Towards a sustainable sugarcane industry in India

Mid-term results of the Solidaridad programme: Increasing water use efficiency in sugarcane growing in India through adoption of improved practices and technologies

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Preface

This mid-term report concerning the programme 'Increasing water use efficiency in sugarcane growing in India', of Solidaridad and its partners, provides detailed insight into the socio-economic conditions of sugarcane producers. These producers are located in the command areas (25,000 ha) of three sugar mills in the southern states of Karnataka and Telangana which are implementing the programme in collaboration with the Vasantdada sugar Institute, Osmania University and eLEAF (Wageningen).

The sugarcane industry is India's second-largest agro-based industry and about 6 million farmers and a large number of agricultural labourers are involved in its cultivation. Sugarcane is a major consumer of water and the decreasing level of the natural groundwater resource threatens food security, economic growth and livelihoods. With support from the Sustainable Water Fund (FDW), the project intends to enhance both sustainability of sugarcane growing and to raise smallholder incomes. Major activities include training on good agricultural practices (e.g. water conserving practices), introduction to improved irrigation systems (e.g. drip irrigation instead of furrow irrigation), and farmer trainings on entrepreneurship and financial literacy.

This mid-term study follows the baseline conducted in 2016 to enable the subsequent evaluation of the socio-economic impact on sugarcane farmers of the Solidaridad field programme. The mid-term evaluation conducted on 798 farmers contained a broad range of data on personal, household, farm, production and income characteristics. The key findings in this report are compared with the 2016 situation and reveal the level of progress towards the final objectives, the challenges faced and suggest some focus areas for the remainder of the project period. The end-term study will be conducted in 2020 or 2021. This will enable to draw robust conclusions regarding the welfare impact and the resource use implications of the project. At this stage we see progress on the adoption of drip irrigation. Challenges remain though at the implementation of several good agricultural practices. We are confident that with continuous intensity, wider implementation of planned activities and full commitment of all parties involved FDW there are prospects for achieving the desired impact.

The final evaluation will offer more insights into the effectiveness of the roll-out of proven farming techniques and the delivery of farmers' training in the application of water-efficient drip irrigation, which leads to the use of good agricultural inputs and practices. The underlying theory of change states that mass adoption of water-efficient farming methods and techniques will improve water use efficiency in sugarcane farming to the point that water extraction is reduced and thus contributes to improved livelihoods as a result of higher productivity.

We kindly acknowledge the support of the field staff of our local research partner Q&Q and the cooperation of the farmers, the mills and staff of the project in the research area. We sincerely hope that this report provides a relevant reference for field staff and stakeholders involved in the further enrolment of the project.

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Summary

Improved agricultural practices for improved water efficiency and productivity in sugarcane farming

The Sustainable Water Fund (FDW), a public-private partnership led by Solidaridad Network Asia ltd, aims to support the roll-out of proven farming techniques and the training of farmers in the application of water-efficient drip irrigation and good agricultural practices. Through the mass adoption of water-efficient farming methods and good agricultural practices the project aims to improve water use efficiency and productivity in sugarcane farming, as well as a decrease in production costs.

Ability to contribute changes to the programme might be limited

The research design chosen at the start (which relies on a gradual and random implementation of programme activities) would ensure a good counterfactual: *what would have happened without project support to the sugarcane producers?* However, project implementation experienced a delay in two out of three mills. Moreover, many farmers have shifted to other crops (e.g. paddy) for various reasons. After consultation with Solidaridad India we jointly decided to move forward with the midline data collection for all farmers as it provides useful data for learning at this stage of implementation. This mean this report should be read as an explorative mid-term report, rather than a mid-term impact report as was initially foreseen.

Mid-term results provide valuable contextual information

Following the baseline study of 2016,[1] this mid-term study provides insights into the progress of the programme, its uptake and farmers' appreciation so far. Forty-one per cent out of the 798 farmers interviewed (78% coverage of the baseline respondents)[2] had been exposed to one or more elements of the training programme. Most of the farmers that have received training belong to the command areas of Mill 1.[3] The project faced various delays in the implementation of activities and the training schedule is therefore lagging behind. At this moment we cannot conclude whether the measured changes are caused by the FDW intervention or by other (external) factors. Still, the data provide valuable and relevant information about the context of the project, changes and current challenges farmers face which can be used for the next stages of the project.

Unique participating mills with diverse profiles of sugarcane farmers

The three participating mills differ in terms of size, capacity, production and also in the climate of the command areas and the soil quality and condition. This diversity of the mills has consequences for technology uptake and implications for the way to assess impact from follow-up surveys. As in 2016, we see again differences between the farmers of the three mills in terms of personal, household and farm characteristics. We therefore present averages for all farmers involved but also for the farmers of each mill.

Results of the mid-term are compared to the baseline of 2016

We present results of the mid-term compared to the baseline. The mid-term survey was based on the baseline and sections on received trainings, appreciation were added as well as questions on mechanisation and available equipment. Results are descriptive and t-tests are applied to test whether differences between 2016 and 2018 and between mills are significant. More advanced statistical analyses (such as regression analysis) are used to test the robustness of these results when we also take into account sugarcane farmers do not only differ in term of mills they supply to but also in terms of personal, household and farm characteristics.

[1] For the baseline report, see: http://edepot.wur.nl/413767

[2] The local research partner faced many challenges in reaching out to all baseline respondents. Some farmers moved, others could not be reached or were not willing to participate.

[3] For confidentiality reasons, in this report the three mills are referred to with the numbers 1, 2, 3 instead of their names.

Farmers remain to be challenged by labour and water shortages

Unavailability of labour and water shortages were reported as the two main challenges for farmers at the time of the baseline. At the mid-term, these are still the most important challenges. They were reported by significantly more farmers at the mid-term evaluation, indicating that the situation regarding labour and water availability is deteriorating for sugarcane farmers. The FDW project adjusted its activities after the baseline results and a mechanisation component was included after consideration of the labour shortages. This turned out to be a good decision as labour is even a stronger issue.

Drip irrigation is increasingly used and financed with subsidies, but farmers in Mill 1 are lagging behind

Fortunately, overall the use of furrow irrigation decreases, and almost all farmers of Mills 2 and 3 now apply drip irrigation. Ninety per cent of the farmers who are currently applying drip irrigation started using it since 2008. Subsidies are the main financial source that are used for financing the implementation of drip irrigation. As in 2016, there is again a strong variation between the farmers of the three mills. Contrary to Mill 2 and 3 farmers, in Mill 1 all farmers still apply furrow irrigation. Interestingly, water scarcity seems to have increased in Mill 1, yet Mill 1 farmers continue to not only use, but also to see furrow irrigation as their preferred irrigation system. This might be because farmers in Mill 1 are unaware of the benefits of drip irrigation or because of the lower shares of subsidies for drip in this Mill. We see that subsidy is a strong driver for farmers to adopt drip irrigation and at Mill 1 farmers indicate to have less access to drip irrigation subsidies.

Biological fertilisers and pesticides used more often, decline in use of chemical pesticides only

With regards to fertilisers, biological fertilisers are used more often, but there is no decline in the use of chemical fertilisers. The frequency of chemical fertiliser application is decreasing somewhat, whereas the frequency of biological fertiliser use is increasing. More farmers now adhere to the government's guidelines regarding quantity and time of application of chemical fertiliser. Regarding pesticides, overall, the use of chemical pesticides only is decreasing, and the use of biological pesticides or both chemical as well as biological pesticides is increasing. Overall, expenditures of all inputs decreased across the board, but mostly for Mills 2 and 3.

Practices regarding row-to-row spacing and seed nurseries improved, while intercropping and trash burning remain more problematic

For the remaining agricultural practices we see varying changes between both rounds of the survey. Correct row-to-row spacing is an important agricultural practice, and more and more farmers seem to comply with these standards. Another positive change took place with regards to seed nurseries. Seed nurseries were hardly used at the time of the baseline, but there is a slow uptake among farmers of all three mills. Of the farmers that use seed nurseries, shade houses are used most often by Mill 2 farmers. Unfortunately, intercropping is still hardly applied. Intercropping is an important element in the training on good agricultural practices, but farmers generally do not seem very interested. Finally, burning trash after the harvest has negative implications for the organic matter content and water conservation in the soil. The project aims to reduce burning by promoting trash shredding and availing machinery. The burning of land and trash after harvest is, however, done by even more farmers, even though trash shredders are increasingly available.

Average productivity is stable, production costs declined and prices received increased

Average productivity across mills (44.1 tonnes per acre) remained almost the same to the baseline productivity. However, there are large differences between mills, with a doubling of productivity in Mill 2 and a significant decrease in Mill 1. Mill 2 farmers were lagging behind in productivity at the time of the baseline so their absolute increase is tremendous but relatively their current productivity levels are comparable to the other two mills. Average production costs are now INR 9,572 per acre, which is a significant decline compared to two years ago. In 2018, a larger share of costs is used for hired labour than for inputs, which was the other way around in 2016. This could be caused by the persisting shortage of labour, driving up labour costs. The average price received per tonne of sugarcane increased from INR 2,324 to INR2,748, which is well above the Fair and Remunerative Price (FRP) 2017-2018 which is set by the Union Government, i.e. INR 2,550 per tonne and INR 2,300 in 2015-2016.

Average farm income from sugarcane of farmers doubled

The average farm income from sugarcane of the farmers in 2015-2016 was INR 84,969, and it increased to INR 176,105 in 2017-2018. The term farm income is used instead of profit as family labour and opportunity costs are not taken into account. The differences between the farmers of the three mills in farm income from sugarcane declined, indicating that Mil 2 and Mill 3 caught up with Mill 1. The large differences in income between both measurements are mainly caused by large variations between both years in total supply of cane to the Mills. Overall, income from sugarcane increased for 55% of farmers and the number of farmers which says to be dissatisfied with their income from sugarcane slightly declined.

Other sources of income become increasingly important

Farmers are becoming less dependent on sugarcane as their main source of income. The share of total income from other *farm-related* activities besides sugarcane production strongly increased in Mill 2, but remained more or less the same for the other two mills. with Mills 1 and 3 also witnessed declining shares of income from sugarcane, but these farmers mainly received a higher share of total income from *non-farm* activities. It was already communicated by Solidaridad and the Mills that there is tendency among farmers to switch to other crops or to cultivate other crops in addition to sugarcane. This result from a period of severe drought and challenges farmers faced in their collaboration with the Mill they supply to.

Unique training needs per mill

As already indicated, there are differences per mill and between the farmers supplying to each mill. This is important for FDW project management to take into account in the further implementation of the trainings and the focus. We have seen for example a low adoption and interest among Mill 1 farmers towards drip irrigation whereas Mill 2 and 3 farmers are increasingly applying drip irrigation. This has serious consequences for the project and the focus of the activities at Mill 1 on drip irrigation and the specific barriers farmers face in adoption. We also asked the farmers for their training needs and preferences. The percentage of farmers willing to receive a training in irrigation practices is still relatively low in Mill 1, whereas it is quite high in Mills 2 and 3. Interests in *trash shredding and mulching* is very strong among Mill 2 and 3 farmers while farmers of Mill 1 are less eager to be trained in these topics. Overall, compared to 2016, farmers do seem to be more interested in mechanisation of farming activities and in good agricultural practices. On average, most farmers are interested in more training topics in 2018 compared to 2016 which indicates an increased interest in being trained and exposed to learning activities.

Overall, a positive trend is observed

We see progress on the adoption of drip irrigation and implementation occurs mainly because of financial support via governmental subsidies. Adoption of good agricultural practices farmers are trained upon gives mixed results. There is an improved use of fertilisers and pesticides but challenges remain at the implementation of several good agricultural practices, i.e. trash shredding. Other studies show that the adoption of good agricultural practices often lags behind the adoption of technology (e.g. Feder, 1985, Pamuk and van Rijn) and confirm our observations in the FDW programme. We also see that farmers are less dependent on sugarcane for their total income which might their risk willingness to invest (financially and in terms of human resources) in the crop. Although there is a tendency to have diverse income sources, income from sugarcane income did increase compared to the baseline.

Impact can be achieved with continued intensity and full commitment

We believe though that with continuous intensity, tailor-made approaches, wider implementation of planned activities and full commitment of all parties involved FDW is likely to achieve the desired impact. The final evaluation will offer more insights into the effectiveness of the roll-out of proven farming techniques and the delivery of farmers' training in the application of water-efficient drip irrigation, which leads to the use of good agricultural inputs and practices.

Recommendations

Based on the findings, we give a couple of recommendations for the next phases of the project implementation. The most important ones are:

- There are large differences between the mills. This also implies that there are unique training needs per mill and a one-size-fits-all approach will probably not lead to maximum impact.
- We recommend to explore further what is required for farmers to make the investments required, particularly concerning Mill 1 farmers who persist in using furrow irrigation. We recommend to check if these farmers might be unaware of the benefits of drip irrigation and how to overcome the lower shares of subsidies from the government in this command area.

- Only few farmers are members of farmer groups, while such groups are beneficial for the uptake of good practices. The project could benefit from organisational structures of collective action in terms of outreach and to stimulate adoption of practices.
- Compared to 2016, farmers do seem to be more interested in mechanisation of farms, and labour shortages continue to trouble farmers. We therefore recommend to prioritise the element of mechanisation in all training programmes.
- We recommend trying to find out why farmers are not intercropping and why they continue to burn trash. It might be interesting to explore which existing incentives prevent Mill 2 farmers from burning trash.

Methodological implications and way forward

The final evaluation should take place after completion of all the FDW activities. In addition, the moment of data collection should be comparable to the timing of the baseline and mid-term to ensure correct comparisons. The contextual and project challenges have implications for the chosen methodological design. First, the drop out is much higher than expected, 22% instead of 5%. The number of farmers participating in the survey is now 798. It is crucial that this number does not decrease at the time of the endline (2020 or 2021). Second, the training schedule lags behind and the original idea of the pipeline approach is therefore challenged. If the number of farmers per cohort (training year) is too low to compare between years, we cannot plausibly contribute any changes to the project. With the endline results we aim to reveal whether we can apply this contribution analysis. To mitigate the risk and to have some insights in contribution of the project activities to perceived changes we will enrich the survey data with qualitative data collection (interviews and focus group discussions).[4]

Main outcomes on practices

- Increased use of drip irrigation
- Higher application of biological fertilisers and pesticides
- Declined use of chemical pesticides
- Improved correct row-to-row spacing
- Increased use of seed nurseries
- Hardly intercropping applied
- Trash burning still common practice

Main outcomes on productivity and income

- Sugarcane productivity increased (44 tonnes/acre)
- Production costs decreased (INR 9,572)
- Price for sugarcane increased (INR 2,748/tonne)
- Income from sugarcane increased
- Sugarcane less important for total income

[4] The exact scope of the additional qualitative data collection will be defined at the moment of the endline and depends on the available resources.

1

Introduction

Introduction

Project aims to enhance sustainability of sugarcane growing and to raise smallholder incomes

The sugarcane industry is India's second-largest agro-based industry and about 6 million farmers and a large number of agricultural labourers are involved in its cultivation. Sugarcane is a major consumer of water and the decreasing level of the natural groundwater resource threatens food security, economic growth and livelihoods. With support from the Sustainable Water Fund (FDW), the 'Increasing water use efficiency in sugarcane growing in India' project, of Solidaridad and its partners, intends to enhance both sustainability of sugarcane growing and to raise smallholder incomes.

A large-scale roll-out of irrigation techniques and farming practices to improve water productivity

The overall objective of the FDW project is:

> 'To stop and reverse the depletion of the critical groundwater resource, thereby sustaining and improving the livelihoods of smallholder sugarcane growers and securing employment at sugar mills and downstream agro-industry in India' (FDW Project Plan Solidaridad 2014).

Achieving this objective requires that less water is extracted in cultivating sugarcane. Therefore, it proposes a large-scale roll-out of irrigation techniques and farming practices that have proven to raise water productivity and farm income of sugarcane farming in smallholder settings in India. Major activities of the project include training on good agricultural practices (e.g. water conserving practices), introduction to improved irrigation systems (e.g. drip irrigation instead of furrow irrigation), and farmer trainings on entrepreneurship, mechanisation and financial literacy. Training is provided to all interested farmers in the command areas of three sugar mills in the southern states of Karnataka and Telangana.

Providing first insights into the effectiveness of the project

Following the baseline study of 2016, this mid-term provides insights into the progress of the programme, its uptake and farmers' appreciation so far. The mid-term survey was again conducted by Wageningen Economic Research and its research partner Q&Q. Data collection was finalised in December 2018, and covers 798 farmers, all of whom were sugarcane farmers during the baseline. Unfortunately, not all baseline respondents (1,018 farmers) could have been surveyed due to several complications in the field. At the moment of data collection, 41% out of these 798 farmers had been exposed to one or more elements of the training programme. All the farmers that have received training belong to the command areas of mills 1 and 25 (30% and 4% respectively). Due to several circumstances, the trainings were not yet implemented among farmers of Mill 3. Only some minor activities have been implemented and farmers refer to these when they mention to have received trainings. Observed changes over time among farmers in this mill must be caused by other (external) factors.

Structure of the report

The report provides a detailed overview into the socio-economic conditions of sugarcane producers. We start with brief description of the methodology, programme engagement and a characterisation of the sugarcane grows. Chapter 3 presents farm and farmer characteristics, Chapters 5-7 show changes in the domains of agricultural practices including irrigation systems used (5), productivity (6) and cost and revenues (7). For a detailed description of the context, the theory of change, and the methodology we refer to the baseline report which can be accessed online via: http://edepot.wur.nl/413767. All the output tables are presented in the separate Appendix file: https://doi.org/10.18174/475710.

[5] For confidentiality reasons, the three mills are referred to with the numbers 1, 2, 3 instead of their names.

2

Context

Context

A comprehensive context description on the sugarcane sector in India is given in the baseline report (page 16-20). In this Chapter we shortly reflect on the period from 2016 to 2018 only.

Challenges in the entire sugarcane sector

The first half of the year 2017 witnessed good rainfall in the region, leading to an increase in sugarcane cultivation. With the increased sugarcane area coupled with non-availability of labour gangs to harvest the cane, the crushing period at the sugar mills had to be extended to ensure that all of the cane in the command areas was harvested. The excess availability of sugar led to the central government fixing a cap for the quantity of sugarcane that could be sold by a sugar company. The notification from the government restricted the selling of sugar, thus limiting the revenue generation for these companies. The effect of the restricted revenues of majority of the sugar companies were felt at the mill level at the time of farmers' payment. The payments to farmers were delayed and as a consequence, all development activities on the ground were deferred. These sector-related issues are a risk for the project as a whole. Working together closely with the mills and making sure the overall goal is kept in mind, is how the partnership mitigates this.

3

Intervention logic

Intervention logic

Enhance the social, economic and environmental sustainability of sugarcane production

Achieving the FDW objective requires that less water is extracted in cultivating sugarcane. Therefore, it proposes a large-scale roll-out of irrigation techniques and farming practices that have proven to raise water productivity and farm income of sugarcane farming in smallholder settings in India. See Appendix 1 for the visualisation of the intervention logic of the FDW project.

Capacity building is assumed to result in increased productivity and higher water use efficiency

At activity level, 35,000 smallholder sugarcane farmers are to be trained in best farming practices by extension workers of the three selected mills and selected lead farmers. The project reaches out via the so-called training of trainers (ToT) and training of farmers (ToF) model, i.e. first 2,000 lead farmers are defined and trained (ToT) who are responsible for training and coaching of the farmers (ToF) which are organised in groups. Theory and practice are both components of the training and 100 demonstration plots are cultivated. An additional 5,000 farmers are trained in financial literacy with the aim to be linked to loans to be able to finance investment in irrigation systems. An additional number of farmers are trained and equipped to provide trash shredding services, produce and supply sugarcane seedlings, and provide drip irrigation maintenance services. Table 3.1 gives an overview of the priority areas of training. Improved practices result in increased production and productivity and in higher water use efficiency. Increased income and water use efficiency result in better livelihoods.

Mechanisation and equipment components new elements of the activity plan

The baseline study done by WUR pointed out that the shortage of labour was the most pressing issue in all three command areas (and in the entire sugarcane sector in India). These observations led to a revision of the originally planned list of hardware and to a request for changes focusing more on mechanisation. Mechanisation will help in increasing the productivity, while reducing the cost of cultivation. It will also enable the farmer to complete farming operations in time. Depending upon the types of crops grown, soil conditions, local situations and requirements in the location, the project team will encourage farmers to use various farm machinery and implement it on an available government subsidy basis. The government subsidy pattern is available up to 50%. Agreeing with all mills on the new list and developing the plans for implementation was an important activity that took place during 2017-2018.

Table 3.1 Priority areas sugarcane producer trainings on irrigation and water conserving practices

Irrigation systems	Water conserving practices
Surface drip irrigation	Improved fertigation
Sub-surface drip irrigation	Trash mulching and shredding
Drip irrigation with fertigation	Composting and bio-fertiliser
	Intercropping and wide-spacing
	Seedlings and gap filling

4

Methodology

Methodology

A short description of the methodology and the data collection of 2018 is presented in this chapter. For the full description of the methodology applied we refer to the baseline report pages 27-33.

Changes in programme implementation have consequences for the impact study

The initial objective of the research was, and is, to demonstrate the level of success of the project, i.e. the effectivity of the intervention to bring about large-scale adoption of improved techniques and best practices, and to translate learnings in a road map for sugarcane sustainability. However, changes in project implementation and shifts away from sugarcane to other crops among farmers in the baseline sample, may make it challenging to fully meet this objective.

The pipeline approach is used to gain insight contribution of observed changes to the programme

The pipeline method constructs a comparison group from subjects who are eligible for the programme but have not yet received it. The mills do not train all their farmers at once in the first year, but approximately one-third per year. As such, we can compare farmers in different stages in the project intervention. For example, on the assumption that farmers trained will apply (or did apply) the lessons learnt and new methodologies within one year (i.e. at the next planting round) the pipeline approach is suitable for estimating one-year effects. The changes in programme implementation, the delay in enrolment and the shift of a number of farmers towards other crops might have implications for the effectiveness of the pipeline approach.

Ability to contribute changes to the programme might be limited

The research design chosen at the start (which relies on a gradual and random implementation of programme activities) would ensure a good counterfactual: what would have happened without project support to the sugarcane producers? However, project implementation was delayed in some cases and many farmers have shifted to other crops (e.g. paddy) for various reasons. After consultation with Solidaridad India we jointly decided to move forward with the midline data collection for all farmers as it provides useful data for learning and accountability at this stage of implementation. This decision has some implications for reaching the objective:

- continuing with the midline data collection at this stage implies that we cannot plausibly contribute any changes to the project for sugarcane farmers who have not been trained yet;
- we cannot detect any changes for farmers that shifted away from sugarcane production;
- due to delayed implementation we may not captured changes in productivity as foreseen in the intervention logic.

At the same this new situation will allow also us to capture an important element of reality: namely the dynamics in farmers choice of crops. Moreover, it is likely that the training will influence practices in other crops – especially if these crops are water intense such as vegetables or paddy. We hope this analysis can shed light on the spillover of the project to other water intensive crops and the dynamics on the ground.

2016 sample size was calculated at 1,018 sugarcane farmers

We used power calculations to determine the appropriate sample size. The sample size is defined by a random selection of farmers from the mills' management information system whereby all farmers were divided into three groups based on the year they are expected to receive the training. The baseline survey is conducted among 1,018 farmers (3% of the total sugarcane population in the area) out of which 50 are lead farmers. The same 1,018 farmers were approached for the mid-term survey and will be targeted at the end-line study (in 2020 or 2021).

Finally 798 sugarcane farmers participated in the 2018 survey

The same farmers of the baseline have been approached to participate in this mid-term evaluation. However not all farmers of the baseline did participate. We put a lot of effort in approaching all farmers and we could manage to survey 798 farmers which is 78% of the baseline sample. The drop out percentage was expected to be lower (5%) (Table 4.1) but there were many challenges in the field and in logistics.

Table 4.1 Sample sizes per mill for baseline and mid-term, %

Survey participation	Total	Mill 1	Mill 2	Mill 3
Baseline only	22	30	20	8
Both surveys	78	70	80	92

In total, 22% of the respondents of the baseline survey did not respond to the mid-term survey. The share of respondents that did not answer the mid-term survey is highest in Mill 1, and lowest in Mill 3. Attrition analysis shows that there is no difference in characteristics such as age, gender, supply or productivity between people that dropped out and those that did not (Table 4.2). There are quite some differences between the farmers of each mill. For some results we see a deviation of the Mill 2 farmers compared to 1 and 3 (e.g. productivity). We do present the averages for the whole groups as well as we the influence of the Mill 2 farmers on the total average is quite small, i.e. the number of farmers participating in the survey is the smallest for Mill 2 (15% Mill 2 of total sample, 47% Mill 1 and 38% Mill 3 based on the total number of farmers per command area).

Table 4.2 Survey participation per mill

Sample size	Baseline 2016	Mid-term 2018	Share baseline
Mill 1	547	381	70%
Mill 2	142	113	80%
Mill 3	329	304	92%
Total	1,018	798	78%

This report covers the farmers who participated in both surveys

The personal characteristics data presented in this study can differ slightly from baseline as the results presented in this report cover those respondents that participated in both the studies (n=798). We also noticed that some respondents of the baseline asked someone else of the household to participate in the mid-term (e.g. a father asked is son to participate). The baseline results presented here have been adjusted accordingly.

Farmer surveys 2016 and 2018 are similar

The survey used for the mid-term is largely similar to the survey that was used for during the baseline. A couple of adjustments have been made based on contextual developments (e.g. cultivation of other crops than sugarcane) changes in the FDW programme (e.g. mechanisation component) and to capture appreciation and satisfaction of the trainings farmers have been receiving. The 2018 survey was further customised to the local context and pilot tested while monitored by a WUR researcher. See Appendix 2 for the full survey. Data are collected on the following 9 topics:

- General characteristics
- Farm characteristics
- Sugarcane production characteristics
- Agricultural practices sugarcane
- Irrigation practices
- Inputs for sugarcane production
- Household income and diversification
- Livelihoods
- Risk, willingness to investment and time horizon

Data from the household survey were provided to Wageningen Economic Research in Excel format in November and December 2018. Data analysis took place with the statistical software STATA in January and February 2019.

Triangulation with other data sources quite challenging

Monitoring and Evaluation (M&E) is conducted with several parties all with their specialism and expertise focusing on a specific target. Increased margins at mill level, Bonsucro certification and sustainable water use (i.e. lower water foot prints) are not incorporated in this study. These indicators are monitored and evaluated by the other parties involved (i.e. eLEAF, Vasantdada Sugar Institute and Osmania University). Data of the different sources are shared and

combined to guarantee triangulation and to be able to report on the achievements of all targets and the intervention logic. Data will be collected on specific targets such as rainfall, temperatures, water efficiency and groundwater levels. Unfortunately it turns out to be difficult to link the data of eLEAF to the WUR data of farmers. There were difficulties faced in both retrieving the data in monsoon time, the delay in training and therefore non-usable information, and the lack of uptake by the mills of data formats. The specific major bottleneck for using the water use efficiency parameters is the cloud cover during the monsoon, which was higher than anticipated. The technical team at eLEAF is currently investigating several pathways how to proceed and how to combine the different data sources.

Results are presented per mill and if applicable per cohort

As in the baseline study results are presented with an average of the whole group and per mill as we have seen there are significant differences between the mills, their command area and the farmers that supply them. To show and correct for these differences, we present descriptive data by mill, and use a t-test to verify the statistical significance of the differences between groups. The descriptive tables are presented in Appendix 3. For the differences per cohort (different starting year of receiving a training) results are presented in the final evaluation (if each cohort has enough respondents).

International standards for significance levels are used

We adhere to the international standards for significance level (α=0.05) and predictive power (1-β=0.8), with corresponding z-scores of respectively 1.96 and 0.84 significance levels are indicated as follows: *** (α = 0.01), ** (α = 0.05) and * (α = 0.1). We only mention a certain change when it the change is meeting one of these significance levels. More advanced statistical analyses (such as regression analysis) were used to test the robustness of these results when we also take into account sugarcane farmers do not only differ in term of mills they supply or cohort they are in, but also in terms of personal, household and farm characteristics. The most important regression models are presented in Appendix 4.

Statistical analysis to give insight into the determinants of envisioned project outcomes

The intervention logic in Appendix 1 clearly shows how FDW aims to enhance the sustainability of the India sugarcane sector. In this report we validate whether the envisioned impact pathways are evident. We use regression analyses to link the different stages of the intervention logic: e.g. in estimating the determinants of productivity we include indicators of adoption. However, the FDW project will not be the only influence on the envisioned project outcome. Personal (e.g. age, education), household (e.g. household size) and farm characteristics (e.g. land size) also matter. Therefore, we use advanced statistical analysis (regression analysis) to gain insight into the relations between key personal, household and farm characteristics (as presented in Chapter 3) and key outcome and impact indicators. This means that we look for determinants of how sugarcane is produced and what outcomes this has from an economic perspective (e.g. profit).

Impact analyses which examine programme engagement were only conducted for Mill 1

Three regression analysis are done to answer the following questions: i) what determines the presence of specific good agricultural practices including drip irrigation; ii) what determines productivity and iii) what determines farmers' farm income of sugarcane. In this study we use the important variable of programme engagement: i.e. whether the trainings or other programme engagements such as access to demonstration plots, are influencing farmers' behaviour on good agricultural practices, productivity and revenue. So the question is whether farmers who did receive training differ from the farmers who didn't on the key outcome and impact indicators, after correcting for personal, household and farm characteristics. There is though a limitation in these analyses as the number of farmers who did receive a training or who have had some exposure to the programme is limited and even zero for one of the three mills. Therefore, this impact analysis was only conducted on the farmers associated with Mill 1. This was done by estimating the abovementioned regression models again, but including an indicator showing whether a farmer (from Mill 1) has had programme engagement or not. The final impact analysis will allow for more robustness as all farmers will have been trained then.

Multiple statistical models were used to ensure robustness of results

Regression analysis focuses on specific key variables to get insights into relations, correlations and possible causal linkages. Different statistical models are used to ensure robustness of results. In total we estimated 4 different models per analysis: i) a standard linear regression without including

indicators for the separate mills, ii) a standard linear regression including mill indicators – this model is leading, iii) a model including a variable for programme engagement, iv) a fixed effects model which controls for the effects of time-invariant variables with time-invariant effects.

Validation and correct interpretation of results

This report shows the differences over time. As the programme is still being implemented, this is useful to see whether the FDW is on track and if new dynamics occur on the ground. The results provide for input for policy and to discuss whether further adjustments or a particular focus are required in order to achieve the goals set. However, to determine which of these changes might have been caused as a direct result of the programme, a simple comparison between 2016 and 2018 indicators is not enough. Changes might have resulted from other issues than the project (e.g. rainfall, economic development, policy changes etc.). We therefore validate findings with the parties on the ground and with literature and studies. At the final impact study (2020 or 2021) qualitative data will be collected as well via focus group discussions and in-depth interviews with sugarcane producers and other stakeholders.

Programme engagement

5

Programme engagement

Delays in out roll due to challenges at ground level

In combination with several challenges at ground level, such as the unrest caused by delay in farmers' payment in the national sugarcane sector, the extended crushing period – which decreased farmers' availability for training - low sugar prices as well as changes in the management of the sugar companies this resulted in a delay in some of the activities, especially related to conducting the training activities and buying the respective hardware that was planned for entrepreneurs. Although the project should be going into its final year, it hasn't reached this step yet.

5,000 Farmers have been trained and uptake seems considerable

In spite of the difficult circumstances, there were many other activities that took place. These included the making of a farmers' film, financial literacy training sessions to farmers, a ground water study by Osmania University, the installation of water meters and distribution of Soil Moisture Indicators (SMIs) and outreach to farmers through various village meetings including initiation of water clubs. The crop calendars, drip diaries and diaries for demonstration plots have been printed in local languages and were distributed to the farmers of Mill 1 and 2. The total number of farmers trained till November 2018 at Mill 1 and 2 are as follows:

1) Training by regional university (ARS Basantpur): 313 farmers
2) Training of farmers through village meetings : 560 farmers
3) Training at VSI, Pune : 99 farmers
4) Financial Literacy : 1,064 farmers

Seedlings productions in shade houses is done and demonstration plots have been set up. Re-orientation training on project- and water-focused activities was carried out for the extension staff. Through the 2018 year's interventions, 5,000 farmers were trained, 1,654 additional farmers adopted drip irrigation which resulted in a saving of 8,146,080 m^3 of water. Moreover, business cases for various hardware items were developed and shade houses still profited despite the low year (source: FDW14IN20 Annual Progress Report 2017-2018).

Limited programme engagement among respondents

Determining the impact of the programme will be done at the end-line. However, for one of the three mills we could include programme engagement in the analyses to test whether farmers who participate(d) in the programme differ from those who don't. Table 5.1 shows an overview of the programme. engagements per mill as of the mid-term survey. In another mill the number of respondents that participated in the mid-line and that have been exposed to any programme intervention is quite low. In the third mill, the trainings have not been implemented yet (Figure 5.1 and Table 5.1). This information is based on response of the farmers we interviewed. We asked them whether they had received any training, and if so, what type, when and from what source. Mill 1 has the highest number of farmers trained or somehow being exposed to the programme (30%), Mill 2 only 4% and Mill 3 only 7%. We know that at one mill the programme has not been implemented formally but some minor activities have been taking place on the ground and farmers referred to these activities. The majority of trainings have been given by either the extension worker of the mill or the lead farmer. Main training topics were good agricultural and irrigation practices.

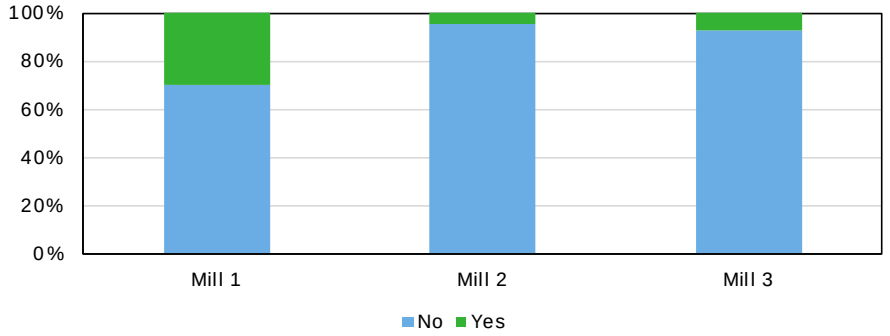

Figure 5.1 Programme engagement by mill

Table 5.1 Overview of programme engagement per mill according to farmers' response (i.e. farmers' perception of training and support received)

Programme engagement	Mill 1	Mill 2	Mill 3
Programme engagement	30	4	7
Of which:			
Access to demonstration plot	6%	0	27
Assistance from extension worker from the mill	97	0	77
Assistance from the lead farmer	85	0	24
Training	21	100	23
Of which:			
- Good Agricultural practices	92	60	40
- Irrigation	92	20	20
- Mechanisation	29	40	40
- Trash	21	60	20
- Financial	0	20	20

6

Profiles of sugarcane farmers

Profiles of sugarcane farmers

This chapter presents the general socio-demographic characteristics of the targeted sugarcane farmers, their views on investment, the farm and production characteristics of their sugarcane cultivation, and the perceived challenges and training needs. It focuses on showing the changes over time.

6.1 Socio-demographic characteristics

We describe farmers in terms of gender, education, household size, income and poverty levels. Table 6.1 shows the overall mean and the means per mill. The personal characteristics differ significantly between the different mills as we have seen already in the baseline. We also see some differences between years as we 'miss' some of the baseline respondents in this analysis (n=798 instead of 1,018) and some respondents were replaced by another member of the household in responding to the survey. Attrition analysis shows that there is no difference in characteristics such as age, gender, supply or productivity between people that dropped out and those that did not (see also Table 4.2)

Sugarcane farmers are predominantly male, received education and have 3-5 people in their households

Farmers are predominantly male (91%) and head of the household (86%), households consist of 3-5 persons on average, and 14% are illiterate (i.e. no education at all).

Table 6.1 Personal and household characteristics

Mean of characteristics	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Farmer is female	11%	9%	10%	12%	8%***	0%	12%***	8%
Farmer head of household	76%***	86%	69%***	90%	96%	95%	79%	78%
Household size	1.5	1.4	0.99***	1.2	1.5	1.4	2.1	1.7
Illiteracy level	22%***	14%	0%***	4.7%	28%	28%	48%***	21%

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

Share of income generated from sugarcane decreased since 2016

The economic relevance of sugarcane for the farmers has decreased since 2016. In 2016, we found that for almost all farmers (94%), sugarcane accounted for 75% or more of their income. Two years later, this percentage has dropped to 61%. There are especially sharp increases in the number of farmers indicating that they depend on sugarcane for half of their income, and between 25-50% of their income (Figure 6.1 and Table 6.2). Nevertheless, sugarcane is the main source of income.

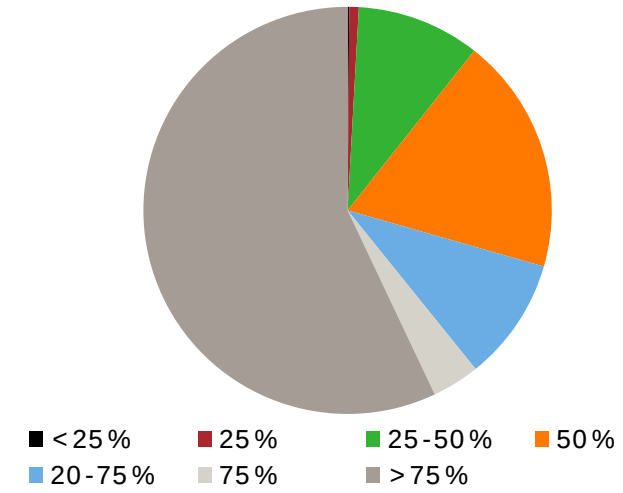

Figure 6.1 Percentage of income from sugarcane

For most farmers sugarcane became less important, but not for all

The average decrease in share of income from sugarcane mainly happens at Mill 1: there is a decline from 93% to 32% of farmers financially depending for at least 75% on sugarcane. Contrarily, for Mill 3, we see quite a few farmers

that became more dependent on sugarcane in 2018, while others started generating more income from other sources. From the farmer perspective it can be a positive trend if they are able to diversify their income sources and spread their risk. Solidaridad confirmed an overall trend in the areas of operation where farmers aim to have various income sources. We do not know exactly whether this is also a positive trend for water use as not all insights are available in what farmers shift to or incorporate in their income activities. We do know that the farmers of Mill 2 increasingly cultivated rice as canal water was made available by the authorities after the intense draught. Rice is a water intense crop but it would be very good to take the issue of income diversification further into account in the final evaluation.

Table 6.2 Percentage of income from sugarcane per mill

Mean per income category	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
< 25	0	0.1	0	0	0	0	0	0
25	0	1	0	1	0	0	0	1
25-50	0	10	0	19	0	0	0	1
50	1	19	0.3	36	3	0	1	5
50-75	4	10	8	12	0	2	2	10
75	35	4	33	1	0	1	50	8
>75	60	57	60	31	97	97	47	75
	***		***					

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

The share of farmers likely to fall below the USD2.50 poverty line decreased

We use the *Progress out of Poverty Index* (PPI)[6] as a tool to measure likelihood of falling into poverty: earning below the minimum of USD 2.50 per day (the Purchasing Power Parity poverty line in 2005). We see a positive change: the PPI was 59% in 2016, and dropped to 45% in 2018. In other words, less than half of the farmers is likely to fall below the poverty line which is far less than in 2016. At this stage there is no clear explanation of this change. There could be a relation with the diversification of income but this assumed relation has to be confirmed with data from the final evaluation and with secondary data which is currently not available in this area.

Significant change at Mill 1 farmers: less likely to fall into poverty

If we have a closer look at the PPI per mill we see an interesting change. The average likelihood of living below USD 2.50 per day in 2016 was the highest in Mill 3 with 70%, but in 2018 the mean poverty likelihood of Mills 2 and 3 are roughly similar (respectively 52% and 54%). In Mill 1, the mean poverty likelihood dropped to 34%. The change at Mill 1 is interesting as we also saw that farmers dependency on sugarcane decreased significantly. As said, we do not know at this stage whether there is a correlation.

6.2 Willingness to invest, risk attitude and time horizon

Adoption of new or improved agricultural practices is influenced by farmer attitudes towards investment and risk

Sugarcane farmers' view in terms of investment, risk, time horizon (short or long) and trust can influence adoption of certain agricultural practices and techniques (Barham et al., 2014; Laeequddin et al., 2012; Kwon & Suh, 2005; Juma, C. 2012; Nato et al, 2016). Willingness to invest is important in deciding whether to adopt a certain practice where investment is needed, i.e. it can be a driver for (willingness) but also a constraint to (unwillingness) changing behaviour and investing in new agricultural techniques.

Farmers became less positive towards investment in general since 2016

The statement '*I will not make any investment because you never know what will happen'* is a means of illustrating the perception of farmers towards investment. In 2016, 59% of the farmers (strongly) agreed to this statement. indicating that the majority of farmers was not very eager to make an

[6] The poverty status of a household (poor or non-poor) derives from a definition of a poverty line and a definition of expenditure. It is important to consider is that the PPI could be somewhat outdated as the latest available PPI used here stems from 2010.

investment. In 2018, we see an increase in farmers (strongly) agreeing: 74%. There was especially a sharp increase in the share of farmers *strongly agreeing* with the statement (9% to 26%). This could indicate that farmers have become even more hesitant to invest which of course can negatively influence uptake and investments in irrigation.

Farmers became more sceptical towards investments in new agricultural practices since 2016

The statement *'Investing in agriculture or new agricultural practices is very risky; I rather do not do it'* is an indicator to measure risk attitude. The farmers that (strongly) agree increased from 58% to 81% and the farmers that (strongly) disagree dropped from 15% to 5%. Farmers thus seem increasingly less likely to take a risk when investing in agriculture. This outcome could negatively influence uptake as well.

Sugarcane farmers seem to think on the longer term more often since 2016

The time horizon (short or long term) of farmers is relevant because it influences willingness to invest and motivation to change. Farmers were asked to choose between receiving (hypothetically) INR 500 right now or a higher amount in one year from now. The average amount of INR needed to choose for receiving money after 1 year is was INR 929 on average at the time of the baseline, almost twice as high as the INR 500. This indicates that on average farmers have preference for short term when it comes to investments. During the mid-term survey the average amount needed to choose for receiving money after 1 year has dropped to INR 787, which indicates a longer time horizon. Farmers might be struggling less with today's challenges, and therefore more willing to take risk and invest now, with outlook for a payback in the future. This is worth to further explore with Solidaridad and partners. There could be a relation with the outcome that they are less likely to fall into poverty. Strangely enough the longer time horizon does not correspond with the increased risk aversion attitude and the decrease in willingness to invest.

Farmers generally trust in the advice of the mill and this increased since 2016

The mills are key partners in the FDW project: they provide training on preferred practices and (irrigation) techniques and coach in cultivation. Therefore, trust in the mills is an important enabling (or constraining) condition for uptake. The assumption is that farmers trust that if they change their behaviour according to what they are introduced to, it will change their life positively. To measure trust with regards to the mills, we use the statement *'I am only willing to invest in new agricultural practices after I find the mill technology reliable'*. At the baseline, 77% of farmers (strongly) agreed with this statement, and during the mid-term survey we find that 91% of farmers (strongly) agree. Especially farmers at Mill 2 show an increase in trust. This is a positive change farmers seem to have more trust in the mill which could positively influence uptake and behavioural change.

6.3 Farm and production characteristics

Summary of current situation of farm characteristics

Farm characteristics are presented in Table 6.3. The farmers own on average 3.4 acres of land cultivated with sugarcane and 1.8 acres of land used for cultivation of other crops. The majority only uses ratoon crop (72%) with 10% cultivating plant crop only and 17% cultivating both ratoon and plant crop. The farmers are on average quite experienced with 15 years of sugarcane cultivation and 14% are member of a farmer group. In total 145 tonnes of sugarcane was supplied to the mills last harvest season and average production of cane per acre is 44 tonne. Over half of the farmers received governmental subsidy, mainly for surface drip irrigation and electricity. The subsequent paragraphs elaborate in depth on the changes between both rounds of the survey.

Leased land as well as land for other crops are on the rise. Farmers on average own 3.4 acres of sugarcane area

Almost all farmers own land with an average of 3.37 acres but with large differences between small and big land owners. Over the years, there are large differences between the mills. Farmers in Mill 1 already had the smallest sugarcane acreage in 2016, but the average acreage of owned sugarcane dropped even more during the mid-term (to 2 acres only). Also in Mill 2, the average owned area sugarcane decreased. In Mill 3, however there was a strong increase (5.1 acres). The overall area of owned land for *other crops* significantly increased. This is mainly due to a sharp increase in Mill 2, from 1 to 3.4 acres. This indicates that farmers in Mill 2 are increasingly focusing on the production of other crops (see Table 6.2 and tables in Chapter 8). The data

show that this is mainly due to increased rice production in Mill 2.[7] Leased land, both for sugarcane as well as for other crops, increased since 2016, but still only concerns a much smaller share of land compared to owned land. This increase in rented land might have negative effects on investments in irrigation techniques and systems, as many studies indicate that adoption of good agricultural practices and changing farming behaviour can be a constraint when it concerns leased/rented land.

The use of ratoon crops increased since 2016, especially for Mill 1 farmers

Cultivating sugarcane by ratoon crops can increase up to 4 or 5 harvests but good quality seeds and agricultural practices are required. Ratoon crops are more cost-efficient but there is a trade-off at a certain time when production decreases and plants might become less resistant to pest and diseases or draught. The majority of farmers cultivate only ratoon crops (72%) which is a large increase since 2016. Almost all farmers in Mill 1 were using ratoon crops in 2018, whereas 41% of the farmers in Mill 1 was still using both ratoon as well as plant crops in 2016.[8]

Mill 1 farmers less often member of farmer groups, while Mill 2 farmers are getting more organised

It is not common in all command areas for sugarcane farmers to be organised in a farmer group: on average 14% of the farmers are member of a farmer group. In 2016 farmers of Mill 1 were most often member of a farmer group (61%), in 218 this decreased to 12%. Contrarily, in Mill 2, farmers are getting more organised (from 24 to 47%). Most members of farmer groups are part of a sugarcane farmer group, although, especially in Mill 2, farmers are also part of water management clubs and credit and saving groups (Table 6.3). As people in Mill 2 have not been trained yet, the project roll-out in Mill 2 could benefit from these new organisational structures. Working via farmer groups can be very effective and efficient in reaching out to thousands of farmers. From the farmer perspective, being a member of a well-functioning and organised farmer group could also stimulate adoption of practices as there is a platform of mutual learning and sharing.

Average supply of sugarcane to mills doubles for Mill 2 and Mill 3, but halves for Mill 1

The farmers supplied on average 145 tonnes of sugarcane to the mills at the last harvest season, which is a significant increase compared to 2016 (Table 6.4). This entails the harvest of both plant and ratoon cane. Supply sharply decreased for Mill 1 farmers, from 153 to 70 tonnes, while it doubled for farmers from the other two mills. In Mill 2, average supply increased from 96 to 211 tonnes, while for Mill 3 it increased from 107 to 215 tonnes. We see a similar pattern for productivity. The high decrease of supply of the Mill 1 farmers can be related to the problematic relations the farmers had with the mill (i.e. late or no payment of cane). There might have been side selling at Mill 1 farmers or the increased their own activities of juice making. Contrarily, the high supply of Mill 2 farmers can be related to their point of departure in 2016. At that time, Mill 2 farmers were lagging behind in productivity so there absolute increase is tremendous but relatively their current productivity levels are comparable to the other two mills.

Average price received per tonne above FRP for all three mills

The FRP of the 2017-2018 season was defined at INR 2,550 per tonne of sugarcane. Prices received by farmers of Mills 1 and 3 were comparable in 2016, where prices were relatively high for Mill 2. In 2018, prices have significantly increased everywhere, but most for Mill 3. The average price received per tonne for Mill 1 is just above the minimum FRP. The average price received per tonne for Mills 2 and 3 are well above the FRP.

[7] According to the local partners, there has been an increased canal water availability after the drought period which allowed the farmers to grow paddy (a short period crop).

[8] It is not possible at this stage to mention this as a good or bad agricultural practice. The project aims to have more productive ratoon crops but only the final impact data will show whether they indeed have had more ratoons than before the project activities.

Table 6.3 Farm characteristics

Character-istics	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Owned sugarcane area	3.3	3.4	2.9***	1.95	4.0**	3.4	3.4***	5.1
Leased sugarcane area	0.2***	0.4	0.4***	0.2	0.00***	0.7	0.1***	0.7
Only plant crop	21%***	10%	13%***	1%	60%	52%	16%***	7%
Only ratoon crop	45%***	72%	45%***	99%	40%	35%	48%	53%
Both plant and ratoon crop	34%***	17%	41%***	0%	0%***	13%	37%	40%
Owned other area	1.3***	1.8	0.9*	0.8	1.0***	3.4	1.9*	2.4
Leased other area	0.1***	0.6	0.1***	0.4	0.0***	1.1	0.03**	0.6
Sugarcane experience (years)	14.2***	15.5	14.5***	15.7	3.7	5.7	17.8	18.8
Member of farmer group	35%***	14%	61%***	12%	24%***	47%	5%	5%
of which:								
Sugarcane farmer group	33%***	14%	59%***	12%	21%***	41%	5%	5%
Water managem ent club	2%	2%	5%***	0%	0%***	14%	0%	0%
Credit and saving group	1%	3%	2%***	0%	3%***	19%	0%	0%

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

[9] Note: production of both leased and owned land

Table 6.4 Sugarcane production and price

Production and price	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Total supply to mill (in tonne)	128**	145	153***	70.3	96.2***	211	107***	215
Production per acre (in tonne)[9]	43.8	44.1	47.4***	40.0	25.9***	53.6	45.9	45.6
Price received / tonne (INR)	2,324***	2,748	2,272***	2,553	2,566***	2,869	2,300***	2,947

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

Over 90% of farmers in Mill 2 and Mill 3 receive a subsidy for surface drip irrigation and/or electricity

The Indian government has been providing subsidies to farmers in various agricultural and development programmes.[10] And indeed, 99.5% of the farmers who received subsidy, received the subsidy from the government. In 2016, there were few differences between the mills, but in 2018, almost no farmers in Mill 1 (3%) still receive a subsidy, while almost all farmers from Mill 2 (90%) and Mill 3 (98%) receive a subsidy. Almost all of the farmers in Mills 2 and 3 that receive a subsidy, receive one with the purpose of surface drip irrigation. According to Solidaridad and partners, due to continue water crisis in the region and slower progress of uptake of drip by smallholder farmers, there have been indeed direct subsidies and financial linkages provided to the farmers of Mills 2 and 3. Additionally, in Mill 3, 92% of farmers also receive a subsidy for electricity (Table 6.5).

[10] For example the government launched in 2005-06 and subsequently upscaled during the Eleventh Five Year Plan (2007-12) the 'National Mission on Micro Irrigation (NMMI)' as a Centrally Sponsored Scheme (CSS).

Table 6.5 Subsidies, %

Subsidies	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Subsidy received	45**	52	49***	3	38***	90	43***	98
Purpose subsidy:								
Fertiliser	53***	1	97**	27	5	0	8***	0
Electricity	52***	68	98	55	5	2	2***	92
Pump	13	2	25	0	0	0	1	3
Surface drip irrigation	6***	96	1***	45	21***	100	8***	96
Sub-surface drip irrigation	1	2	1	27	0	0	2	1

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

6.4 Challenges in sugarcane farming

Self-reported challenges give insight into project relevance

Table 6.6 summarises a number of potential challenges farmers face. These challenges give insight into what farmers consider as the main challenge and can thus serve to evaluate project relevance (though factual challenges may differ) and the motivation of farmers to change current practices or techniques.

Unavailability of labour is the main challenge according to farmers

Almost all farmers (98%) agree that unavailability of labour is a serious challenge which is confirmed by Solidaridad. The government has been promoting self-employment and rural employment and the internal migration has slowed down, especially rural to rural migration. The bulk of rural poor are migrating to urban areas. The face of agriculture is changing and to address the same there is a need to provide emphasis on mechanisation and agri-entrepreneur services. The project's components on mechanisation and entrepreneurship addresses this to further enhance the provision and availability of mechanised farming to the farmers. Table 6.6 shows that for all three mills, there is a significant increase in the number of farmers that report unavailability of labour as a challenge, indicating that the problem is worsening.

Water shortage is a serious challenge for farmers of Mill 1 and 3

The second biggest challenge faced is unavailability of water of irrigation. This issue is not new and forms the basis of the FDW project. However, its relevance is confirmed by the farmers themselves. On average, the number of farmers that report water shortage as a challenge increased, but this is mainly caused by an increase in Mill 1 farmers reporting this as a challenge. The water shortage problem might therefore especially be an urgent and increasing problem for farmers associated with Mill 1. On the other hand, Mill 2 farmers report a sharp decrease in water shortage as a challenge.

Table 6.6 Reported challenges of the farmers, %

Characteristics	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Enabling environment								
Unavailability of labour	74***	98	62***	99	69***	98	89***	98
Unavailability of water for irrigation	66***	80	46***	87	88***	19	83***	94
Unavailability of agricultural inputs	33	32	25**	47	62*	50	33***s	7
Production / technique								
Attack of pest and diseases	50***	23	68***	16	60***	21	24**	33
Poor quality of soil	29**	24	41***	19	29*	40	14***	25
Contract / market / resources								
Low price of sugarcane	57***	41	59***	33	28***	58	64***	45
Delay in getting cutting order	61***	46	69***	55	18***	54	68***	31
Not profitable	23	24	14**	21	4***	26	41***	28
No resources for agricultural inputs	38***	8	49***	4	70***	20	13*	8
No facility for soil testing	38***	45	32***	44	26***	55	51**	42
Bad condition of drip irrigation	28***	6	33***	3	60***	11	10	7
Other:								
Delays in payment	0	10	0	1	0	1	0	24

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

No facility for soil testing is another, upcoming, challenge

Most other challenges are, on average, reported less frequently by farmers in 2018 compared to 2016. An exception to this is the lack of facilities for soil testing, which farmers in Mill 1 and Mill 2 report more frequently.

6.5 Support and training needs

Importance of gaining insight into support received in the past

It is important to know whether other sources of support (e.g. trainings) exists to get a clear understanding of the context and the (im)material resources of farmers. Besides, it is important to have insight into potential external influences of other actors active in the same area which could contribute (or counteract) potential impact. It also shows the relevance of an intervention when no other projects or supporting activities are present.

Fewer farmers interested in receiving training on sugarcane cultivation

Overall, 91% of the farmers indicate they never received any support[11] from organisations or interventions similar to Solidaridad and the FDW programme in sugarcane cultivation. At the time of the baseline, this was 98%, indicating that there is an increase in support for farmers, which mainly came from Solidaridad. Eighty-two per cent of the farmers indicate they were interested in receiving training on sugarcane cultivation, whereas 100% of the farmers were interested at the baseline. This shows that fewer farmers are interested in receiving trainings. Most of these are from Mill 1, where a share of the farmers have already received training. This indicates that farmers might either be fully satisfied with the training which they have already received, and do not demand more training, or they might not have been satisfied with the training. The training topics that the farmers mentioned being most interested in are: (i) good agricultural practices (70%), (ii) mechanisation of farm (63%), (iii) irrigation systems (59%) and trash shredding and mulching (iv). See Table 6.7 for all the results on training topics.

Table 6.7 Interest in training topics, %

Preferences for training	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Mechanisation of farm	15***	63	15***	50	33***	51	7***	83
Irrigation systems	43***	59	24**	31	92	96	55***	79
Good agricultural practices	55***	70	30***	56	93***	77	80	84
Intercropping	13***	19	14	11	38	31	1***	26
Trash shredding and mulching	47***	57	82***	49	15***	94	0***	54
Soil testing	61***	31	47***	17	87***	98	74***	25
Financial farm management	13**	18	11***	2	32***	81	8**	14

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

Unique training needs per mill

There are differences per mill. This is important for the specific mill to take into account in the design of the training modules. The percentage of farmers willing to receive a training in irrigation practices is still relatively low in Mill 1, whereas it is quite high in Mills 2 and 3. Interests in *trash shredding and mulching* strongly increased in Mills 2 and 3, while it decreased in Mill 1. Compared to 2016, farmers do seem to be more interested in mechanisation of farms and good agricultural practices. On average, most farmers are interested in more training topics in 2018 compared to 2016.

[11] This does not include governmental subsidies.

7

Agricultural practices

Improved agricultural practices and irrigation techniques

Improved agricultural practices are key to FDW's theory of change

It is assumed good agricultural practices lead to higher production levels, higher productivity, higher farm incomes from sugarcane and increase water efficiency. While this assumption is based on solid experimental proof from an agro-economic point of view (FDW Project Plan Solidaridad 2014 and Catalyst Business Case Report 2014), it is not yet certain this will hold for all farmers targeted by FDW. This chapter presents the agricultural practices and irrigation techniques of 2018 compared to 2016. For a good understanding of the changes in practices, this chapter follows the following structure: 7.1 Input use, 7.2 Row spacing, intercropping and trash shredding and 7.3 Irrigation practices. In Chapter 8 the next steps in the theory of change of productivity and farm income are elaborated upon.

Summary of current situation

All farmers apply chemical fertilisers and the majority (66%) follow the official guidelines of correct application. Most farmers (94%) also apply biological fertiliser in addition to the chemical variants. The main biological, or organic fertiliser, is cattle manure from farmers' own farm/cattle. A declining majority also applies pesticides (70%) and applying *both* chemical pesticides as well as organic pesticides is common practice (60%). If all input costs are compared, it appears that the largest share of the money spent on inputs is on both chemical and biological fertilisers. Row spacing is *3 feet* or more (90%). Intercropping and trash mulching hardly occurs. *Furrow irrigation (56%) and surface drip irrigation* (52%) are the predominant techniques. The following paragraphs present all results in depth and distinguish between both measurements as well as between mills and farmers.

7.1 Input Use

Farmers mostly use traditional setts; this did not change over time

Farmers mostly use traditional setts for planting new crops (87%) and 9% of them plants directly single bud setts. This is a decrease compared to the baseline, where 98% of farmers used traditional setts for planting new crops and where 41% directly planted single bud setts. Seed nurseries were hardly applied at the time of the baseline (by 1% of the farmers only), but they are slowly increasing in use in all three mills (9% at the mid-term). Of the farmers that use seed nurseries, shade houses are used most often by Mill 2 farmers. However, overall, there is still high potential to introduce the farmers to this practice, as use of seedlings saves one month of irrigation while also increasing productivity by minimising plant mortality, and it also saves seed usage (FDW Project plan Solidaridad 2014). The set variety is in 43% of the cases CO86032, but mainly in Mill 3. In Mill 2, most of the farmers now indicate that they use whatever the mill provides, whereas 70% of these farmers indicated using CO86032 in 2016. Also in Mill 1 49% of the farmers use whatever the mils provides them with.

94% of farmers use chemical and biological fertilisers

All farmers apply chemical fertiliser and 94% use both chemical and biological fertiliser. In Mill 3 the use of biological fertiliser was relatively low in 2016, but increased from 59 to 88% in 2018. The method of applying fertiliser stayed roughly the same, with 93% of the chemical fertiliser now being applied by broadcasting and 19% via irrigation water. The frequency of chemical fertiliser application is decreasing somewhat, with the percentage of farmers applying chemical fertiliser twice per season increasing from 22 to 39%, and the percentage of farmers applying chemical fertiliser four times per season decreasing from 23 to 11%. With regards to biological fertiliser, frequency is

increasing, as 51% of farmers now applies it 2-3 times per season, against 28% of farming applying biological fertiliser at the same frequency in 2016. The source of biological fertiliser remained unchanged and is still in most cases (81%) the own farm and in some cases the mill (12%). Cattle manure is still the predominant biological fertiliser but its use is declining in all three mills, whereas the use of compost and press mud is increasing in all mills. In Mill 2 and Mill 3, over half of farmers now use compost. All three types are part of biological fertiliser and as such stimulated by the programme (Table 7.1)

Application guidelines are more often followed

The share of farmers following the government's or the mills' guidelines increased significantly from 20 to 66%. Most of the farmers in Mill 1 (83%) and Mill 2 (87%) follows the guidelines. In Mill 3, the share of farmers applying the guidelines also increased significantly, but as only 38% of Mill 3 farmers follow them, further improvements can be made.

Table 7.1 Application of fertiliser, %

Fertiliser	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Chemical fertiliser	100	100	100	100	100	100	100	100
Follows recommendations[12]	20***	66	13***	83	87	87	3***	38
Biological fertiliser	81***	94	98	99	84***	96	59***	88
Of which								
Cattle manure	98***	93	100***	98	87*	96	98***	86
Compost	2***	30	1***	8	1***	56	3***	50
Press mud	6***	13	7***	11	12	15	2***	15
Of which source:								
Own farm	84	81	97**	93	69***	96	65	57
Other farmers	2	5	3	3	0	0	0	11
Mill	12	12	17***	3	12***	36	1***	16
Government	1***	6	2***	11	0	1	0	2

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

[12] Governmental/ mill guidelines on application of chemical fertilizer.

Mill 3 farmers are strongly decreasing their use of pesticides

Pesticides were applied by 95% of the farmers at the time of the baseline, but the results of the mid-term survey show that this has decreased to 70% of the farmers. This change is largely due to a strong decrease for Mill 3 farmers. Their pesticide application dropped from 99 to 23%. Overall, the use of chemical pesticides only is decreasing, and the use of biological pesticides or both chemical as well as biological pesticides is increasing. Mill 1 and Mill 2 farmers less often reported pest and disease as a challenge, while Mill 3 farmers reported this more often. It would be good to check how the decline in pesticide use in Mill 3 relates to the increase in pest and disease as a challenge. Overall there is a slight decrease in preventive application and an increase in curative application. The latter is especially prominent for Mill 3. Application frequencies did not change a lot since 2016, with the majority of farmers applying fertiliser 2-3 times a year (Table 7.2)

Table 7.2 Application of pesticides, %

Pesticides	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Farmers applying pesticides	95***	70	100	99	99	100	88***	23
Of which:								
Only chemical	75***	35	75***	32	16	11%	99***	88
Only organic	0***	5	1***	5	1	0	0***	9
Both	25***	60	24***	62	83	89	1	3
Of which:								
Preventive	19*	16	21*	15	3***	26	25***	3
Curative	32**	38	23***	39	0	0	59***	97
Both	48	46	56**	46	97***	74	16***	0

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

Input costs per tonne on all types of inputs are decreasing

To examine the absolute and relative use of different types of inputs, we use the money spent on different types of agricultural inputs per tonne of produced sugarcane per mill (Figure 7.1). Input expenditures decreased across the board, but mostly for Mills 2 and 3. Total input costs for Mill 2 (INR

605 per tonne) and Mill 3 (INR 679 per tonne) are now almost equal, whereas input costs of Mill 1 (INR 277 per tonne) is still lower. Table 7.3 shows the share of money spent on each type of input. The largest share of the money spent on inputs is on fertiliser, both chemical and biological. Compared to 2016, more money is spent on biological fertiliser, and relatively less on chemical fertiliser.

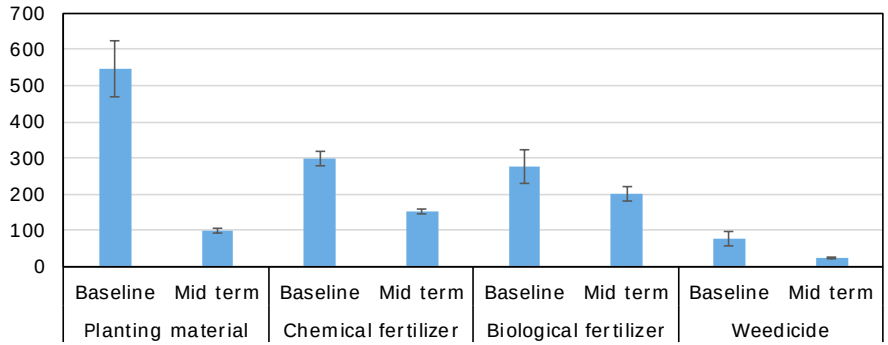

Figure 7.1 Money spent on inputs in INR[13]

Table 7.3 Share of money spent on inputs, %

Money spent on inputs	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Planting material	43***	22	38***	28	47***	24	49***	15
Chemical fertiliser	33***	40	45	45	25***	34	20***	35
Biological fertiliser	19***	32	13***	20	22***	36	25***	45
Weedicide	5***	6	4***	6	7**	5	6	6
Share chemical of total fertiliser	67***	58	79***	69	57**	51	57***	46

*** (α = 0.01), ** (α = 0.05) and * (α = 0.1)

[13] The graph shows not only the averages (the bars) but also the errors (vertical lines). Error bars are used to compare visually two quantities and determines whether differences are statistically significant.

Costs of purchased biological fertiliser per tonne decreasing, but still higher compared to chemical fertiliser

Biological fertiliser is usually obtained for free from the own farm and in some cases from the mil, the government or other farmers. The farmers who do purchase manure or other biological fertiliser (e.g. from the mill or other farmers) reported high costs during the baseline (443 INR per tonne), but these costs decreased to INR 219 per tonne during the mid-term. In the same period the price for chemical fertiliser per tonne decreased almost twice as much. This may have an influence on the uptake of biological fertilisers strived for by the project.

7.2 Row spacing, intercropping and trash shredding

More farmers are applying correct row-to-row spacing

Correct row-to-row spacing is an important agricultural practice. The standard for a good agricultural practice according to Solidaridad is 3 feet with regular irrigation and 4 or more with drip irrigation. At the baseline 59% of farmers applied right row-to-row spacing, whereas at the time of the mid-term this share increased to 79%. Therefore, more and more farmers seem to comply with these standards.

Intercropping still hardly occurs

Intercropping is still hardly applied. Compared to 2016, there is even a slight decline; only 1% of the farmers do intercropping in 2018. Intercropping is an important element in the training on good agricultural practices, but farmers generally do not seem very interested to be trained in intercropping. It is important to discuss with the farmers why they do not intercrop and use that knowledge in the design of the training how to stimulate this practice.

Burning of trash getting more common; even though trash shredders are increasingly available

Burning the trash after the harvest has negative implication for the organic matter content and water conservation in the soil.[14] The burning of land and

[14] FDW Project Plan Solidaridad, 2014.

trash after harvest is, however, done by even more farmers. Especially in both Mill 1 (from 88 to 96%) and Mill 3 (from 42 to 86%) and it does not occur at all in Mill 2 (Table 7.4). The increase of trash burning in Mill 1 and Mill 3 is remarkable, as farmers associated with these two mills also indicate sharp increases in access to trash shredders. Only 1% of the farmers had access to a trash shredder for trash mulching in 2016, against 28% of farmers in 2018. In Mill 1, nobody used to have access to trash shredders, but now 42% of farmers is able to access them and in Mill 3 this changed from 1 to 11%. In Mill 2 still hardly anyone has access to trash shredders.

Table 7.4 Trash burning

	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Trash burning	59%***	79%	88%***	96%	5%	4%	42%***	86%

Farmers with larger farms and with shorter time horizons more often burn trash

Aside from the command area and training, farm or household characteristics may also determine whether or not farmers adopt certain agricultural practices. To investigate this, we run a regression analysis to explain use of burning (yes or no) by the farm and household characteristics as described in Chapter 6. There are a few characteristics influencing the habit of burning. First of all, farmers with a shorter time horizon more often burn their fields, which makes sense as burning of the fields is the fastest way to clear the land, but the negative effects are more clear at a longer term. Vice versa, we find that if farmers are more willing to invest, they are less likely to burn trash. This make senses as costs are involved in shredding trash instead of burning, so an investment should be made. Moreover heads of the household less often indicate to burn their fields. Finally respondents with more sugarcane land more often burn land after harvest.[15] This can be explained by the fact that trash shredding has costs per acre and costs increase if land size is high. So to save costs big farmers may prefer to burn instead of the shred. In addition to that, key resource persons underlined the strong cultural practice of burning land, it is very deep rooted to do so and it will take time to change that habit, even if technology is available.

7.3 Irrigation systems

Irrigation techniques influence water use efficiency and productivity

Improving irrigation systems is another key concept in the intervention logic which should in the first place lead to increased water efficiency, but also to higher production levels as leaching of soil nutrients could be prevented with a well applied drip irrigation systems. Four types of irrigation systems are applied in the command areas of the mills. Furrow irrigation is the most applied system, which is also the most common method of water delivery in sugarcane growing in India (FDW Project Plan Solidaridad 2014), but has low water efficiency and harms soil in the long run by leaching soil nutrients. Surface-drip irrigation is more water efficient compared to furrow as it eliminates conveyance losses and percolation losses and can boost the yield by more frequent water delivery. Sub-surface drip irrigation is installed in the root zone and drip irrigation with fertigation combines drip irrigation with fertiliser.

Access to water change

We asked the farmers their perception on access to water compared to 2016. Table 7.5 shows the statements and the number of farmers in % who agreed. There are not only striking differences per mill which could explain some of our findings, we also see the deterioration in water availability (Statement 2). Especially for Mill 3 (94% agrees), and Mill 1 (51% agrees) natural water availability deteriorated. Interestingly, at Mill 2 the majority (58%) of farmers says natural water availability improved because of access to a canal. For them, the water was made available to the farmers via a canal (due to a canal project by the government). At Mill 1, the canal water is restricted (also due to the Kaveri river dispute) water availability has been fairly restricted.

[15] Not robust to different estimation methods.

Table 7.5 Change in water availability

Statement / % of farmers agreeing	Total	Mill 1	Mill 2	Mill 3
1. Natural water availability for irrigation is the same	27	47	19	5
2.Natural water availability deteriorated	64	51	23	94
3.Natural water availability improved because of access to canal	9	2	58	1

Surface drip and drip combined with fertigation increasingly popular among farmers

Figure 7.2 and Table 7.6 provide an overview of the used irrigation systems by the farmers. They show that overall, fortunately the use of furrow irrigation is falling, whereas the use of surface drip irrigation and drip irrigation combined with fertigation is increasing. In Mill 1 however, the use of furrow irrigation is still most predominant, with 100% of the farmers applying furrow irrigation. Surface drip is most common in the other two mills, with 89% of Mill 2 farmers and 98% of Mill 3 farmers applying surface drip irrigation.

Water scarcity in Mill 1 seems to increase, yet Mill 1 farmers continue to use and prefer furrow irrigation

All farmers of Mill 1 use predominantly furrow irrigation, despite its lower water efficiency. In 2016, the share of farmers in Mill 1 who consider the unavailability of water as a challenge, was much lower compared to the other mills. However, in 2018, this share has increased sharply for Mill 1 (from 46 to 87%). It is therefore surprising that only in Mill 1, the majority of farmers (97%) still sees furrow irrigation as their preferred irrigation system. In the other mills, nearly nobody prefers furrow irrigation anymore. Moreover, the interest in irrigation systems as a training topic is still lowest in Mill 1 (see Table 6.7). This might be because farmers in Mill 1 are unaware of the benefits of drip irrigation or because of the lower shares of subsidies for drip in this mill.

Table 7.6 Irrigation systems used 2016 and 2018, share of farmers in %

Irrigation systems	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Furrow irrigation	69***	56	97***	100	53	45	40***	6
Surface drip irrigation	8***	52	1***	5	47***	89	3***	98
Subsurface drip irrigation	1**	2	1	3	0	0	1***	2
Drip irrigation combined with fertigation	25***	37	2	2	21	31	56***	83

Drip irrigation is financed with external source: governmental subsidy

Ninety per cent of the farmers who are currently applying drip irrigation started using it since 2008. *Subsidies* are the main financial source that finance drip irrigation. The amount of people that indicate to use drip irrigation is more than 6 times higher compared to 2016 and the share of farmers indicating they financed their investment by means of a subsidy increased from 60 to 90%. There seems to be a very clear incentive from the government to apply drip irrigation. Also the majority of farmers in both these mills express an interest in training on irrigation systems. This shows that farmers in Mill 2 and 3 might therefore be both motivated as well as financially supported to use drip irrigation. The results from the data are confirmed with contextual information provided by key stakeholders. There is a difference between Karnataka and Telangana states in the procedure of subsidy provision for irrigation investments. It turns out to be more easier and less risky to apply for subsidy in Telangana as the farmer only pays the 10% upfront and the government immediately adds the 90% of the investment. A farmer in Karnataka has to pay the full amount for the irrigation investment and applies for subsidy after the purchase. As a consequence, only the farmers who are able to pay the full amount upfront are able to invest in the irrigation system. In addition, it is risky for a farmer to do so as he is not 100% ensured of subsidy, the government only decides afterwards to grant the application. The results show that this state policy has huge implications for adoption of drip irrigation technology.

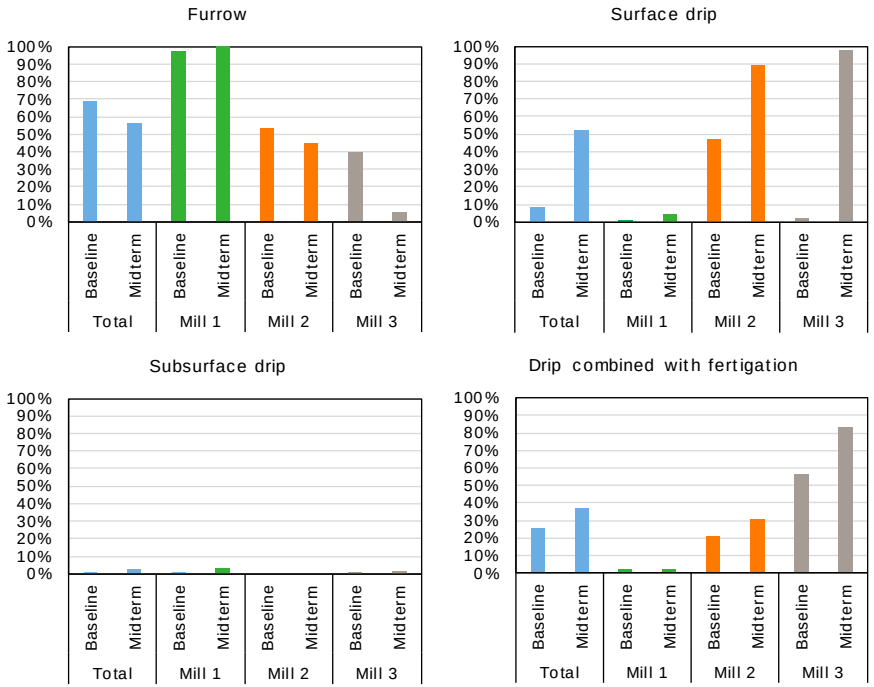

Figure 7.2 Irrigation systems applied 2016 and 2018

Education, sugarcane importance and risk attitude are positively related to adoption of drip irrigation, experience negatively.

In addition to subsidies, farm or household characteristics may also determine whether or not farmers adopt drip irrigation. Education level, size of land owned used for sugarcane cultivation, and membership in a sugarcane farmer group all increase the likelihood farmers adopt drip irrigation. The education level may increase the awareness of farmers that drip irrigation is necessary in the long term; or may facilitate farmers to implement it. The more land a farmer owns, the higher the probability that the farmer uses drip irrigation. This is in line with the expectation that less land can be a constraint in the application of good agricultural practices or irrigation. Also farmers for whom sugarcane contributes to more than 75% of their income more often apply drip irrigation. Finally, farmers that are more willing to invest are more likely to apply drip irrigation. However, the years of experience in sugarcane cultivation are negatively related to drip irrigation use. It could be the that these farmers are less likely to change their practices as they have already been farming in the same way for a long time. It could also be that these farmers are relatively older which has often a negative relation with change in adoption of new practices.

Farmers that were engaged in the programme are more likely to apply drip irrigation

Although a small number of farmers, the Mill 1 farmers that indicated having engaged with the programme (through trainings, access to demonstration plots, assistance from the lead farmers or though assistance from the extension worker) more often apply drip irrigation. This is a positive sign that the programme seems to be changing these farmers' practices with regards to drip irrigation.

Maintenance of irrigation systems is improving

Maintenance of irrigation systems is crucial for its duration functionality. According to the implementing parties, good maintenance of the drip irrigation systems is a serious challenge for the farmers for three reasons: a) they do not have the knowledge and expertise for maintenance and they b) they do not see the relevance of it and/or c) they do not have the financial resources. Whereas 35% of respondents in 2016 indicated that their surface drip irrigation system was in good condition, this number now rose to 59%. For drip irrigation with fertigation this rose from 38 to 56%. Although the condition of the irrigation systems, as indicated by the farmers themselves, seems to be getting better, there is still room for further improvement.

Satisfaction with current irrigation system may hamper uptake of drip irrigation

Eighty-three per cent of the farmers who use furrow irrigation indicated that it is their *preferred* irrigation method, versus 93% in 2016. The remaining 17% of farmers are mainly interested in surface drip irrigation and drip irrigation with fertigation. Even though this is already an improvement, the vast majority of furrow irrigation users still does not seem to be willing to change practices. At the same time, the number of farmers that know about drip irrigation rose from 78% to 100%, which indicates that a lack of knowledge about the system is not the main reason why users of furrow irrigation do not switch.

7.4 Mechanisation

Most farmers apply mechanisation to at least one activity

A new component of the FDW programme is about mechanisation and the provision of equipment. We see that 94% of farmers indicate to have at least one production activity mechanised. The farmers who do not have any activity mechanised belong to Mill 1. The main reasons given are: the high price of power tillers and spare parts (100%), mechanisation is too expensive (92%), no machinery available (65%).

Harvesting, intercultivation and land preparation activities most often mechanised

Figure 7.3 shows the share of farmers that mechanised each activity for the top 6 activities in terms of mechanisation. Harvesting, intercultivation and land preparation are most often mechanised. The majority of the farmers that mechanises an activity does so using borrowed equipment. The only exception are water meters, which are more often owned than borrowed.

Plant protection, incorporating trash and ratoon managing were most often mechanised within the last two years

We also asked respondents who indicated that they mechanise a certain activity since when they have been doing this. The activities that were most often mechanised within the last two years (2016-2017) are plant protection (29%), trash incorporation (27.7%) and ratoon managing (24.6).

Water meters have been introduced in Mills 2 and 3

As a part of the project, water meters have been introduced to farmers, with which they can measure the water content of their soils. Figure 7.4 shows the large differences between mills with regards to water meter use. In Mill 1, only 1 farmer is using water meters, whereas in Mill 2, everyone is using them. In Mill 2 89% of farmers is using them with borrowed equipment. Finally, in Mill 3, 70% of farmers are using water meters, of which the majority has their own equipment. The project also promotes soil moisture indicators, but only 1 person out of the entire sample across 3 mills has used one. Interestingly, the Mill 3 farmers have hardly been exposed to the project activities. This means that the water meter has been introduced already among these famers. A positive trend but it cannot be related to the FDW project.

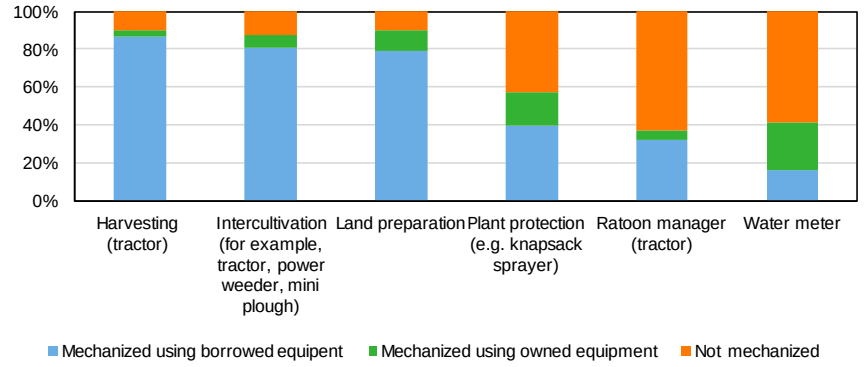

Figure 7.3 Mechanisation of different activities

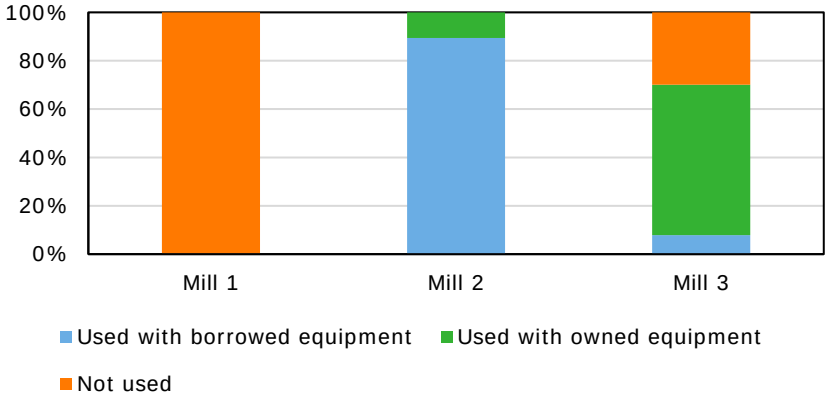

Figure 7.4 Use of water meter

8

Productivity and costs of sugarcane

Productivity and costs of sugarcane

Improved agricultural practices are to reduce costs and increase quality and productivity

Following the intervention logic, improved agricultural practices, input use and irrigation systems are the immediate outcomes of the intervention which would lead to the intermediate outcomes of higher crop productivity, lower production cost, lower water use and higher quality and price for the crops. This chapter examines these intermediate outcomes. Water use is outside the scope of this research.

Summary of current situation

The average crop productivity of total land cultivated with sugarcane was around 44 tonnes per acre in 2016 and in 2018. But only 43% of the farmers were satisfied with their harvest. Approximately 68% of the farmers reported an increase in quality of their cane produce. The average total production cost is *INR 49,572 per acre* and farmers received on average *INR 2,748 per tonne* of sugarcane produced.

8.1 Sugarcane productivity

Average productivity is stable; but large difference across Mills

The productivity per acre is based on *owned and leased* sugarcane area. In 2016 productivity was 43.8 tonnes per acre and it increased slightly to 44.1 tonnes in 2018. In Mill 1 there is a significant decrease from 47.4 to 40 tonnes per acre, but we see an extreme increase in productivity in Mill 2: from 25.9 to 53.6 tonnes per acre (Figure 8.1). As indicated in Chapter 6 on farm characteristics and production, the high decrease of supply of the Mill 1 farmers can be related to the problematic relations the farmers had with the mill (i.e. late or no payment of cane). There might have been side selling at Mill 1 farmers or the increased their own activities of juice making. Contrarily, the high supply of Mill 2 farmers can be related to their point of departure in 2016. At that time, Mill 2 farmers were lagging behind in productivity so there absolute increase is tremendous but relatively their current productivity levels are comparable to the other two mills. For all mills, the average is well above the average national crop productivity (Agricoop 2018, Statista 2018).

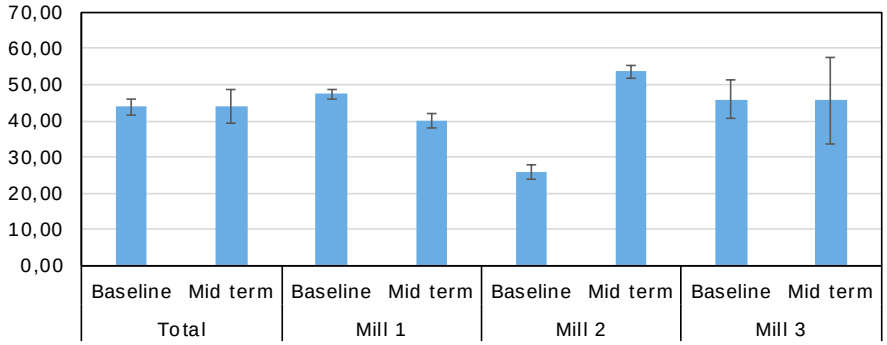

Figure 8.1 Sugarcane productivity per acre (in tonnes)

Sugarcane acreage is related to lower productivity, there is no relation between productivity and several agricultural practices

We find that owned and leased sugarcane area is negatively and significantly related to productivity, indicating that the smaller the sugarcane area, the more intense the cultivation. As expected, there is also a high degree of correlation between the mills and average productivity. Drip irrigation (when properly used) is expected to reduce water stress and as such to increase yield through a more frequent and controlled water delivery. We do not find a significant relation between productivity and the use of drip irrigation or other important agricultural practices such as the use of chemicals or trash burning.

Productivity is positively related to a higher dependency on sugarcane and a higher level of education

We also see that farmers who depend for more than 75% of their income on sugarcane have higher productivity. As sugarcane farming is the main occupation of these farmers, it could be they invest more in their produce resulting in higher productivity. They might be able to pay more attention to their sugarcane production as they are more dependent on their sugarcane income, compared to farmers who earn more income from other sources. Finally, farmers with higher levels of education have higher productivity. It could be the case that these farmers know better which practices increase their productivity, or how to apply them.

Satisfaction with yields is in line with actual yield

Overall, the share of farmers reporting to be satisfied with their production remained more or less the same. However, if we compare between mills, it shows that the share of farmers that are satisfied with their production slightly dropped for Mill 1 from 64 to 57%, and strongly increased from 6 to 42% for Mill 2 farmers (see A3.13). This more or less confirms the findings from the data which showed sharp increases in production for Mill 2 and a decline for Mill 1.

Sharp increase in sugarcane self-reported quality for Mill 2 farmers

At the time of the baseline, only 10% of Mill 2 farmers reported an increase in sugarcane quality over recent years. At the time of the mid-term this share increased to 69%. For Mill 1 farmers, perception of improvement in quality remained the same over the years. According to Mill 3 farmers, their sugarcane quality decreased. There is no clear explanation from the Mills to explain this increase. For Mill 2, it could be related to the fact that it is a relatively newer mill and it was easier to reach out to farmers and stimulate them to adopt the improved varieties, practices. Also at Mill 1 and 2, the extension staff of the mills made clear that the farmers have been regularly told about the improved varieties plus the training sessions have supported in making them more aware.

8.2 Production costs

The average production cost per acre is INR 49,572 per acre

The average total production cost is INR 49,572 per acre (Figure 8.3) and INR 209.10 per tonne (Figure 8.4). This includes costs for planting material, fertilisers, weedicides and hired labour. Own labour costs are not included. In 2018, a larger share of costs is used for hired labour than for inputs. In 2016 this was the other way around. This is true for costs per acre and per tonne sugarcane produced.

Total production costs per acre decline in Mill 1 and Mill 3, but increase in Mill 2

Figure 8.2 shows that costs per acre decreased from INR 58,460 per acre to INR 49,572 per acre. There are significant decreases for Mill 1 and Mill 3, although costs per acre and per tonne vary a lot between farmers. Only in Mill 2, the total costs per acre significantly increased. Overall, the labour costs per acre increased, whereas the input costs per acre decreased. We see an almost similar pattern for production costs per tonne. The increases in labour costs might be partially explained by the high unavailability of labour (resulting in higher wages), which almost all farmers indicate to be a challenge.

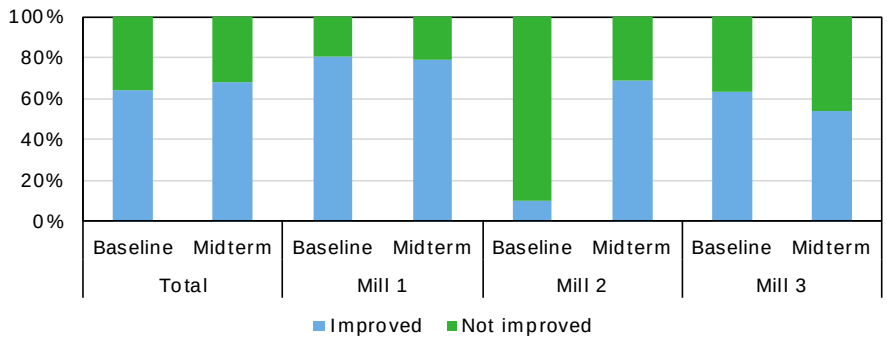

Figure 8.2 Change in self-reported sugarcane quality over recent year

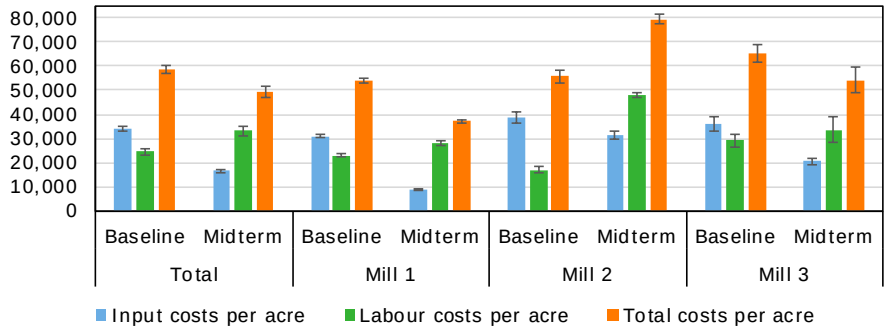

Figure 8.3 Labour and input costs per acre

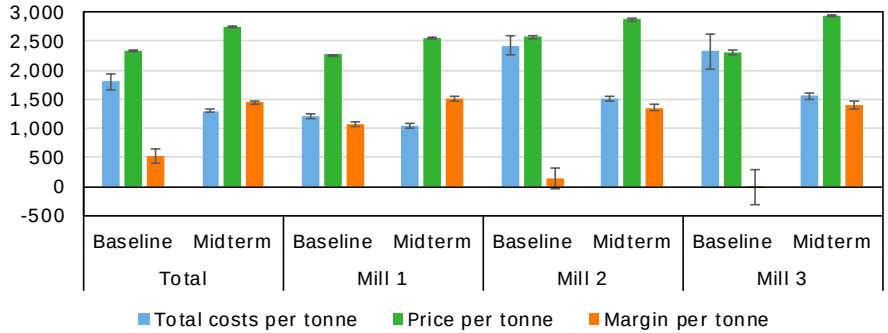

Figure 8.4 Sugarcane production costs and price per tonne

8.3 Sugarcane price

Sugarcane prices above the Fair and Remunerative Price for all three mills

In 2016, farmers received on average INR 2,324 per tonne of sugarcane (Figure 8.4). This was just above the Fair and Remunerative Price (FRP) of 2016-2017 of INR 2,300 per tonne, well below the State Advised Price (SAP) of INR 2,850 per tonne.[16] The average price received in 2018 increased to INR 2,748, which is above the FRP of 2017-2018 of INR 2,550. The price received per tonne increased significantly for all three mills. Overall, fewer farmers indicate low price of sugarcane as a challenge.

[16] http://www.thehindu.com/news/cities/chennai/sugarcane-sap-fixed-at-rs-2850-per-tonne/article8094351.ece

9

Farm income of sugarcane

Farm income of sugarcane

Lower production costs, higher prices and yields are expected to increase profits

The immediate and intermediate outcomes would lead to the ultimate outcomes in the theory of change, which are increased farm incomes and water efficiency of the farmers. This chapter examines total farm incomes from sugarcane, as well as income per acre and per tonne of sugarcane produced of the harvest in 2018.

Summary of current situation

Results show that the average farm income from total cultivated sugarcane land was INR 176,105 in 2018, which is not satisfactory for 26% of the farmers. Owned sugarcane acreage is related to higher profits, whereas leased area is related to lower profits.

Average farm income from sugarcane of INR 176,000 is above GDP

The average farm income from owned and leased sugarcane land of the farmers in 2015/2016 was INR 84,969, and it rose to INR 176,105 in 2017/2018. This farm income is above the GDP which is, according to the World Bank (2017) USD 1,942 (INR 125,249) per capita. The term farm income is used instead of profit as family labour and opportunity cost are not taken into account. This means that the actual margins, profits, are lower.

Differences between mills in farm income per tonne and acre decrease

The total farm income from sugarcane, per acre and per tonne used to be the highest in Mill 1 compared to Mills 2 and 3 (Figures 9.1 and 9.2). At the time of the mid-term survey, the other two mills have caught up, and Mill 3 now has the largest income per acre. The large differences in income between both measurements are mainly caused by the differences in supply. As described in Chapter 6, total supply halved for Mill 1, whereas it doubled for Mills 2 and 3. Total farm income from sugarcane strongly decreased in Mill 1, whereas it increased by about 500% for Mill 2 and by about 800% for Mill 3.

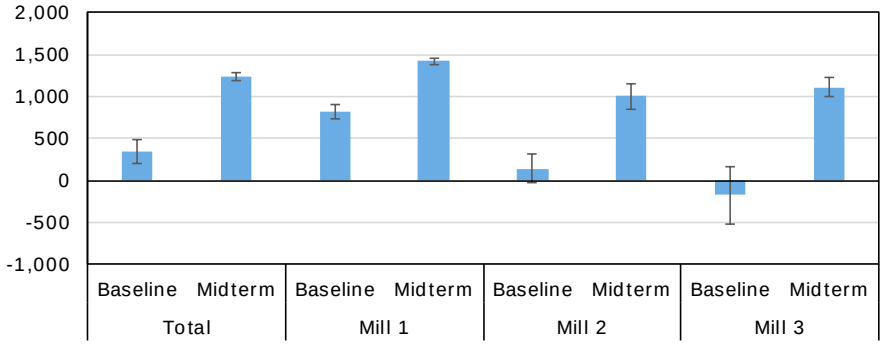

Figure 9.1 Farm income per tonne

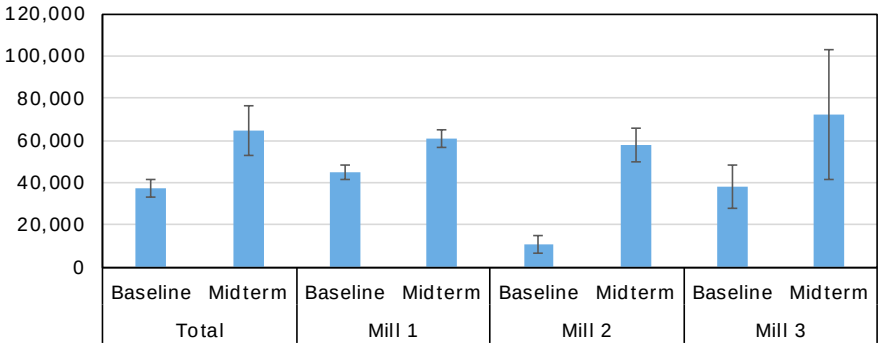

Figure 9.2 Farm income per acre

More farmers are more satisfied with their income from sugarcane

The share of farmers reporting to be dissatisfied with their income from sugarcane declined from 46% to 26%. Forty per cent now report to be satisfied, and 35% are neutral. Increases in satisfied farmers were highest for Mill 1. Overall, the majority of farmers in Mill 1 is now satisfied with their sugarcane income, and the majority of Mill 2 farmers are neutral with regards to their income from sugarcane satisfaction. Regardless of the large increases in sugarcane income as measured by the survey, the majority of farmers in Mill 3 remain to be dissatisfied with their income from sugarcane.

Owned sugarcane acreage is related to higher profits, whereas leased area is related to lower profits

The acreage owned for sugarcane has a positive relation with gross total profit and profits per tonne and per acre: the larger the owned area for sugarcane is, the higher incomes are. However, this is not the case for leased sugarcane area. For leased sugarcane area, we find a negative relation with profits.

Other sources of income become increasingly important

We have seen in Chapter 6 that farmers are becoming less dependent on sugarcane as their main source of income. When asked for other sources of farm and non-farm income we see significant changes compared to 2016 (from 69% to 73%). Figure 9.3 presents the average differences between the years for all farmers. The main changes occur among farmers of Mill 2, they have received more income from other farm related activities than sugarcane production (e.g. diary) (Table 9.1). Also the share of income from non-farm activities increased over the year from 3% to 34% (Figure 9.4 and Table 9). Mainly farmers from Mill 1 increased their non-farm income activities. Income from remittances decreased though significantly, especially at Mill 1 so there could be a relation between less remittance and more other non-farm activities.

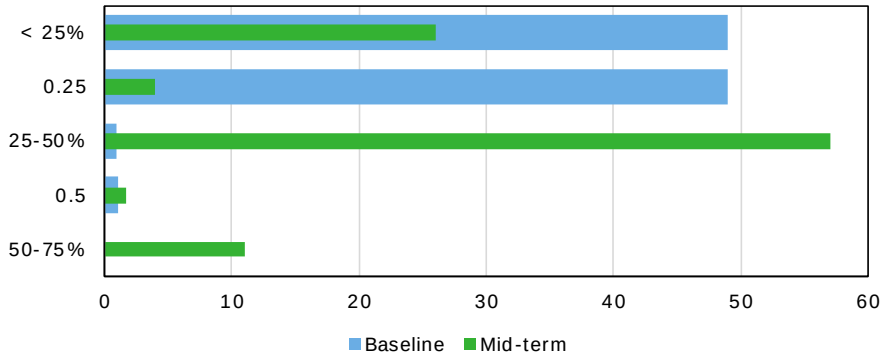

Figure 9.3 Percentage of income from other farm-related activities per mill

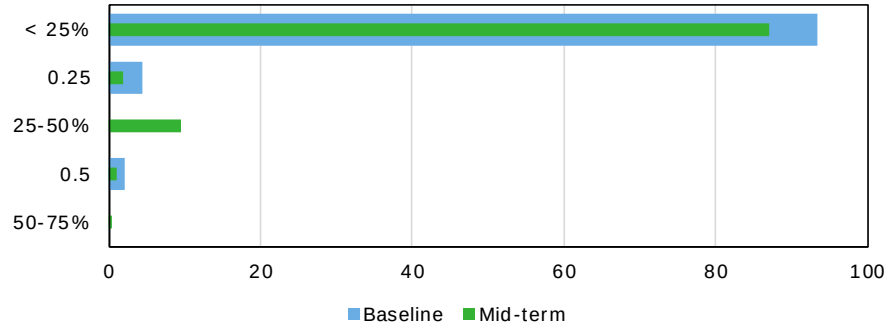

Figure 9.4 Percentage of income from non-farm activities per mill

Table 9.1 Other farm income sources, %

Income sources	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Other farm activities	69	73	100	99	2	42	55	52
Of which:								
Other cash crops	80	66	76	69	0	0	89	79
Dairy	71	29	96	23	0	38	16	42
Husbandry	45	57	63	82	100	43	1	3

Table 9.2 Non-farm income sources, %

Income sources	Total		Mill 1		Mill 2		Mill 3	
	2016	2018	2016	2018	2016	2018	2016	2018
Non-farm activities	3***	34	6***	49	1	0	12***	27
Of which:								
Government	15**	2	13***	0	100	0	0	7
Family member works for government	11	23	9*	27	100	0	0	14
Employee	19	26	13	21	100	0	33	38
Family member As employee	26	36	21**	47	0	0	67**	11
Remittances	52	13	57***	6	100	0	0	31

10

Conclusions and Recommendations

Conclusions and Recommendations

Sugarcane remains vital for farmers' livelihoods although dependency is lower than in 2016

In 2016, we found that for almost all farmers (94%), sugarcane accounted for 75% or more of their income. Two years later, this percentage has dropped to 61%. For most farmers sugarcane thus became less important. We consider this a good trend, as financial reliance on one crop in general increases farmers' vulnerability. Moreover, reliance on sugar – or other water intensive crops – will have negative consequences on water use. However, we do not observe this trend for all farmers. In fact, in Mill 3, we see quite a few farmers that became more dependent on sugarcane in 2018. Therefore, we recommend to address this in the training, in particular in the command area of Mill 3.

Uptake of better agricultural practices is at stake because of a decreasing willingness to invest

Farmers became more sceptical towards investments in general (from 59% to 74%) and in new agricultural practices in specific (from 58% to 81%). Farmers thus seem increasingly less likely to take a risk when investing in agriculture which will influence the uptake of better agricultural practices that requires investment in terms of time, labour and/or capital. Farmers do generally trust in the advice of the mill and this increased since 2016 (from 77% to 91%). The mills are key partners in the FDW project: they provide training on preferred practices and (irrigation) techniques and coach in cultivation. Therefore, trust in the mills is an important enabling condition for uptake. We recommend to explore further what is required for farmers to make the investments required. This may be through additional (focus group) research, but also by discussing it in the training with the farmers in more detail. Given the high level of trust in the Mills, they may be in a good position to do so.

Leasing land is gaining popularity and farmers are usually not in farmer groups, which may both hamper adoption of good practices

Leased land as well as land for other crops are on the rise. The latter corresponds to the decrease in dependency on sugarcane and is considered positive. However, the increase in rented land, especially for Mill 2 and 3, might have negative effects on investments in irrigation techniques and systems. Additionally, It remains uncommon in all command areas for sugarcane farmers to be organised in a farmer group: 14% of the farmers are member of a farmer group. As people in Mill 2 and 3 have not been trained yet, the project roll-out in these mills could benefit new organisational structures in terms of outreach and to stimulate adoption of practices.

Unavailability of labour and water shortage remain the key challenges

There is a significant increase in the number of farmers that report unavailability of labour as a challenge (from 74% to 98%). The project's components on mechanisation and entrepreneurship addresses this to further enhance the provision and availability of mechanised farming to the farmers. Compared to 2016, farmers do seem to be more interested in mechanisation of farms (from 15%-63%). We therefore recommend to prioritise this in all training programme. The number of farmers that report water shortage as a challenge has also increased, but this is mainly caused by an increase in Mill 1 farmers reporting this as a challenge. The fact that the percentage of farmers willing to receive a training in irrigation practices is still relatively low in Mill 1, therefore does require more attention. Most other challenges are, on average, reported less frequently by farmers in 2018 compared to 2016. An exception to this is the lack of facilities for soil testing, which farmers in Mill 1 and Mill 2 report more frequently. We recommend to discuss this with farmers of both Mills in more detail to understand changes and possible solutions.

Increase in the use of more productive and more environmental friendly inputs but too early to contribute to the FDW project efforts

While there is ample room for better input use, we do see positive developments. First of all, we see that the use of seed nurseries (versus using traditional sets) increased from 1% to 9% in 2018. To further reduce irrigation required as well as plant mortality, we therefore advice to continue promoting the use of seed nurseries. Second, more farmers indicate to follow the

government's or the mills' guidelines in terms application of chemical fertilisers (an increase from 20% to 66%). All farmers still use chemical fertilisers, but an increasing number also uses biological fertiliser (an increase from 81% to 94%), which is stimulated by the programme. To enable a further decrease we recommend to look into options to reduce the price of biological fertiliser relative to chemical fertiliser even more. The fact that the use of chemical pesticides only is decreasing, and the use of biological pesticides or both chemical as well as biological pesticides is increasing is also a positive sign.

Intercropping and trash shredding remain uncommon

Farmers that use drip irrigation almost all apply correct row-to-row spacing. However, intercropping still hardly occurs (only 1%). It is important to discuss with the farmers why they do not intercrop and use that knowledge in the design of the training how to stimulate this practice. Moreover, we also find that burning of trash is getting more common; even though trash shredders are increasingly available. To prevent negative implication for the organic matter content and water conservation in the soil, we recommend this topic is highlighted in the training programme, but also to explore what incentives are in place to prevent farmers not to burn trash.

Surface drip and drip combined with fertigation increasingly popular among farmers, but not for farmers from Mill 1

The use of surface drip irrigation and drip irrigation combined with fertigation is increasing which should lead to higher production levels and less leaching of soil nutrients. Surface drip is now common in two out of three mills; with 89% of Mill 2 farmers and 98% of Mill 3 farmers applying surface drip irrigation. However, while water scarcity in Mill 1 seems to increase, all farmers continue to use and prefer furrow irrigation – even though we see a positive relation to project participation for those few farmers that do adopt other systems as well. Moreover, the interest in irrigation systems as a training topic is still very low (24%). We recommend to discuss with farmers from Mill 1 whether they are indeed unaware of the benefits of drip irrigation and how to overcome the lack of subsidies from the government in this command area. Another topic for further discussion or research on the ground is that the financial subsidy for drip irrigation. This seems to be the main enabler for farmers investing in drip irrigation. However, Mill 1 farmers seem to have less access to these subsidies. The data provide a good starting point for policy discussions with the government on the subsidy policy in place. For Mill 2 and 3 the focus would be on further improvement in maintenance; 2 out of 5 farmers still indicate the system in not in a good condition.

Improved agricultural practices are to reduce costs and increase quality and productivity

The average crop productivity of total land cultivated with sugarcane was around 44 tonnes per acre in 2016 and in 2018. There are however large differences across Mills, with Mill 1 experiencing a strong decrease and Mill 2 a strong increase. Only 43% of the farmers were satisfied with their harvest. Interestingly, we do not find a significant relation between productivity and several of the agricultural practices promoted. This may mean that farmers are not adopting the practices in the right way, or simply that other factors are more influential when it comes to productivity (such as the area of sugarcane or other crops owned, side selling (Mill 1) or very low production levels at the start (Mill 2).

Costs for labour increased, but overall production costs decreased for two out of three mills

The average total production cost is INR 49,572 per acre and INR 209.10 per tonne. This includes costs for planting material, fertilisers, weedicides and hired labour. Production costs per acre declined in Mill 1 and Mill 3, but increased in Mill 2 In 2018. We also see a larger share of costs is used for hired labour than for inputs. The increases in labour costs might be partially explained by the high unavailability of labour (resulting in higher wages), which almost all farmers indicate to be a challenge. The recent focus on mechanisation may therefore indeed be really worthwhile for sugarcane farmers. The average price increased from INR 2,324 in 2016 to INR 2,748 in 2018, which is above the FRP of 2017-2018 of INR 2,550. The price received per tonne increased significantly for all three mills (also when taking into account inflation).[17] Overall, fewer farmers indicate low price of sugarcane as a challenge.

[17] With cumulative inflation the price would be INR 2,496 so the current price of INR 2,748 is quite good.

Average farm income from sugarcane has increased for 55% of farmers

Lower production costs, higher prices and yields are expected to increase profits. Results show that the average farm income from sugarcane land increased from INR 84,969 in 2016 to INR 176,105 in 2018 for 55% of all farmers. This is a strong increase for all Mills in terms of total income, but also per acre and per tonne. In addition, we find that other sources of income become increasingly important; for Mill 2 this mostly relates to other farm related activities and for Mill 1 mostly related non-farm income activities. Altogether this means that sugarcane farmers are better off now than they were in 2016, despite the fact that project activities have not yet fully materialised. The positive perspective is that the risk for financial dependency on one crop is more spread. From adoption perspective it can be more of a challenge to change farmer behaviour towards good agricultural practices as the incentive to change sugarcane cultivation or to invest in sugarcane can be less strong for farmers having various income sources.

Impact can be achieved with continued intensity and full commitment

To conclude, we believe though that with continuous intensity, tailor made approaches, wider implementation of planned activities and full commitment of all parties involved FDW is likely to achieve the desired impact. The final evaluation will offer more insights into the effectiveness of the roll-out of proven farming techniques and the delivery of farmers' training in the application of water-efficient drip irrigation, which leads to the use of good agricultural inputs and practices.

Methodological implications and way forward

The final evaluation should take place after completion of all the FDW activities. In addition, the moment of data collection should be comparable to the timing of the baseline and mid-term to ensure correct comparisons. The contextual and project challenges have implications for the chosen methodological design. First, the drop out is much higher than expected, 22% instead of 5%. The number of farmers participating is now 798 and it is crucial that this number does not decrease at the time of the endline (2020 or 2021). Second, the training schedule lags behind and the original idea of the pipeline approach is therefore challenged. It the number of farmers per cohort (training year) is too low to compare between years, we cannot plausibly contribute changes to the project. The endline data will reveal whether we can apply this contribution analysis. To mitigate the risk and to have some insights in contribution of the project activities to perceived changes we will enrich the survey data with qualitative data collection (interviews and focus group discussions).[18]

[18] The exact scope of the additional qualitative data collection will be defined at the moment of the endline and depends on the available resources.

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Appendices

The Appendices to this report can be accessed by following this link:
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