



Comparative Study of Micro Irrigation: Present Scenario, Adoption, and Future in Mewat

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The World Food Prize Foundation

2017 Borlaug-Ruan International Internship

S.M. Sehgal Foundation

Gurugram, Haryana, India

Summer 2017



THE WORLD
FOOD PRIZE

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Personal Introduction

If you happened to haphazardly pass over the cover page with intense anticipation for the research to follow, let me begin with an introduction; my name is Nick Battles. I am pursuing a dual degree at Iowa State University in both Global Resource Systems and Agriculture and Society as a first-year student (with additional studies pertaining to Learning and Leadership Sciences). If someone had asked me to predict my future majors and interests when I was a freshman in high school, they most certainly would not have received an answer that resembles my present-day. My enthusiasm for my major, my desire to make the world a more food-secure and fair place, and my love of agriculture would not exist were it not for the World Food Prize Foundation and its youth programs.



My journey with the World Food Prize Foundation (although, hopefully far from over) began during my sophomore year of high school. I was exploring different topics for my independent study class, in which I could study whatever my heart desired for a semester. My advisor for the class, Mrs. Cindy Bauer, brought the Iowa Youth Institute to my attention and laid out the path for me to get there. I was hooked. I chose to research malnutrition within India. Little did I know at the time, but that simple choice of what to do in an independent study class would eventually lead me to stepping off a plane in New Delhi, India nearly three years later to begin an entirely new research project, in an entirely new place, and on an entirely new adventure.



Not only was my initial research as a high schooler about India, but the country's name is within the name of my hometown: Indianola. Needless to say, it was meant to be. Indianola is a rather modest town, but I see it as a place full of phenomenal opportunity and even better people. As an Iowan, I have been surrounded by agriculture and the people involved with it all my life, yet never had I been thoroughly exposed to all that it encompasses, not to mention its importance, until my time at both the Iowa and Global Youth Institute. I attended in the fall of 2015.

Sir Fazle Hasan Abed was the laureate. Sam Harris was my group leader. Ambassador Kenneth Quinn was there. Secretary Tom Vilsack was there. President Joyce Banda was there. Each and every one of these people (and many others) played a part in educating me and entralling me to the point of no return. I could not have been better off for it. By being introduced to the world's biggest challenge, the people doing their part to find solutions, and Norman Borlaug's work, I gained an entirely new perspective on what it means to be from Indianola, Iowa and the newfound role I could have in this fight against the most significant challenge the world has ever known. What better way to do my part than through the Borlaug-Ruan International Internship, an incomparable opportunity to continue Norman Borlaug's legacy.



Program Background

The majority of my time in India was spent in Gurugram (formerly known as Gurgaon). At the heart of sector forty-four, one will find the beautiful, environmentally friendly, and motivational campus of S.M. Sehgal Foundation, also known as my host center for two months. The foundation's primary campus is set within a city that hardly existed not too long ago. Travel back a couple of decades and you would have found little more than a collection of villages. It is now a city of hustle, bustle, and seemingly endless skyscraper construction. Travel just an hour away and you will find the rural district of Mewat, the primary place for research, development, and outreach for Sehgal Foundation.

Backdrop aside, the foundation was founded by Suri and Edda Sehgal, two passionate and generous advocates for those in need around the world, especially in rural India (where Suri is from). The five primary programs its employees are engaged in are the following: good rural governance, water management, agricultural development, rural research, and community media. Their initiatives target over seven hundred villages within six districts and five states of India. Each program, reaching far and wide with specific projects, seeks to benefit the people in the most need, with a special emphasis on women and children. They understand that change takes time and use that knowledge to their advantage when creating "community-led development initiatives to achieve positive social, economic, and environmental change across rural India," (Sehgal). Other than the farmers I spoke with, I have yet to meet a group of people more dedicated, persistent, and inspirational than the hard workers of SMSF.

Luckily for an Iowa native like me, I received a project within the Agricultural Development program. It was an incredible chance to learn more about a topic so close to home, yet so universal while also doing productive work for the foundation. Much of this program's goal is to provide farmers with the knowledge and ability to farm sustainably. Whether it be through soil health, nutrient management, or irrigation, the farmers are engaged in better ways to farm.

With the exception of Padmavathi Arun's guidance and facilitation, Arvind Rana, the program leader of agricultural development, was the one person with which my project was organized, discussed, and completed. In addition to having a Bachelor of Science degree in Agriculture, his role at SMSF consists of the following: "Rural development program planning and implementation; value addition and innovative packaging, commodity procurement, strategic planning and value chain management, and agribusiness operations," (Sehgal).

Other than the village selection, general goal, and title of this research project, much of this endeavor was left to me. Never before had I been given such ample responsibility and opportunity to chart my own path in a project. It was extraordinarily exhilarating and terrifying at the same time. The questions asked, data collected, and established analysis was left to my own devices. All the while, however, Arvind provided the insight and wisdom that was necessary for me to expand my understanding of Indian agriculture beyond my wildest dreams.

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Foreword

It is rather apparent that water plays a role in the lives and decision-making process of farmers throughout the world. In India and specifically Mewat, access to water and how it is used are factors that frequently require more attention than others around the world are used to. Water is a constant element of thought in the minds of Indian farmers. By no means, however, is it the sole factor of farming. More goes into agriculture, quite obviously. With that said, there's no doubt water plays a role.

Subsequently, irrigation is not the only aspect attributing to farming decisions. Nonetheless, it holds significance in the realm of agriculture. Upon reviewing the findings that follow, it can be understood that the use of micro irrigation systems does indeed affect the decision-making process of farmers. Furthermore, numerous aspects of agriculture determine whether or not a farmer adopts micro irrigation systems. This study was completed in an attempt to use my perspectives, experience, and data analysis to assist S. M. Sehgal Foundation (SMSF) do its best work now and in the future.

Abstract

Micro irrigation systems can have a tremendously positive impact on a farmer's ability to save water, long-term cost, and increase output. Drip irrigation systems, although adopted less frequently, allow for a more incremental watering of crops directly to the roots. Sprinkler systems serve to reduce water use by efficiently creating irrigation similar to rainfall, spreading the small drops over a vast area. In recent years, there has been a slowing of the adoption of micro irrigation throughout India. Just about ten percent of the total area in India that is capable of its implementation is being used as such. That adoption rate is dismally slow when considering the state of water scarcity, especially in rural areas like Mewat that are often devoid of extensive infrastructure or developmental progress.

To best evaluate why some farmers readily adopt micro irrigation systems while others do not, one-on-one interviews and focus group discussions have been completed in two villages. These first-hand accounts have provided significant insight into the challenges that prevent farmers from adopting micro irrigation systems and the reasons behind why other farmers have made the investment. Analysis of the impact a system has on agricultural decisions has also been completed with the data received. Both villages have received similar support over the past two to five years, yet a disparity is seen in the number of farmers using the systems. Insights now

show that awareness, facilitation, support, time, crop selection, groundwater, subsidies, funding, or the lack of any of these factors can substantially impact a farmer's ability or decision to adopt micro irrigation. Obtaining this enhanced cognizance of the current situation in these villages allows for a more pointed approach by SMSF and others to effectively support and encourage the adoption of micro irrigation throughout Mewat and greater India.

Background

Micro Irrigation

To best understand the primary reason for this study, its objectives, and why it is needed, one must first grasp a solid comprehension of micro irrigation, its benefits, relation to India, and the current situation it finds itself in. On a rather basic level, Merriam Webster defines irrigation as, "the watering of land by artificial means to foster plant growth" (Irrigation). With sporadic rainfall (and an increasingly volatile climate), farmers can benefit immensely from some form of irrigation to grow crops. This simple aspect of agriculture can vary greatly in its implementation and type, however.

For many, especially in untouched and underdeveloped areas, irrigation means, at the most, flooding a field of crops through a network of furrows. This frequently accomplishes the task of watering crops, but at a great cost to the farmer. Micro irrigation offers a different approach.

With a direct and incremental irrigation of crops, drip irrigation is able to target the roots and base of a plant in a potent way through a system of pumps, controls, pipes, and emitters. Another type of micro irrigation can be seen in different-sized sprinklers that replicate the small droplets of rainfall. The low rate of water delivery to the plant over time allows it to maintain the prime amount of irrigation required for maximum yield. As the FAO rightfully emphasizes, "Crop water use does not change with the use of drip irrigation. Water savings are seen in reductions in deep percolation, in surface runoff and in evaporation from the soil," (Natural).

Drip irrigation and sprinkler irrigation, as alluded to, are the primary forms of micro irrigation and they vary in a few ways. Other than the physical systems and their setup, the most noticeable difference is cost. When installing drip irrigation, the systems can cost anywhere from Rs. 20,000 to 70,000 per acre. Sprinklers, on the other hand, often bring the cost down by a multiple of four (Agroman). Further, due to the difference in the delivery of water, each type has particular advantages for specific crops (Agrifarming).

A strategy paper done by Grant Thornton India LLP, deciphers the benefits and long-term vision that micro irrigation can provide by saying, "Given its higher efficiency, micro irrigation systems can go a long way in addressing the issues faced by the country and the agricultural sector," (Accelerating). They note further that the return on investment after installation of drip irrigation systems is between just 1.5 to 2.5 years.

The International Journal of Environmental Sciences stated in 2012 that sprinkler systems, themselves, can be 63% more efficient than flood irrigation (Mehtra). Moreover, the use of water is often reduced by anywhere between twenty and fifty percent. Fertilizer usage can be reduced,

less soil erosion can occur, and an increase in productivity can yield, on average, a 42% rise in annual income (Bera). Clearly, this approach can have an incredibly positive impact on agriculture.

India

Within India, micro irrigation has been a significant part of agricultural policies since 2006. Its adoption of the systems has seen acceptance and extensive desirability, yet just slightly more than ten percent of the total land capable of using micro irrigation has implemented the technology as of 2015 (Bera). Just as Sayantan Bera states, it is dismally slow progress for a technology that has been around for more than ten years and is needed now more than ever before.

“India is home to 17.5% of the world’s population, but only 4% of its fresh water resources,” (Gulati). Ashok Gulati, in the financial express, goes on to discuss why the coverage of micro irrigation must expand, especially with upwards of eighty percent of the country’s fresh water use going towards agriculture. In a country that has over five hundred million people indirectly relying on the agriculture industry and challenges that consistently progress, micro irrigation is one way in which these challenges can be addressed and agriculture in India can improve (Agriculture).

Mewat

The district of Mewat within Haryana, consisting of one million people and predominantly “small-scale, rain-fed agriculture”, was the central point of analysis for this project. Sehgal Foundation’s IRRAD 2011 publication of Krishi Jyoti, summarizes the state of agriculture best by saying, “Most of Mewat falls under the semi-arid tropics agro-climatic zone, characterized by low-to-medium rainfall, poor soils, and lack of irrigation...subsistence agriculture is still the norm.” Despite “[faring] well in agricultural production—it is often called the “food mine” of the country—Mewat lags behind not only in agriculture but also in many other areas of social development,” (Krishi).

With the aforementioned characteristics in mind, it is not difficult to imagine that much can be done to improve crop productivity, efficiency, and agricultural management in Mewat. Micro irrigation and its long list of benefits is just one way in which farmers in the area are attempting to take part in a long-term vision of betterment for themselves and Indian agriculture.

“Developing infrastructure takes years while bringing an area under micro irrigation is a task only requiring a few months,” (Accelerating).

Introduction

Methodology

Having taken in all of the details regarding the current state of Indian agriculture and irrigation, it was determined that to properly examine the trends of micro irrigation and its growth in India, a comparative study would be completed. Two villages, Satakpuri and Shehzad-pur, were chosen because of their relatively close geographical area, reception of comparable amounts of support, and difference in the number of farmers using micro irrigation systems. It was determined that one-on-one interviews would be completed with farmers, in addition to focus group discussions.

The focus group discussions served to confirm and/or deny the information given in individual interviews.

Two questionnaires were then created (these questions were used for the focus group discussions, as well). One consisted of twenty questions and was aimed at farmers that currently use some form of micro irrigation. The other questionnaire contained ten questions and was used with farmers that do not currently use the technology. Other than questions like crop yield, name, and age, they were all multiple choice. These closed-ended questions allowed for simplicity and efficiency. Close to ten basic questions were shared amongst the two surveys. They typically discussed the status of crop selection, current environmental factors, and personal reasoning for their decisions. The ten additional questions on the user survey dealt with the process of implementation, external influences, and subsequent satisfaction ratings.

These interviews and focus group discussions took place over the course of two weeks and yielded enough data to properly accomplish the predetermined objectives. In total, thirty-four farmers were interviewed (thirteen, of which, were currently using micro irrigation systems). Through the analysis of this data, with general knowledge of micro irrigation in mind, the following overarching questions, objectives, and hypotheses that essentially describe the findings of this project could be answered, accomplished, and tested.

Objectives

The following objective and sub-objectives were decided upon:

- To develop an explanatory theory that analyzes the adoption rate of micro irrigation systems in Mewat and examines contributing factors that affect the future outlook of the technology
 - To identify the factors associated with differing adoption rates of micro irrigation systems
 - To compare the agricultural conditions in Satakpuri and Shehzad-pur
 - To analyze the decision-making process of Mewat farmers
 - To determine necessary actions to increase the likelihood of farmers choosing to adopt micro irrigation systems

Hypotheses

The following hypothesis and sub-hypotheses were decided upon:

- If a village experiences a convergence of more complex and numerous challenges, there will be fewer farmers with the capabilities or the willpower necessary to adopt micro irrigation systems.
 - If a farmer uses micro irrigation systems, their agricultural decision-making will be affected.
 - The more support a farmer receives from outside sources, the more likely one is to adopt micro irrigation systems.
 - If farmers receive more information from outside sources, the likelihood of a farmer adopting micro irrigation systems will increase.

Questions Posed

After completing analysis of the data received, a clear and sequential organization emerged as the de facto approach in understanding the results. The way in which the results are discussed, through these questions, and the purpose for each one is as follows:

1. What is the current state of agriculture, support, and reasoning in Satakpuri and Shehzad-pur?
 - 1.1. The data that answers this question serves as a snapshot of 2017 conditions for future inquiries of each village.
2. What differences can be derived from the current states of each village?
 - 2.1. The purpose of this question is to serve as a snapshot for future reference as well as a focus point for targeting farmers without micro irrigation systems.
3. How do the differences affect adoption of micro irrigation systems?
 - 3.1. This question takes the data discussed in the previous question and provides a spotlight necessary for present and future work to bridge the gap of micro irrigation adoption.
4. How does the adoption of micro irrigation systems affect agricultural decision-making?
 - 4.1. Answering this question serves to reveal correlations that can be used for further comprehension of all aspects and to facilitate helpful dialogue.
5. What do these decisions say about the current mindset, needs, and priorities of farmers?
 - 5.1. Understanding the needs and priorities of farmers will allow for a better connection between all parties.
6. What does the future of micro irrigation adoption in Mewat look like and what can be done to increase the adoption rate of micro irrigation?
 - 6.1. These suggestions represent future actions that can be taken to push farmers, in the best way SMSF is capable, towards adopting micro irrigation systems by often channeling their priorities, needs, and mindset.

These questions go beyond descriptive research and require analysis or, in other words, they look for correlations, explanations, generalizations, predictions, and comparisons, as seen in the results to follow.

Results

Present Scenario

1. What is the current state of agriculture, support, and reasoning in Satakpuri and Shehzad-pur?

In broad terms, the present scenario, or current context of agriculture in both Satakpuri and Shehzad-pur is relatively similar. Reported depths to groundwater of past and present, as averages, are astoundingly close for the two villages. Also, the difficulty in accessing it as conditions worsen is a shared struggle. Although groundwater availability clearly remains a primary factor in choices made, the similarity of these statistics negates the validity of groundwater playing a singular role. For groundwater conditions to be similar, yet the decision to use micro irrigation to differ, there must be additional factors that take part. Regardless of village, the average depth to groundwater five years ago was about thirty feet. Now, everyone is averaging about fifty feet to reach groundwater.

Further, there are farmers in both villages using and not using micro irrigation. There are, however, more than ten farmers in Satakpuri using some form of micro irrigation and only four reportedly do the same in Shehzad-pur. One of the most fundamental questions asked was rather straightforward: “Do you use a micro irrigation system? If so, what type(s)?” The answers to this question, whether it was no, yes, drip, sprinkler, or drip and sprinkler, display the primary focus of the data collected.

It is important to note that similar crops are being grown in both places. If a crop is being grown in Satakpuri, it is more than likely being grown in Shehzad-pur, as well. Crop selection was more dependent on the use of micro irrigation rather than location. One factor that showed a consistent increase, no matter the use of micro irrigation or location, was the number of unique crops being grown by each farmer. Over the past five years, nearly every farmer has increased the number of crops they are growing as individuals. Even the ages of farmers, despite a slightly younger set of interviewees in Satakpuri, was comparable between villages.

The history and presence of S.M. Sehgal Foundation is said to be near-identical for both villages. Over the past two to five years, there has been an equal amount of support provided by Sehgal Foundation. When asked for the sources of financial aid and the percentage covered, the same answers corresponded. When asked how much of the total cost was taken care of by outside sources, only two answers were given. A farmer either stated that zero percent was covered or sixty-to-eighty percent was covered. The only answer given when asked for the source of this support, was the exclusive combination of the Haryana state government and Sehgal Foundation.

Several of the questions asked, as the prior paragraph alludes to, revolved around the support received from sources outside of themselves. These inquiries represent an attempt at better understanding what factors predominantly sway the adoption rate amongst all farmers. Firstly, nearly two-thirds of current users reported receiving information, training, and financial support from Sehgal Foundation. On every occasion, if financial support was listed, then information and training were too.

Further, two-thirds of the farmers that reported these three factors of SMSF support had adopted both drip and sprinkler irrigation systems, thus displaying the much greater probability of a farmer adopting both forms of micro irrigation systems if receiving this trifecta of support from SMSF.

On average, the farmers currently using micro irrigation systems rated their satisfaction with them as an 8.7/10. Interestingly, the two lowest satisfaction ratings (both were a five out of ten) came from farmers who had received no outside funding and minimal support. One of them even reported having received no guidance. Despite the smaller survey size, one can rightfully claim that an increase in support and financial aid will increase satisfaction in the long run for those that want to receive support.

Crop yields, although they were inconsistently reported, displayed equivalency. Motivations for micro irrigation systems and the satisfaction from them, amongst users, is largely indistinguishable when viewing reports from Satakpuri and Shehzad-pur.

In the realm of nonusers, farmers in both areas expressed similar challenges and reasoning for their absence of micro irrigation systems. A lack of electricity was the primary reason given by sixteen of the twenty-one farmers that do not use micro irrigation systems. This lack of electricity equates to a lack of available groundwater or, at least, more expensive access to groundwater. For many, the running of the water pumps requires far too much electricity that cannot be afforded. Despite the challenges faced, everyone found the technology to be desirable.

Decidedly, Satakpuri and Shehzad-pur hold similarities that make it ideal for the discovery of small differences that can make a big impact.

2. What differences can be derived from the current state of each village?

& 3. How do the differences affect adoption of micro irrigation systems?

In spite of the broad similarities in all of the categories discussed above, several differences, if delving deep enough, emerge from specific points of interest. For one, the individual responses to the depth to groundwater question in Satakpuri, for both users and nonusers, were incredibly consistent. They varied just slightly off the calculated averages, as seen in Figure 7. It is rather apparent that the averages of thirty feet in the past and fifty feet in the present are the averages

Name	Tally	Value
10ft		0
15ft		6
20ft	\	0
25ft		1
30ft		4
35ft		5
40ft		6
45ft		6
50ft		12
55ft		0
60ft		1
65ft		3
70ft		0
75ft		0

Figure 7: Depth to Groundwater Reports in Satakpuri (past and present)

because the majority of farmers reported distances at, or close to, those distances.

A difference emerges, though, when looking at a Figure 8 from Shehzad-pur.

name	daily	value
10ft	\\	2
15ft	\\	4
20ft	\\	1
25ft	\\	2
30ft	\\	2
35ft	\\	2
40ft	\\	4
45ft	\\	0
50ft	\\	5
55ft	\\	0
60ft	\\	1
65ft	\\	0
70ft	\\	5
75ft	\\	1

Figure 8: Depth to Groundwater Reports in Shehzad-pur (past and present)

As seen, both users and nonusers in Shehzad-pur clearly reported numbers less consistent with their peers in the same village. Rather than the average being a product of consistent reporting, it is frequently the meeting point between extreme distances like seventy-five feet and ten feet. This seems to reiterate, based on personal perceptions and experience, that there is a greater sense of community amongst peers in Satakpuri than Shehzad-pur. There was a closeness and aura of cooperation when visiting Satakpuri that was not seen elsewhere. During individual interviews and even the focus group discussion within Shehzad-pur, the farmers seemed to be isolated from each other.

For villagers to cooperate and assist one another well, especially when it comes to micro irrigation systems, it helps to have extraordinarily similar circumstances. Shehzad-pur shows less of those similarities amongst themselves in terms of groundwater, reasoning, and other factors.

In regard to the type of systems being used, Shehzad-pur farmers entirely use both drip and sprinkler systems as individuals. In Satakpuri, the vast majority of farmers with micro irrigation systems use just one or the other (usually sprinkler). So, despite the small number of farmers installing the systems in Shehzad-pur, the ones who have seem to be getting more use out of the technology than those in Satakpuri.

Moreover, when focusing on farmers that do not use micro irrigation systems, the reasons given and the number of reasons given for not using it varied significantly between villages. The farmers in Satakpuri, eight times out of ten, simply stated one reason. Whereas, only one of the eleven farmers interviewed in Shehzad-pur stated a sole reason. More often than not, there were three barriers reported. A cause of the increased complexity came, in part from answers exclusive to Shehzad-pur like, “difficulty getting subsidy” and “lacking information”. The aforementioned lack of connection and less sharing of information might have led to these two answers being exclusive to Shehzad-pur. Also, the lack of funds, while mentioned three times in Satakpuri, was brought up eight times by farmers in Shehzad-pur.

This disparity is one of the most compelling answers to why fewer farmers in Shehzad-pur use micro irrigation. Although every current nonuser stated that they would like to use the systems in the future, it looks to be apparent that more barriers spur less motivation. In any situation, when one faces more obstacles, it is less likely that one will see a plausible way to overcome them and reach the goal, which in this case is a system of micro irrigation.

4. How does the adoption of micro irrigation systems affect agricultural results and decision-making?

As can be seen in the pie charts that follow (Figure 1, Figure 2, Figure 3, & Figure 4), users of micro irrigation systems have diversified their crop selection in the present far more than non-users have. While the use of micro irrigation is, by no means, a sole reason for this shift, it can be reasonably assumed that it certainly takes part. The past and present graphs of nonusers, regardless of location, show that the four crops of wheat, pearl millet, mustard, and jowar (sorghum) have consistently taken up more than three quarters of the crop selection for these farmers. The quarter of crops that display diversity has even shrunk by thirty percent over the same time period.

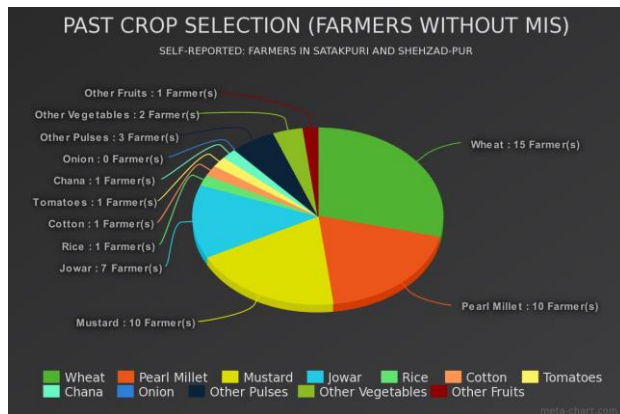


Figure 1: Past Crop Selection of Nonusers

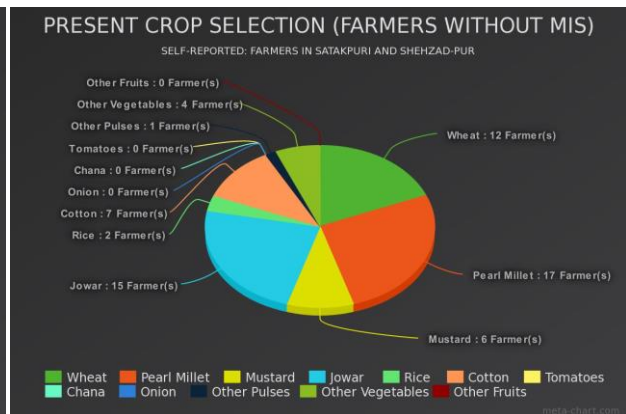


Figure 2: Present Crop Selection of Nonusers

The graphs that follow (Figure 3 and Figure 4) display the striking shift that current users have made over the past five years. As compared to the thirty percent decrease in the collective number of unique crops being grown by nonusers, a one-hundred percent increase can be seen over the same five years by users of micro irrigation.

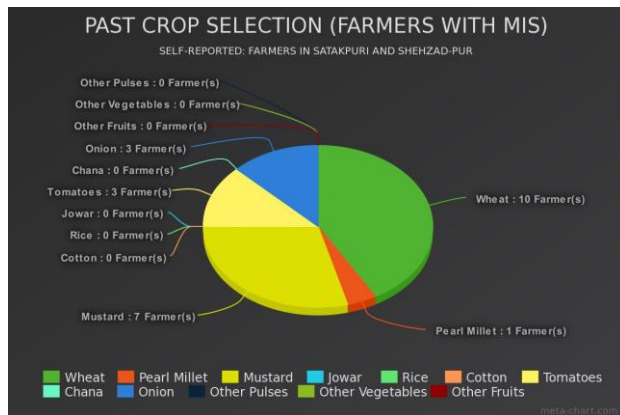


Figure 3: Past Crop Selection of Users

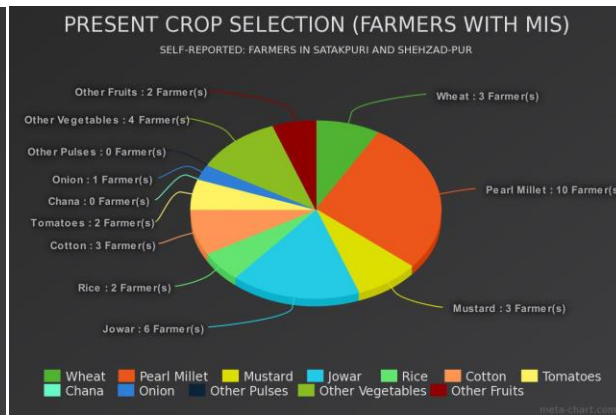


Figure 4: Present Crop Selection of Users

A possible explanation for the disparity would be that the farmers without the systems find it more difficult to keep up with the changing environmental factors than the users do. When a farmer saves money, water, etc., they are more likely to withstand periods of difficulty and unpredictability. Subsequently, they can maintain crops that require more resources.

Additionally, on more than one occasion, cash crops have been introduced by users. This increased prevalence of cash crops, even if slight, raises the probability of a farmer making a profit capable of providing necessities, and perhaps more, for one's family. This is due to less money being put into the crop (savings of water, labor, and subsequent cost). A farmer without a micro irrigation system would likely make less money from a cash crop for this reason. The stark reduction in the number of farmers growing wheat amongst users displays less dependence on the crop for self-consumption. Dissimilarly, the prevalence of cash crops in the fields of nonusers has dwindled. The decision by farmers to plant more fruits and vegetables is also a testament to the more efficient watering process that allows for more water-absorbent crops to be grown.

In terms of crop yield, the change of crop selection from the past to present for users of micro irrigation prohibited farmers from reporting yields of the same crop over time, thus rendering it impossible to measure the effects of micro irrigation systems on crop yields. Nonetheless, on the occasion that the yield was reported for the same crop under both past and present circumstances, the yield had increased considerably (varying between an 11% and 25% increase).

Overall, it is clear that the facilities available to farmers, like micro irrigation systems that save water, certainly contribute to a farmer's willingness and ability to diversify and/or begin planting cash crops like cotton, rice or other fruits and vegetables (or at least benefit further from them). The difference between sprinkler and drip use is that farmers using drip irrigation alongside sprinkler irrigation, on average, grow the most diverse selection of crops with the largest yields. Less notable effects are seen with sole sprinkler use.

5. What do these agricultural decisions say about the current mindset, needs, and priorities of farmers?

Desire to Improve (Save Effort, Labor, & Time)

The fundamental question of, “Do you use a micro irrigation system? If so, what type(s)?” discussed under question one resulted in answers that display, if nothing else, which form of micro irrigation is preferred by the thirteen farmers that reported to use some form of it.

It is significant that twelve of the thirteen use sprinkler systems, while just six use drip systems. This explains the cost disparity between the two. Although drip irrigation systems offer a more rewarding return on investment in the long-term, the often-staggering price required for initial installation can be discouraging for farmers. Therefore, the abundance of sprinkler systems should not be surprising. For the lower cost of installation, one is able to effectively irrigate in a way that requires a lot less labor and efficiently water crops through a targeted approach. A lack of information also contributes to this issue.

Desire to Lessen Risk

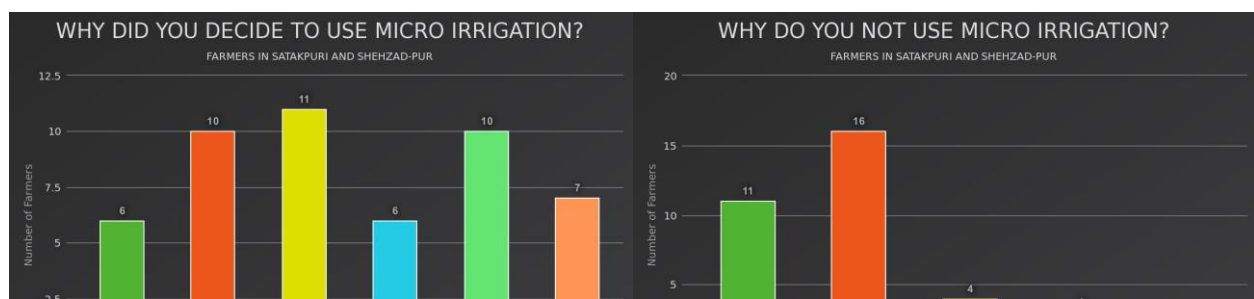
This aforementioned increase in diversification identifies an attempt by farmers to prepare for potential pitfalls, often due to climate volatility. By choosing more crops to plant, they are more likely to be food secure if one or more crops fail during the growing season. In this case, crop diversity can serve as an extra layer of food security.

Additionally, without taking into account the village or irrigation use, the majority of farmers have either implemented or stuck with the crops that are capable of withstanding unpredictable and harsh environments throughout a crop season. These include, but are not limited to: jowar (sorghum), mustard, and pearl millet. The prevalence of these crops backs up the claim that farmers are motivated to lessen the risk they often experience throughout a year.

Desire to Find Information

Despite the occurrence of a persistent, overarching problem like electricity and successive funding issues, one can interpret what they chose to omit as positive. Firstly, only one person reported awareness as being a hurdle that needed jumping over. This provides a solid foundation to claim that farmers are more self-aware of the problems they face. Whether it be depleting water tables, crop degradation, or electricity and funding, many farmers proactively seek out solutions to better understand how to approach setbacks. This self-found need leads to farmers asking for information from the government or organizations like SMSF. If anything, it’s the information they lack, not the awareness. The reported statistics display that.

Further, less than twenty percent report a difficulty obtaining subsidies. Access and facilitation by external parties appears to be doing the trick in terms of making one of the most necessary forms of government assistance easy to understand. With electricity being reported as a problem with four times more frequency than subsidy barriers, it proves that it is the opposite of a prominent problem. Even farmers who currently use micro irrigation systems, when asked what their primary motivations were, rarely responded with the obtention of subsidy. This seems to show that subsidies are the least of concerns for farmers, due to their ease of access on the majority of occasions.



As expected, the farmers that reported the saving of fertilizer as a motivator were almost always users of drip irrigation systems. Perhaps more farmers would be encouraged to use drip irrigation systems if they were informed of the potential cost savings associated with using less fertilizer. More profound were the seven individuals that, without prodding or the listing of it as an option, stated the saving of labor, effort, and time as a key motivation to their adoption of micro irrigation systems. That addition speaks to the modernization that a micro irrigation systems can bring to a farm in rural villages like Satakpuri or Shehzad-pur. It could also explain why one-hundred percent of all current non-users find it desirable. The information discussed here comes from figures 5 and 6.

6. What does the future of micro irrigation in Mewat look like and what can be done to increase the adoption rate of micro irrigation?

Future

Well, everyone wants it (or so they say, at least). This, alone, is a milestone achievement if one considers the skepticism that was once present. The first farmer to use micro irrigation systems in Satakpuri relayed the time when no one heeded his suggestions for adoption until seeing the tangible demonstration between a field using micro irrigation systems and one that was not. When one hundred percent of farmers want something, it is far more probable that they will obtain it in the future.

Additionally, every farmer present in focus group discussions and in interviews had previously been aware and informed about the potential of using micro irrigation systems. I can presume this awareness came about, not only through efforts of SMSF and others, but through the word of mouth and demonstration by current users. Based on individual self-reporting, each farmer had, on average, informed and/or motivated seven others in their respective villages to look into or supposedly use micro irrigation systems. One can assume, capabilities aside, that the community discussion and individual conversations pertaining to micro irrigation systems would be quite successful, taking into consideration the high satisfaction rating amongst all users.

If further research were to be warranted, it might be interesting to look into the steady decline in the prevalence of both wheat and mustard. Another topic of future inquiry could pertain to the potential correlation between cash crop growth and the ability to pay for electricity. Does the extra profit made from cash crops translate into less of a challenge in paying for utilities? This question came about when farmers with micro irrigation in Satakpuri, with less cash crop growth than Shehzad-pur, reported more struggles with electricity than their counterparts in the other village.

Another aspect of future problems, although specific to Satakpuri, came from a nearby factory that had damaged nearby crops through the uncontrolled release of its waste and the ensuing pests. Attempts to have the government improve the situation have been met with little initiative, even after inspection, because of undue demands. Government issues can also be seen in

Shehzad-pur, in which a farmer reported that from village to village there are vacant government offices, therefore leaving no one to properly assist in times of need or inquiry.

It is important to understand the aforementioned struggles, but despite the challenges that lie ahead, the future of micro irrigation adoption looks bright.

Recommendations

With the present situation and future in mind, the suggestions that follow are my recommendations for efforts that can be undertaken or continued to increase the adoption rate of micro irrigation systems in the future. These recommendations are based on my perceptions and experiences throughout this research and during my time at S.M. Sehgal Foundation. Each was suggested with the content beneath questions one through six of this paper serving as reason.

Policy Advocacy

1. Ensure farmer-friendly disbursement of subsidy (E.g. Gujarat, Andhra Pradesh).

Farmers are in need of simple, consistent, and streamlined ways of obtaining a subsidy that do not require them to pay one-hundred percent upfront. States like Gujarat and Andhra Pradesh have shown tremendous progress in creating pathways that are better for farmers.

2. Look into pricing and quality of electricity supply for agriculture and ensure competition amongst suppliers.

With so many nonusers, regardless of location, reporting electricity as a primary barrier to micro irrigation use, there needs to be further inquiry made into this sector to answer questions that have yet to be answered.

Agricultural Development

1. Encourage the use of drip irrigation alongside sprinkler irrigation by highlighting the long-term return on investment.

- 1.1. This can be accomplished by facilitating discussion and meetings between farmers with and without micro irrigation systems.

- 1.2. Continue spreading information, training farmers, and providing compatible financial support. Two-thirds of the users that reported receiving all three of these forms of support ended up adopting both drip and sprinkler irrigation systems, thus taking the most advantage of the technology. The data showed that the more support a farmer received throughout the process, the more satisfied they were in the present day.

- 1.2.1. Streamline a consistent process that provides this “trifecta of support”. Improving the way support is given and reducing its oftentimes sporadic nature would improve the stability across the board.

2. Ensure farmers understand how to properly manage systems.

- 2.1. Visit and check on crops, farmers, and micro irrigation systems. Farmers frequently stated their appreciation for Sehgal Foundation’s efforts to come back after giving initial support. They reported it as being beneficial and that the practice should be continued.

- 2.2. Institute a system of surveys and input - nothing can be achieved unless we know what needs and priorities of the people being helped are. By better understanding the concerns, mindset, and conditions that farmers face, adoption and preservation of use can be achieved.

3. Look into precision agriculture and smart irrigation technologies.
 - 3.1. Research the ability to implement in-field monitors and sensors for data. Technologies like this are capable of making irrigation and nearly every part of agriculture even more precise and efficient.

Conclusion

Encapsulating the diverse and extensive results that have been discussed into a concise and worthy conclusion is no easy task, but here it lies, nonetheless. As mentioned when introducing the background of Indian agriculture and the current state of both water-use and irrigation, there is a dire need for progress. Many broad and positive statistics, far too often, disguise the lack of sustainable development and little to no vision for long-term goals.

The questions that organize this report put forth a systematic approach to understanding a plethora of data collected from just thirty-four farmers. Such a straightforward and simplistic study, such as this, allotted a space for the discussion of important factors that affect the lives of farmers and their families in a place at the heart of India's growing responsibility to adapt.

Irrigation, in general, is just one factor of agriculture. No approach to improving agriculture in India is complete without taking into consideration everything that goes into it. (The importance of community consultation should also not be understated.) Nonetheless, the role irrigation plays, and the increasing contribution of micro irrigation, is vital to making positive change, especially in a place often devoid of proper development such as Mewat and its villages. Those who seek the long-term vision that is progressively needed can find solace in micro irrigation, especially drip, taking part.

What the results show, more than anything else, is change occurring over time. Although the fundamental aspects of agriculture have remained since the beginning of human civilization, the sector, undeterred by history, continues to evolve to suit the rapidly transforming world we find ourselves in.

The current state of agriculture in each village is one of worsening environmental conditions, predictable crop selection, and changes made by farmers to address the associated problems. The two villages in question, although close in geographical location, revealed distinctions that yield improved comprehension of why farmers do or do not adopt micro irrigation, like the complexity of barriers faced. Changes and differences such as crop diversification, partly influenced by the adoption of micro irrigation, allowed for an interpretation of present mindsets and priorities of farmers in the area. Their desire to improve, lessen risk, and seek information for their own betterment coalesced into a hotbed, of sorts, for potential solutions to the problems they face.

Problems that confront farmers do indeed affect the adoption of micro irrigation and if Mewat (not to mention Greater India) is to effectively increase the rate of its implementation and subsequently use less water, increase productivity, manage water-use efficiently, and continue to improve the state of agriculture for generations to come, then steps should be taken now. The recommended steps, whether they be through policy advocacy or agricultural development, are

based on the perceptions and experience of someone who saw, at least at a glance, the present scenario and conditions of micro irrigation adoption. They also serve as a prime example of someone who believes in the future of Mewat and the people that are trying to make it better.

Final Reflection

Farming is life. For so many in India and Mewat and Satakpuri and Shehzad-pur, the livelihoods of families depend upon agricultural productivity. Agriculture is their source of food and their source of income, but sometimes it is neither. Proper irrigation of crops is a fundamental part of that agriculture. Without water, crops do not grow. Throughout India and throughout the world, water is becoming scarcer. Climate volatility and weather variability are becoming increasingly grave issues that farmers everywhere must deal with. As Norman Borlaug would say, food is a moral right for all who live on this Earth. Farmers and farming families cannot always get the food they need when they have little, if any, awareness of or access to the technologies that make cultivation easier. Too many farmers are being denied their moral right to food through the lack of agricultural development in their area, by little to no fault of their own.

Micro irrigation systems, especially drip irrigation systems, can be a unbelievably positive part of the required solutions. Collecting and analyzing this data established an understanding for what the present situation is and what the future looks like in these villages. Through my interviews and focus group discussions, we were not only able to gain unparalleled insight into the state of agriculture in these villages for Sehgal Foundation's archive of data, but we were able to spread some information amongst those we talked to. Field staff had the chance to explain to some farmers the importance of incremental irrigation with an analogy that will stick with me for years to come. It went like this.

A farmer asked why drip irrigation was better than the irrigation system he was currently using. An employee of Sehgal Foundation's field team first described the inability of a human being to wake up in the morning and drink sixty-four ounces of water in one sitting. That much water in such a short amount of time would make a person sick and performance would be decreased for quite some time. If a person drinks an occasional eight ounces of water evenly throughout the day, it would have a much better effect on the person. Much of the same can be said for crops. If a plant/crop is to be flooded with water, all at once, many negative side effects can occur. The incremental and targeted approach of a drip irrigation system allows for greater efficiency, productivity, and less waste.

That simple and understandable explanation created a moment of learning for that farmer. He walked away having been briefly educated on something that could increase his food security in the long-run. The language was important and deliberate. Communicating and advocating for increased adoption of micro irrigation systems will be easier for Sehgal Foundation having this study completed because we know more about the farmers, their environmental conditions, their practices, and more. In addition to the plethora of quantitative data collected, a lot of the qualitative information can be interpreted to make the foundation's approach and strategies more successful.

In my original research on India as a sophomore in high school, I suggested a system of surveys be implemented across the country in an attempt to gain an idea for the experiences, concerns, perceptions, and desires of those in the most need. In this research, I had the chance to do exactly that. It was a remarkable way for Sehgal Foundation to better understand how to best carry out their mission and initiatives of agricultural development in a way that makes it as easy as possible for farmers to get the technology they need to increase their food security. I am extremely humbled to have had the privilege to play a marginal role in the grand vision of S.M. Sehgal Foundation.

Spending two months in India changed my life. It was my first time outside of the United States. Before, I was comfortable in my Iowa town of about fifteen thousand people. So, what better way to expand my comfort zone than to travel to a place on the outskirts of a city of about twenty-two million people? That question is rhetorical. There is no better way. It was the best opportunity to grow as a person that I have ever had in my life. It helped me pinpoint my strengths and weaknesses (I am the ultimate strategist, but not the best yet at handling homesickness). I learned what trips my trigger and gets me excited (soil health, policy, and talking to people). I discovered a new world and met people that changed my perspective. My time there and interactions with people reiterated the definition of my favorite word, *sonder*: the realization that each random passerby is living a life just as vivid and complex as your own.

The food, dancing, languages, religions, holidays, celebrations, transportation, hobbies, and everything else that makes up culture was new. I miss it more and more each day. As much as these characteristics may differ between cultures, I was reminded how similar all people around the world are. We are all humans with similar values, concerns, worries, triumphs, and pitfalls. Some are facing greater challenges than others and it is the responsibility of everyone else to help those who are suffering. No world can succeed until the fair and equal opportunity for success and wellbeing has been given to every person, no matter our differences. Food security is tough; it is complex; and there is no simple solution, but with the efforts of many and the ideas of even more, there is no doubt in my mind that the world is capable of doing what is needed and what is morally right.

I learned more about agriculture throughout my time in India than I had throughout my entire life previously. That revelation alone has altered my goals in the best way possible. As Dr. Akinwumi Adesina would say, agriculture truly is a “cool” profession/career/sector. Agriculture runs the world and I am dedicated to making sure the world knows exactly that.

I stepped foot back on US soil on August fourteenth feeling far more confident in my abilities to solve any problem that comes my way. Whether that problem be trying to negotiate the price of an auto-rickshaw or solving food insecurity, I know I am capable, competent, motivated and more optimistic than ever before that I, myself, can have a positive impact on the world.

Acknowledgements

First and foremost, I want to thank Dr. Norman Borlaug. Without him, the World Food Prize Foundation would not exist. His life-changing youth programs would never have been created. People, like me, would know far less about the world's most important and time-sensitive uphill climb. His mission, vision, actions, and words inspire me every day.

Thank you to Ambassador Kenneth Quinn, Lisa Fleming, and the rest of the incomparable staff at the World Food Prize Foundation for their constant support, enthusiasm, facilitation, assistance, trust, guidance, and all the work they do to inspire, motivate, and change lives.

Thank you to Arvind Rana, Padmavathi Arun, Jay Sehgal, Veena Sehgal, Vanshika Mullick, Vidhi Dugar, Mariya Daginawala, Natalie Bidner, Prasant Mohanty, Devika Batra, Ram, Laxman, Aayush Arora, and everyone at Sehgal Foundation who not only allowed me to be there, but also helped in so many ways.

Thank you to my fellow 2017 Borlaug-Ruan International Interns for their endless camaraderie, compassion, humor, high-fives, hugs, and encouragement. It means the world.

Thank you to my parents for their undying love, support, inspiration, wisdom, and patience.

Thank you to Cindy Bauer, my mentor, for introducing me to the World Food Prize Foundation, constantly pushing me to be better, do better, inspiring me day-in and day-out, providing wisdom, advice, encouraging me, bragging about me, supporting me, and changing my life.

My gratitude is boundless. Thank you all so

much.

Photos



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Appendix

<http://docdro.id/UMvCefG> - Field Data Spreadsheet

<http://docdro.id/TsmDbdM> - User Individual Questionnaire

<http://docdro.id/WQ5MhU7> - Nonuser Individual Questionnaire