming. Overwhelmingly, the reason was a lack of finance – they may have felt that the precision farming techniques demonstrated by the Andhra Pradesh or Maharashtra schemes were good but they could not afford to buy the drip irrigation system or the fertigation tank. Even the farmer who had received a subsidy from the Silk Board to put some of his land under drip irrigation, could not afford to extend it to the rest of his land. Interestingly, given the discussion above about the important role played by TNAU scientists in the project, four farmers who had seen a similar scheme in Andhra Pradesh also mentioned concerns about a knowledge deficit: although they had seen the scheme they felt that they lacked the necessary knowledge to implement precision farming on their own – they felt more detailed technical facts needed to travel and that would require expert guidance. Two of the farmers also explicitly cited concerns about quality. One farmer said that government schemes that existed prior to the TNPFP provided poor quality equipment and did not provide proper training or support. The state officials would 'say something, bring something else' and would not provide full support during implementation. He was also concerned that under these previous schemes he would not get the full subsidy, that the officials would 'take their share'. The subsidy issue also came up in another interview. This other farmer mentioned that the university had held a meeting in his village to explain the benefits of their scheme prior to its start but whilst most farmers at the meeting accepted the claims of the university staff about these benefits many of the farmers at the meeting were unwilling to join the

project because they did not believe that the subsidy would reach them.[18] Thus, the delivery of the subsidy in effect became another claim by the scientists, a fact that could only properly travel to the wider community once it had actually been experienced by beneficiary farmers in the first stage of the project. Once this experiential fact did travel farmers, as the evidence from table 1 demonstrated, were more willing to apply to join the project.

We have also included as an enabling institution help provided through the TNPFP to farmers with the management of post-harvest and marketing issues. This aspect included improvements made in the techniques used to prepare and transport produce to commodity markets or directly to buyers. Precision farming techniques improved, or in many cases introduced, a system of sorting harvest into quality grades using fairly simple methods. One of the most effective was the sorting of produce into crates indicating different quality grades. Sorting helped in easy identification of grades and helped to obtain better prices for produce. Thus, through the TNPFP beneficiary farmers either learnt about or improved their existing knowledge about both the broad institutional aspect of modern commodity markets and the benefits they could achieve by following some of the rules (such as sorting and grading according to set standards) of such markets.

Evidence that facts traveled well in this space comes from changes in the marketing practices of the beneficiary farmers. Interviews with terminal market operators suggest that precision farms were beginning to establish a marketing network, were gaining a recognition in the market, and that they could access various markets, beyond their local markets.[19] This, coupled with improved post-harvest practices such as transport of produce in crates, or improved packing practices, meant that beneficiary farmers could decide on the best markets to sell. Another example is the efforts to create a brand

[18] For a discussion of the weaknesses of the traditional extension education system, including its vulnerability to corruption see Chambers and Wickremanayake (1977, pp160-3) and Birner and Anderson (2007, pp14-16).

[19] This information is based upon an interview conducted with a senior executive of the SAFAL Market, a commodity exchange and terminal market for horticulture crops located in Bangalore, India.

name for the products grown under the TNPFP. The idea is that precision farming products are now been branded which will help with market recognition: 'the brand name helps buyers to identify the source of the product and therefore that it is of better quality (because they are associated with precision farming techniques) and this helps with price.'

As an enabling space, farmers associations appear to perform two vital roles in the dissemination and success of precision farming technology. They serve as nodes for exchanging knowledge and information and they help farmers obtain better value for produce as well as inputs. Although, the extension model used in the TNPFP relies upon direct scientist-farmer interaction to transfer key precision farming technologies, the associations perform a vital support function as information nodes. According to the president of the Moliyanur Precision Farmers Association they hold regular monthly meetings to discuss marketing and other issues on the 2nd day of every month. Regular meetings such as these help beneficiary farmers to raise, clarify and solve cultivation, marketing and farm management issues. Often TNAU scientists attend these meetings and are able to offer expert advice, but even in their absence local issues are raised and resolved multi-laterally. Many association meetings are also attended by non-beneficiary farmers, which not only raises the profile of the TNPFP, but substitutes for the lack of direct scientist-farmer interactions in this case. The associations act as vehicles to disseminate both knowledge and information about the techniques and the impact that they have on cultivation and post-harvest results. They appear to help reduce the knowledge and information deficit.[20]

Several farmers felt that the associations could help farmers to get either bank loans or government subsides. According to one farmer, the associations 'meet government officials to keep track of subsidies or schemes' and then pass this information on to their members. They also 'pass on this information to non-beneficiary farmers, including information

[20] One farmer felt he did not need the associations. Although he did discuss issues with members of his association, he felt most of his learning was 'from his own fields'. This view was unusual, and most of the farmers we talked to viewed the associations positively.

about new technology.' Yet another farmer felt that associations were very helpful in disseminating information about the use of technology. For example, he was better informed about plant protection measures through the associations. Another farmer felt that the benefit of association was the regular meetings 'on how to improve individual farms, use technology, and discuss marketing.' A non-beneficiary farmer who attended local association meetings, said that he learnt a lot about precision farming methods in these meetings. He said that he 'got to know how the drip irrigation system can save water' through regular interactions with precision farmers at such meetings. He further said that the farmer meetings and discussions 'have taught [me] about plant protection measures, what chemicals to use and how much to spray'. Thus, when 'representatives of pesticide companies visited me, I was able to make up my own mind about what is [good] for my crops.' Another non-beneficiary farmer claimed that he continues to receive 'new knowledge' through association meetings and field visits to precision farms.

The associations also seem to help the farmers obtain better value by improving their negotiating position vis-à-vis buyers or input providers: they 'bring unity among farmers will give them better bargaining power'. Organized markets increasingly prefer to deal with farmer associations as it helps to eliminate risks of delivery failure while providing a greater assurance of quality. This is also beneficial to the farmers as it helps them to secure better value by costing out delivery failures and in-transit damage to produce out of the revenue. By assuring minimum quality through proper grading and sorting, associations help farmers obtain better average prices than comparable produce sold without the association's involvement. The associations also help the farmers in many other ways: to negotiate better prices for inputs such as fertilizers, pesticides, seeds, etc. by guaranteeing minimum quantity; to negotiate for or arranging *timely* supply of inputs; and by helping to pool together resources to transport produce to the market, saving time and effort, and guaranteeing delivery.

The marketing aspects of the farmer associations have also been appreciated. One farmer said that the role of the association was vital in facilitating in the marketing of the produce. Another said the several precision farmers from his cluster would collectively send about 40-50 crates of produce each to the market. Such practices, according to yet another farmer, meant that it led to ‘sharing cost of transportation between farmers and saving of time for all.’ A fourth farmer claimed that the associations really do help the farmers collectively in both marketing, as well as ‘approaching the government as it is difficult to do this individually: we get better benefits if we go through he associations’. He also explained how large buyers approach the associations with large volume requirements, which then coordinates how the fulfilment is met. In another related development, all 200 Dharmapuri beneficiary farmers formed a private limited company, Dharmapuri Precision Farmers Agro Services Limited (DPFAS). It was formed as the result of regular meetings between farmers associations and encouragement from TNAU . DPFAS represents a significant institutional development as it acts as the distributor or dealer for several agri-product corporations and sells input materials such as seeds, fertilizers, plant protection materials, and other agriculture inputs. The products sold are of better quality and at cheaper rates. Furthermore, it has become a dealer for Jain Irrigation Systems Ltd, the supplier of the fertigation tanks and drip irrigation equipment used in the TNPFP, and in an intriguing twist has begun selling fertigation equipment to all farmers.

TNAU had made the formation of associations a pre-condition for the receipt of precision farming technology. Most of the associations that has been formed were working smoothly although in the Krishnagiri district, where they were proximal to a large market in Bangalore, the significance of the associations appeared to be less. Whilst his aspect needs to be studied further, on the whole, there is sufficient evidence to suggest that the associations were vital in the successful transfer of precision farming

techniques to the beneficiary farmers, as well as beyond to the non-beneficiary farmers.

9. Travelling beyond the project

One way to judge whether the facts about precision farming travelled successfully is the extent to which such techniques travelled beyond the TNPFP. We will consider this from two aspects: first, whether or not the beneficiary farmers extended precision farming techniques to their non-TNPFP land; second, did non-beneficiary farmers adopt precision farming?

Among our sample of beneficiary farmers more than half had already extended or were in the process of extending precision farming techniques to their non-TNPFP land. This extension was done at their own cost even where it involved buying another fertigation tank. Indeed, at least three of the farmers had or were about to convert all their land to precision farming, while another farmer said that he intended to purchase 4 more acres and planned to use drip irrigation to growing roses and vegetables on it. The largest extension mentioned was that of a farmer from Thirichipalli who said that he and some other farmers had bought equipment that would allow them to extend precision farming to another 20 acres. A related measure of the success of the TNPFP is whether the beneficiary farmers would continue with precision farming after the project, and hence after the subsidy and TNAU support, ended? Overwhelmingly the beneficiary farmers responded that they would continue because of the impressive benefits precision farming delivered. Of course, we do not know how many have followed through but, for example, the creation of the DPFAS to help and promote the interests of the 200 Dharmapuri beneficiary farmers at the very least is a support and commitment mechanism that suggests precision farming in the district will be a long term phenomenon.

The impact of the TNPFP as a demonstration project was also noticeable in terms of the extent to which the precision farming technologies travelled beyond the beneficiary farmers. In the survey conducted, it became

evident that several non-beneficiary farmers had adopted some of the precision farming techniques. This was primarily due to their interaction with beneficiary farmers, which confirms the signalling effect that these demonstration farms have had on the larger farming community in the region. Although the TNPFP was set-up as a demonstration project TNAU did not collect any information on whether their precision farming techniques did travel beyond the beneficiary farmers and so our knowledge about such travelling is based primarily on our interviews and to that extent may be subject to selection biases.

The discussion of the farmer associations above has already shown that facts were travelling from the beneficiary farmers, and the scientists, to non-beneficiary farmers through that particular node – and the reason why non-beneficiary farmers were responding positively in this situation was because they could see the benefits of the TNPFP. We also asked two-thirds of the beneficiary farmers if their neighbours talked to them about precision farming: all but one said that this was indeed the case. For example, one farmer claimed that he had received many visitors and that his field has become an ‘exhibition plot’, and that several visitors have started growing the same hybrid bananas that he does. Similarly, another farmer claimed that he had ‘plenty of visitors’ and that most of them were generally aware of the TNPFP. He claimed that ‘after seeing [his] results, they regretted not having applied for the scheme.’ This suggests that the ‘local’ aspect of the demonstration was having the desired impact – indeed, as noted above, this aspect of travelling in the project helped overcome the initial reluctance of some farmers about applying to join the scheme and helped with the greater take-up in years 2 and 3.

The interest in precision farming did not mean, however, that non-beneficiary farmers were willing, or able, to adopt precision farming without a subsidy. When beneficiary farmers were asked if the people who had come to talk to them about precision farming had adopted such techniques outside the scheme the general response was that they had not because of their

financial circumstances – they needed the subsidy.[21] Given the significant financial returns generated by precision farming this suggests a very conservative attitude to risk either by farmers or by those who could extend credit to them.[22] One beneficiary farmer suggested that there was an overall reluctance to adopt precision farming because ‘people in this area are not well educated and are very tied to traditional crops and methods’. Nevertheless, there were some cases reported where such a conservative attitude was overcome. One farmer reported that ‘some people with 50% subsidy have adopted precision farming although they have only adopted drip irrigation and not water soluble fertilisers.’ According to another, in a statement loaded with both precision and vagueness, that ‘just 5% of people outside [the TNPFP] scheme have adopted precision farming’. The most impressive example of travelling related by our beneficiary farmers did not relate to the core technology. A floriculturist told us that he tried the ‘open system’ of Dutch rose cultivation on advice on university staff and that as a result of its impressive impact on his yield and income, 50 farmers in his area (only 5 of whom are in the TNPFP) abandoned their traditional system of cultivation and had adopted the open system.

Officially eight of the non-beneficiary farmers interviewed had applied to join the TNPFP and been rejected, while one other had been rejected when applying in the name of his father. When asked why they did not apply to join the TNPFP, of the remaining eight non-beneficiary farmers who gave comprehensible answers, three had not heard about the project until quite recently, one was waiting to see how his brother (a beneficiary farmer) did, and the remaining four had wanted to join but were prevented from doing so, each for a different reason (lack of adequate water or electricity or land or, in one case, incapacitation - he was in hospital). We then asked them if, having

[21] Access to credit is well-known to be a major problem facing many small-scale farmers in India. See, for example, J. Harriss (1977) and Binswanger *et al* (1993).
[22] The reasons for slow adoption, and the role of risk and uncertainty, has been noted by, among others, classic articles by Ryan and Goss (1943) and Griliches (1957); for a Tamil Nadu perspective see B. Harriss (1977).

seen the benefits of drip irrigation, they would invest in this technology.[23] One farmer stated that he had already done so whilst three others said they probably, or possibly, would do so using their own money or by getting a loan. The TNPFP has now ended but the state planned to introduce a new scheme based on this in 2008/9; the level of subsidy offered in this case was to be only 50%. The farmers were aware of this new scheme and three of our non-beneficiary interviewees said they would adopt drip irrigation only if they were successful in their application to the new scheme. Finally, only two of the farmers said they were unlikely to adopt drip irrigation despite now understanding the benefits it could provide; they said they were constrained by either basic water supply problems or finance problems. Although claims that non-beneficiary had adopted the core technology cannot be easily verified, the increased sale of fertigation equipment to non-beneficiary farmers in Dharmapuri district can be considered as direct evidence of the impact of precision farming on the larger community. One of the DPFAS members claimed that as distributors of Jain Irrigation in Dharmapuri, DPFAS had supplied fertigation equipment to about 82 farmers without any subsidy involved in the eight months beginning January 2007. During the same period, about 50 beneficiary farmers of the PFP were supplied with fertigation equipment to extend the existing area under fertigation.[24]

Nevertheless, the adoption of the core technologies - fertigation and drip irrigation - by the non-beneficiary farmers has been limited, whereas the adoption of the secondary technologies – hybrid seeds, plant protection measures, field preparation methods, etc. - has been comparatively greater.[25] However, all non-beneficiary farmers felt that the benefits that they had gained were at best marginal and most felt that in order to gain the full benefits enjoyed by the beneficiary farmers they would have to adopt the

[23] The answer by one farmer to this question was very confused and so has been ignored here.
[24] We have been unable to verify these figures with the equipment supplier.
[25] Given that the core technology represents the main fixed cost part of the TNPFP package this would seem to confirm the conclusion of Feder and O'Mara (1981, p.73): 'risk aversion can be argued to be a deterrent to innovation adoption by small farmers only to the extent that adoption entails fixed costs.'

core technologies. Interestingly, half of the non-beneficiary farmers told us that they attended the regular meetings held by the precision farmers and that from these meetings they learnt valuable information about a range of issues.

Incidentally, we were also able to assess the extent of travel of TNPFP facts beyond the farming community *per se*. According to a senior executive of a terminal market, when precision farming products were displayed for auction, 'buyers were keen to grab these products first.' He further stressed the importance of marketing through farmers associations, similar to the marketing practices of some of the TNPFP associations. According to him, buyers preferred to contract with such farmers associations because 'getting large volumes is not a problem, the supply could be consistent and continuous, products are traceable as they are very sure of the source (which is very important today), and associations which can give provide high and consistent quality are very few in number.' He further stressed that there was a noticeable difference in the way precision farms were managing their supply chain compared to other farms.

Facts about precision farming have also traveled into the policy and development domains. Reporting on the TNPFP, a member of the State Planning Commission, India, remarked that

> the time has come for switching from the past conventional production approach to a new dynamics of technology and market driven agricultural production. The underlying assumption, perhaps, is that production and productivity should be adequately taken care of by the new technology to be released for adoption while the incentive of increment in incomes [is] to be ensured through reorganisation of the whole range of marketing facilitates and better realization of prices for farmers.[26]

Thus, the core message that TNAU was attempting to convey – that precision farming would result in better and more consistent quality of produce and an overall increase in profit margins – did travel across to the

[26] G. Chidambran, 'Tamil Nadu Precision Farming Project: An Assessment', June 2007. This is a report prepared by a member of the State Planning Commission, Government of Tamil Nadu, India

policy space. Building on the success of TNPFP project the precision farming protocol was scaled up to cover 12,800 hectares throughout the state (TNPFP2).[27] However, there are two significant differences between the two projects. Firstly, TNPFP2 is being implemented by three agencies: Tamil Nadu Agricultural University (TNAU), the Commissionerate of Horticulture and the Directorate of Agriculture. Second, the level of subsidy is lower, 50%. Thus, the core facts about the likely impact of precision farming seemed to have travelled well into this space. However, the institutional facts – the level of financial assistance required, and the most effective mode of agricultural extension – appears not to have travelled well. Regardless, a detailed study of TNPFP2 is necessary to verify if this is indeed the case.

10. Conclusions

Our aim has been to assess not only how facts travelled but the wellness of their travel with respect to the technology transfer scheme that was the TNPFP. Within the core technology space the physical technology of drip irrigation and fertigation tank, which were new to most farmers in the scheme, travelled extremely well to the beneficiary farmers. We came across no evidence or statement, from either beneficiary or non-beneficiary farmers, of a farmer abandoning the drip irrigation and fertigation tank. The reason for this was not however the technology itself or the facts embodied in it, the reason was money. In this case the subsidy ensured successful travel. Indeed, it seems subsidy was a necessary condition of travel: there was a lot of prior knowledge about the benefits of precision farming but farmers were still unwilling or unable to invest in drip irrigation and/or fertigation tanks. This is underscored by the evidence from non-beneficiary farmers, most of who were convinced that the technology worked due to the success of the TNPFP. They adopted some of the secondary technologies, but were largely unable to make the initial investment required to install the fertigation system. In this instance, it would seem that economic facts trumped scientific facts.

[27] This is a significant increase from the 400 hectares covered by TNPFP

The WSF and the fertigation schedule were both new in the experience of the farmers but both again travelled very well to beneficiary farmers. One of the major reasons for adherence of farmers to the fertigation schedule in the first year a farmer was part of the TNPFP appears to be the fact that TNAU scientists would be present during the mixing of WSF. This ensured that the correct dose was applied during fertigation, which also had a demonstration effect on the beneficiary farmers who could observe and learn the proper methods of mixing and applying the WSF, thus improving their experiential knowledge. In subsequent years, the farmer had a strong incentive not to stray from the fertigation schedule as the improvements in yield and market value in the first year of precision farming were directly attributable to the precision farming practices and fertigation. The apparent success in productivity and value improvements acted as strong motivators to maintain the schedules recommended by the scientists. Thus, in the first year the facts associated with WSF and the fertigation schedule travelled well because of expert supervision and monitoring but thereafter it was because the farmers accrued experiential facts that supported the expert claims and thus led them to believe in the core package. In terms of the non-beneficiary farmers, it seems that these experiential facts, as testified by the beneficiary farmers, did travel extensively but it seems that financial considerations again meant that very few adopted WSF. As to the fertigation schedules their travel beyond the beneficiary farmers is uncertain.

The secondary technology space encompassed many traditional concerns of extension education in India. As such many of the technologies in this space were, at least at a general level, familiar to both beneficiary and non-beneficiary farmers or dealt with issues, such as crop spacing, where farmers felt they had a lot of experiential knowledge. Thus, whilst these technologies did travel they did so with deviations. It could be argued that the dichotomy in the project between the core technology space and the secondary technology space was, either by design or accident, an important aspect of the project design that helped the fertigation technology to travel. In

the core technology space, particularly in the crucial first year, the farmer had to follow what the scientists said. It is unlikely that any technology transfer project is going to be successful if it relies on the recipients giving up all independent thought or action in order to unquestioningly follow what outside experts tell them to do. However, in the TNPFP the farmer was allowed to exercise their own independence in the secondary technology space and this almost certainly made it easier for them to accept the control of the fertigation technology by the scientists. It should also be noted that even within the core technology space the scientists made great efforts to present the implementation process as a co-operative one. In this regard the 17 field scientists were crucial: they developed strong relationships on the ground with the individual farmers both explaining every aspect of the technology and its implementation carefully and listening to what farmers had to say and at times making adjustments to the implementation process on the basis of what the farmers told them.

Finally, many of the issues related to post harvest management were new to the beneficiary farmers and the farmer associations were, from their perspective, also an innovation. The post harvest management techniques appear to have travelled well to the beneficiary farmers, although it is less clear that they travelled to non-beneficiary farmers. It appears that facts about post harvest management travelled relatively well within the project because the other technological, scientific and experiential facts had already travelled well. This made beneficiary farmers more willing to accept claims by scientists that embracing the post harvest techniques would lead to a better market value of their produce. Being a part of a farmer association was one of the pre-conditions for a farmer being accepted into the project. The farmer associations have been both an important node for fact and knowledge transmission, embracing non-beneficiary farmers as well as beneficiary farmers, and a mechanism for improving the economic bargaining position of farmers. However, it is clear that this particular institution, and the facts it embodied, travelled better in Dharmapuri than in Krishnagiri; what is less

clear is why this was so. The success of the farmer association in Dharmapuri cannot be under-estimated and the local associations have been joined by a new and significant institutional development, the DPF Agro Services. This re-enforces the commitment mechanisms for the precision farmers but more importantly has gone beyond what was envisaged by the project when it was first set up. In a similar vein, the development of a dedicated Precision Farmers brand demonstrates how successful the project has been in ensuring that facts about how modern commodity markets operate has travelled to the beneficiary farmers. Ultimately, whilst the TNPFP at one level was a technology transfer project, and did succeed in allowing important technological and technical facts to travel, perhaps in the longer term the most important facts it facilitated the travel of were those which have allowed farmers to more willingly embrace modern science in farming and modern markets and marketing.

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