SECURING WATER FOR FOOD

WASTE Performance Evaluation

Circular Economy Model with Black and Greywater Recycling in India

AUGUST 2019

SECURING WATER FOR FOOD: A GRAND CHALLENGE FOR DEVELOPMENT

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ABSTRACT

WASTE, a Netherlands-based organization in partnership with the Rural Development Organization (RDO Trust), Nilgiris District, developed a model for producing high-quality co-compost from wastewater and faecal sludge for the cultivation of exotic vegetables by women farmers in the District. To enable target consumers to buy the co-compost, WASTE implemented THE DIAMOND MODEL to provide tools for private financing and potential market linking strategies in addition to generating quality co-compost and providing access to greywater. The innovation received a monetary award and support from Securing Water for Food (SWFF). The innovation's aim is to establish a local circular economy model in sanitation for agriculture that is scalable and enables women agri-entrepreneurs to have better crops with market quality compost application and an extended crop season to advance green growth in the Nilgiris District.

This report details the monitoring and evaluation of the recent innovation by WASTE among the small-scale farmers of the horticulture district of Nilgiris in the state of Karnataka in July 2019. Fifty independent farmers were selected for interviews through a random sampling with a mix of male and female headed households. Criteria was established to assess household income, crop yield, water practices, expenses, and perceptions and expectations of the circular economy model.

It also measures the innovation's impact in water-stressed regions and explores the possibilities related to soil fertility, gender disparities, climate change, income changes, water management, irrigation practices and technologies, and market dynamics of the region.

Respondents were positive about the innovation's ability to become sustainable and scalable. With the introduction of the innovation, farmers could cultivate an additional part of their farmland. The positive impact would largely influence food security, women accreditation, income advancement, and soil restoration for the entire region. An additional benefit surfaced when 12 percent of farmers requested the installation of solar pumps to power electric fencing to protect crops from wild animals. The innovation also helped vegetable farmers by improving crop yield through co-compost application, resulting in higher sale prices in the markets.

INTRODUCTION

The agriculture industry in India faces a severe water crisis and soil fertility declines with high usage of chemical fertilizers and there is an immediate need to manage these resources efficiently. To reduce irrigation dependence on fertilizers and fresh water sources which have been exploited and reached a level of scarcity, focus must be on increasing treatment capacity of solid and liquid waste streams for recycling irrigation. While the release of untreated wastewater and faecal sludge creates severe environmental damages, channelizing these waste materials as resources for irrigation would not only help farmers to earn sustainably but also save catastrophic environmental pollution.

Natural sources of water, such as ground water resources, have been exploited inequitably and without considering the sustainability across the country. As a result, their availability is declining enormously. Over the years, a shift has occurred from manure or other composting techniques to vast usage of chemicals and other fertilizers to speed crop growth which ultimately leads to soil fertility decline. Chemicals offer greater control and are used in smaller applications than their organic counterparts. However, long term application of chemicals has stripped the soil's water retention capabilities and disturbed soil fertility so as to cause a major shift in crop patterns. There is no life left in the soil as rapid depletion of natural resources advances. Farmers are unable to continue to grow water intensive crops. Cultivated crops are poorer quality, leading to less than competitive prices at the market.

Acute weather irregularities and climate change have caused rainfall to be unpredictable, resulting in a rapid decline in water availability and ultimately reducing groundwater availability. Water availability is now limited to four to six months annually. Water crises have resulted in limited availability for irrigation purposes. Ultimately, farmers incur exuberant cost in buying water resources which makes the cost of inputs crudely high. There is an urgency to mitigate further depletion of resources and come up with solutions that cater to the climate's ever-advancing irregularities. Crops are increasingly exported from one state to another and across international borders. Essentially, this is transportation of virtual water.

Specifically, the Nilgiris District in the state of Tamil Nadu, India, is facing a period of dry weather, which affects tea plantations, horticulture, and vegetable cultivation. Farmers are in dire need of access to water and the return of moisture content to the soil, which has been reduced as high temperatures and low humidity increase evaporation.

Crop cultivation is an interplay of inputs, such as seeds, fertilizers, pesticides, water, and credit which determine crop production and productivity. It becomes pragmatic to utilize inputs more efficiently and diversify cultivation to more sustainable and higher value crops.

WASTE Intervention

The intervention has two major technical applications: a) greywater recycling at the local level, and, b) faecal sludge recycling with organic solid waste using co-composting methods. Typically, faecal sludge was collected and dumped either at open grounds at distant locations or into the nearest body of water, resulting in heavy freshwater contamination. The WASTE intervention collects faecal sludge from private vacuum truck operators, transports it to the treatment site and feeds into the system.

Diamond Model

The Diamond Model produces nutrient rich co-compost to be used as a soil conditioner for cultivation of exotic vegetables by female farmers in the District. The model focuses on four key areas for successful implementation and sustainability in the agriculture sector: a) farmers raising the demands, b) female Self Help Group (SHG) members involved with companies producing and managing the co-compost supply, c) agri-marketing companies to manage finances, and, d) government authorities to implement the project focused on treatment of faecal sludge and grey water.

The technical innovations within the model involve recycling grey water and using treated water for irrigation in critical periods of lower rainfall and dry seasons. The other innovation focuses on recycling of faecal sludge in the region's on-site sanitation systems. Private emptying operators and government vacuum trucks regularly empty these containment systems, and the faecal sludge is transported for treatment to produce co-compost. The co-compost unit is operated by women in cooperation with town panchayats to mix faecal sludge and organic solid waste. Women farmers who procure the co-compost are members of the Women Farmers Producer Companies and Groups.

The innovation answers the agriculture challenges of water scarcity and soil productivity in one single attempt. It addresses both major challenges and also solves the menace of solid and liquid waste management in the region, which is a win-win situation for all stakeholders. Additionally, the model incorporates market linkages for continuous business for farmers cultivating exotic vegetables and enables mobilization of private financing to overcome economic challenges for the involved stakeholders.

BACKGROUND

Growth for any region that depends on agriculture for sustenance encompasses two crucial factors: a) inclusive economic growth, and b) poverty reduction. If the sector fares well, both these vital factors strengthen, resulting in an inclined economic growth rate for the region. The state of Tamil Nadu has always performed well ahead of other states with a stellar record production of 10.1 million food grains in 2011 and 2012 and the highest productivity of sugarcane and other important crops, such as oilseeds and maize. Unfortunately, the growth rate in agriculture over the last decade has taken a dip because of rainfall deficit and limited or non-availability of sufficient water. The continuous shortfall of rains in the last few years in Tamil Nadu invariably explains the poor growth rate of returns from the agriculture sector (Table 1).

TABLE 1: RAINFALL IN TAMIL NADU

YEAR	SOUTH – WEST MONSOON	NORTH – EAST MONSOON	ANNUAL
Normal	321.3	440.4	921.0
2009-10	317.0	482.6	937.8
2010-11	383.6	605.2	1165.1
2011-12	300.5	540.8	937.1
2012-13	245.9	370.5	743.1
2013-14	325.4	294.3	790.6
2014-15	305.5	430.3	987.9
2015-16	295.7	695.8	1138.8

Source: India Meteorological Department, Chennai-600 006

The irregular rainfall over time resulted in substandard production of standing crops that are dependent on rainfed conditions. There is a need for renewed innovative methods to meet the ever-increasing requirement of food, in view of the limited scope for expanding cultivation under irrigation.

INTRODUCTION TO REGION WHERE THE INNOVATION HAS TAKEN PLACE

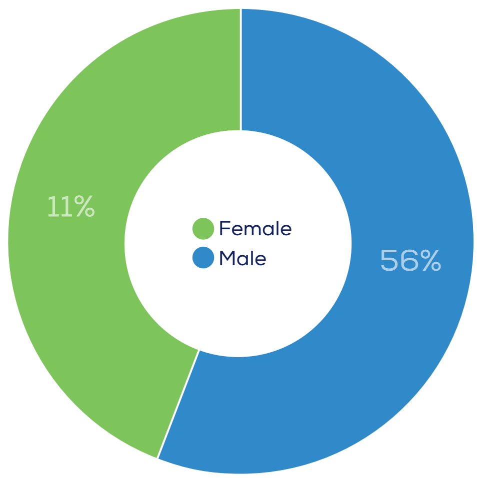
The Nilgiris District (horticulture district) in the state of Tamil Nadu, India, is home to several indigenous communities, flora, and fauna whose livelihood and interaction is shaped by the water flow landscape. Nilgiris has a population of 7.35 lakhs with over 40 percent of the total working population associated directly or indirectly with agriculture, making it the region's principal source of livelihood (Census 2011). Nilgiris is known for cultivating exotic vegetables, such as carrots, potatoes, beans, broccoli, Chinese cabbage, beetroot, garlic, strawberries, etc. With population growth, urbanization, and a positive shift in exotic vegetable consumption, there is a need to focus on terrains to produce such crops. These crops are in demand from the hotel industry. Meeting this need can boost the contribution of agriculture sector to Growth State Domestic Product (GSDP) which has rapidly declined in the last few years. The Nilgiris water is scattered in between the cast landscape of tea, coffee, and vegetation and is heavily exploited for hydroelectric power generation.

MAP 1: GEOGRAPHICAL LOCATION OF NILGIRIS DISTRICT IN THE STATE OF TAMIL NADU

Gender

There was a mix of male and female respondents, although the majority was male. Of the 50 respondents, females constituted 44 percent (22) respondents, while males comprised 56 percent (28) (Graph 1).

GRAPH 1: GENDER OF INTERVIEWED FARMERS (n=50)

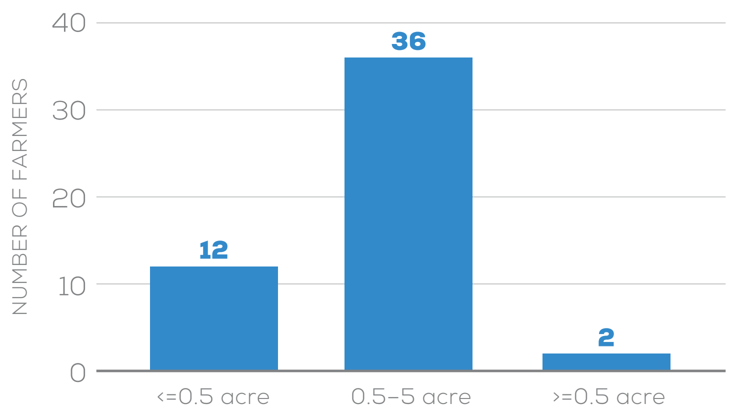


Across the Nilgiris District, women play an important role in agriculture. They are agriculture community leaders and were extremely enthusiastic about the innovation, especially the women agri-entrepreneurs that formed as a part of innovation. They felt empowered by sustaining themselves and their families through agri-businesses and requested further improvements in the innovation in the form of seeds, pipes, drips, and other agri-inputs as compared to requests from men. Women had an important role in leading the cooperatives formed by RDO Trust. Although men are usually the legal owners of the farmland, women almost always head the farming decisions since they were involved in the farming practices from the beginning and men typically joined after retiring from another professional jobs. Also, men were likely to share technical information on themes, such as the quantity and prices of inputs for farming, transportation, and storage.

Farm size

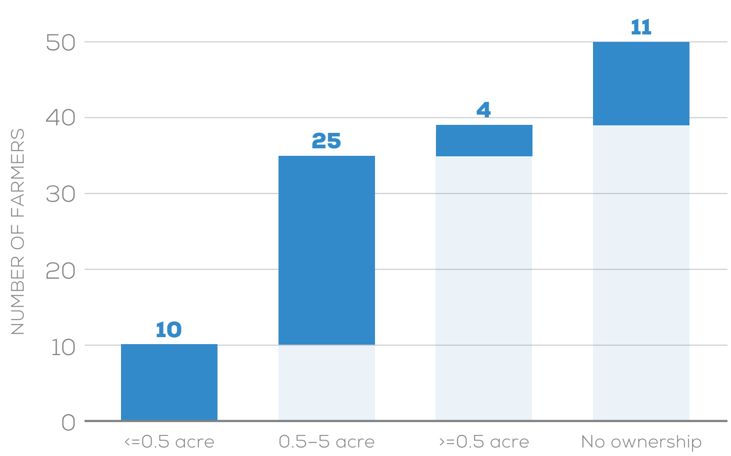
Most farmers in the region practice mid-scale agriculture, which was consistent with the farm sizes of those interviewed (Graph 2).

GRAPH 2: RANGE OF LAND SIZE VISITED BY THE EVALUATOR (n=50)



The amount of land owned by the 50 respondents varied, with 20 percent of farms (10) equal to or smaller than 0.5 acre, 50 percent (25) larger than 0.5 acre and up to five acres. Only eight percent (4) of farmers own farms with an area equal to or greater than five acres. Additionally, 22 percent (11) of farmers did not own land (Graph 3).

GRAPH 3: RANGE OF LAND SIZE OWNED BY FARMERS (n=50)

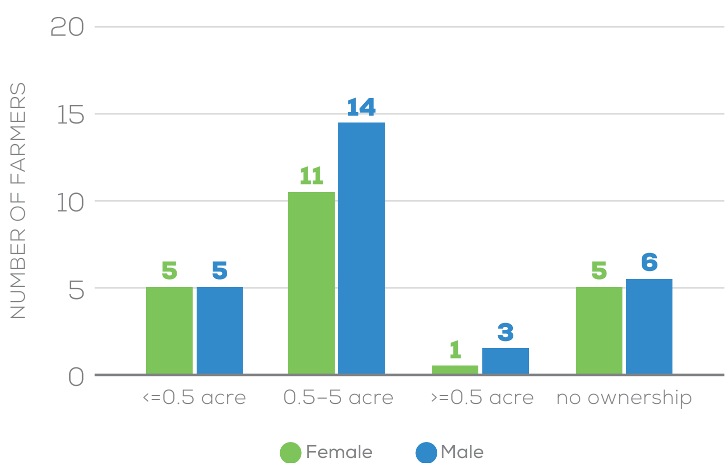


Farm land in village Dhoodhany

The average farm size owned by respondents is 2.4125 acre, and the median is 1.75 acre. This excludes 11 farmers (6 male, 5 female) who did not own land.

Of the 50 respondents, women farmers own smaller amounts of land than male farmers (Graph 4). Among women, 41 percent (16of 39) have farms up to five acres, while 49 percent of men have farms up to five acres. Of those 39 farmers, only three men and one woman own farms larger than five acres, which aligns with the observation that Nilgiris has almost if not equal female headed households.

GRAPH 4. SIZE OF FARMS OWNED BY FARMERS OF EACH GENDER (n=50)

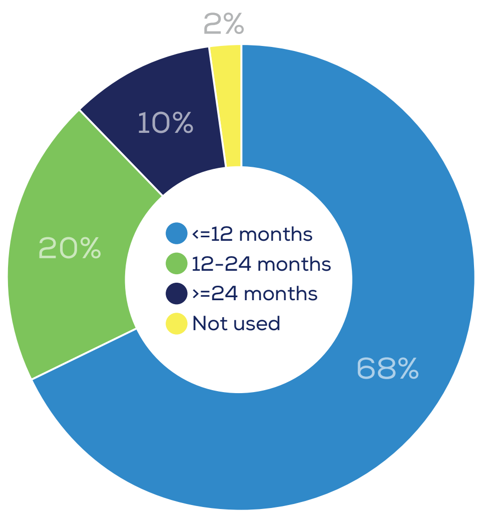


Farmer's experience

Forty-nine of the 50 interviewees reported their primary occupation was farming, with the only responding "Retired from the animal department – pension seeker and part time farming."

Of the farmers, 68 percent have used the innovation (co-compost) for 12 months or less, 10 percent for more than 12 months but less than 24 months, and 20 percent for 24 months or more. Only two percent have not used the innovation in their farming practices (Graph 5).

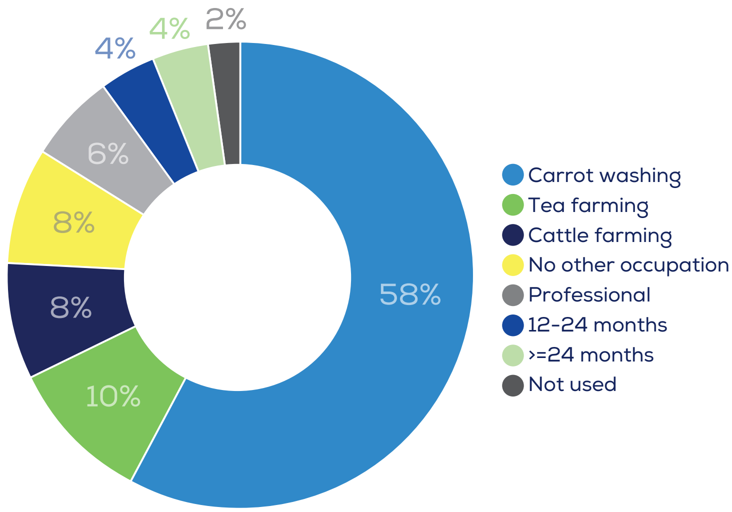
GRAPH 5: RANGE OF MONTHS FARMERS HAVE USED INNOVATION (n=50)



Other occupations or sources of income

Most respondents (58 percent) have no source of household income other than farming (Graph 6). In other sectors of the economy, five farmers work as a daily wage laborer on a wealthy farmer's land when they cannot afford agri-inputs or during the dry season to ensure sporadic income in their household. Four farmers raise cattle during lean periods or the dry season and sell cow dung as manure to other farmers. An additional four farmers receive monthly pensions as retired government officials and now are working in agriculture full-time. Three farmers have small enterprises to sell agri-inputs, such as fertilizers, pesticides, and herbicides to other farmers. Two farmers practice law in the afternoons and during time off as a side profession. Two farmers are employed as carrot washing executives for additional income, and one farmer practices tea farming in addition to agri-farming.

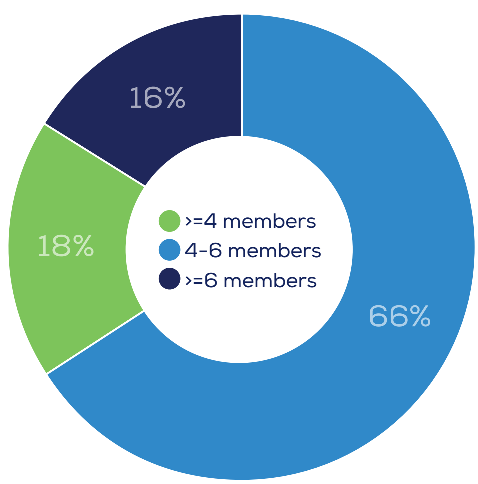
GRAPH 6: PERCENTAGE OF FARMERS WITH SOURCES OF INCOME OTHER THAN FARMING (n=50)



Family size

With 50 responses, the mean family size was 4.24, and the median was four members. In total, 212 family members were represented within 50 families. Of these, 66 percent (33) had four or more members. Eighteen percent (9) had four to six members. Sixteen percent (8) had six or more members (Graph 7).

GRAPH 7: HOUSEHOLD SIZE (n=50)



METHODOLOGY

The questionnaire created for the SWFF-WASTE Evaluation study included questions about livelihood, income, crop yield, innovation benefits, innovation accessibility, improvements in innovation, water use, agricultural inputs usage, and drawbacks and suggestions associated with the innovation.

WASTE's local implementing partner, RDO, keeps the coordinates of the Nilgiris District villages and a well-maintained database of the farmers who have used the innovation in the past. Because a few interviews were previously conducted, the SWFF team suggested using villages that had not been investigated but had used the innovation in the last three years. Farmers that had used the innovation was the primary filter because they may have better and specific knowledge of the innovation and thus can provide greater details. Of these villages, primary interviews were selected through a random sampling of the database provided by SWFF. A translator contacted the selected farmers a day in advance to ensure their availability on the day of the scheduled interview. Interviews were conducted by visiting farming areas, walking through the fields, and meeting in the farmer's home in the case of heavy rains. All interviews were conducted one-on-one with individual farmers to avoid as much bias as possible, such as a respondent with limited knowledge on a specific question looking to village level farming leaders to provide the exact answer for the respondent.

Data was collected through individual interviews with 50 farmers from the eight villages spread across Nilgiris district: Dhoodhany, Oranalli, Thilluvaluvar Nagar, Salamoor, Kecketti Hada, Shanthoor, Jendamedu, and Ketti Palada (Table 2). All interviews were conducted in-person by the monitoring and evaluation intern in the local dialect of Tamil Nadu with the help of local translator, Divya Kartik. The questionnaire was designed by SWFF staff and stored in the Fulcrum mobile and website application. Responses were stored in Fulcrum and interviews were recorded on a cell phone, which also was used to capture still images from the field with the farmer's consent.

TABLE 2: SELECTED VILLAGES ACROSS NILGIRIS DISTRICT

VILLAGE NAME
Dhoodhany
Oranalli
Thilluvaluvar Nagar
Salamoor
Kecketti Hada
Shanthoor
Jendamedu
Ketti Palada

The location covered in the survey was mentioned in the WASTE reports provided to the evaluator. The villages were chosen based on innovation use of three to 36 months. Farmers were chosen from a randomized list of those who had benefited from WASTE's grey water and co-composting application innovations (Map 2).

MAP 2: GEOGRAPHICAL LOCATIONS OF (n=50) FARMERS INTERVIEWED IN THE SURROUNDINGS OF EIGHT SELECTED VILLAGES, IN THE NILGIRIS DISTRICT IN KARNATAKA.

Based on information provided by WASTE, with the use of Google Fusion tables. Some of the dots are not visible as they overlap each other.

All interviews were scheduled in advance with the help of a translator using the contact information provided by the RDO Trust. In a few cases in different villages, the chosen farmer was not available and the farmer's community leader identified farmers who have been supported by the innovation for interviews.

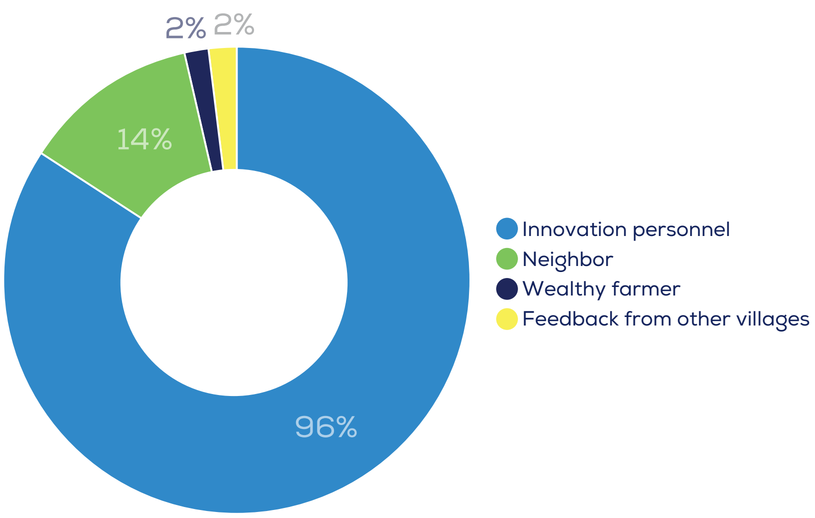
RESULTS

EXPERIENCE WITH INNOVATOR

When asked if farmers will use the innovation again in the next five to 10 years, 100 percent agreed on using co-compost going forward and did not have any problems understanding co-compost usage. Farmers using other sources of compost also indicated they would shift to co-compost in the next agricultural cycle.

Several questions were asked to understand how farmers first heard about the innovation. Among the 50 farmers, 96 percent (48) reported hearing about the innovation through an RDO outreach program. Fourteen percent (7) reported hearing from a neighboring farmer who know of the innovation. One heard from the community's wealthy farmers and another heard feedback from the other villages (Graph 8).

GRAPH 8: WAYS IN WHICH FARMERS FIRST HEARD ABOUT THE INNOVATION (n=50)

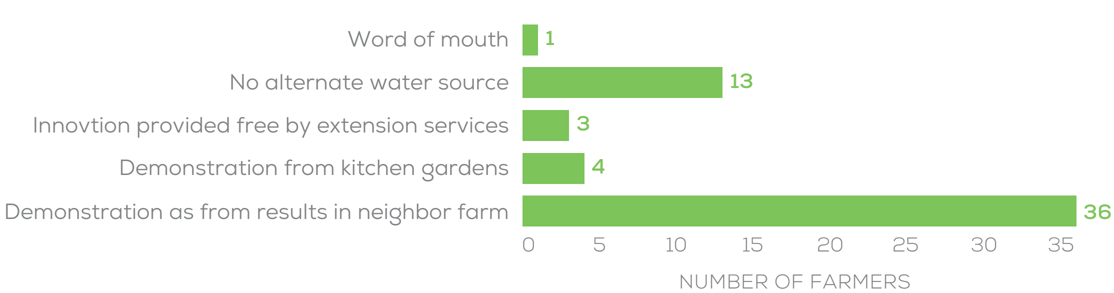


Several factors influenced usage of the innovation, with 36 of 50 farmers observing better yields from neighboring farms which encouraged them to use the co-compost. Thirteenfarmers reported no access to any alternative source of water, so it was critical to use the grey water as a part of innovation. It is interesting to note that the innovator came up with an idea to pilot co-compost in the kitchen garden initially. Four out of 50 farmers observed good quality yields in the vegetables. They

Texture of Double Beans (Mandra Avarai) after using co-compost in kitchen garden. Quality has increased with bigger size and better taste.

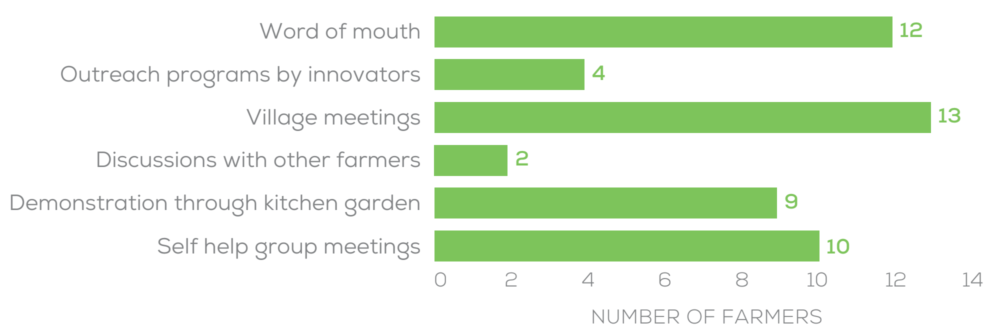
cooked them and learned the positive changes in the color, size, and taste of the vegetables and flowers, giving them confidence to use co-compost. Three farmers reported using the innovation free of cost because it was provided by extension services, and one farmer learned about the innovation through word of mouth (Graph 9).

GRAPH 9: FACTORS WHICH INFLUENCED FARMERS FIRST TO USE THE INNOVATION (n=50)



Farmers showed a complete willingness to share the knowledge and information about the innovation. Twenty-six percent (13 of 50) mentioned the co-compost and its benefits to other farmers, friends, family, and other people at periodic village meetings. Twenty-four percent (12) shared knowledge by word of mouth, while 20 percent (10) disseminated information through RDO self-help group meetings. Eighteen percent (9) demonstrated the benefits through kitchen garden trials, eight percent (4) taught the techniques to other farmers and villagers through outreach programs by innovators, and four percent (2) suggested the innovation through discussions with other farmers (Graph 10).

GRAPH 10: HOW FARMERS SHARED KNOWLEDGE AND INFORMATION ABOUT THE INNOVATION (n=50)



BENEFITS OF INNOVATION

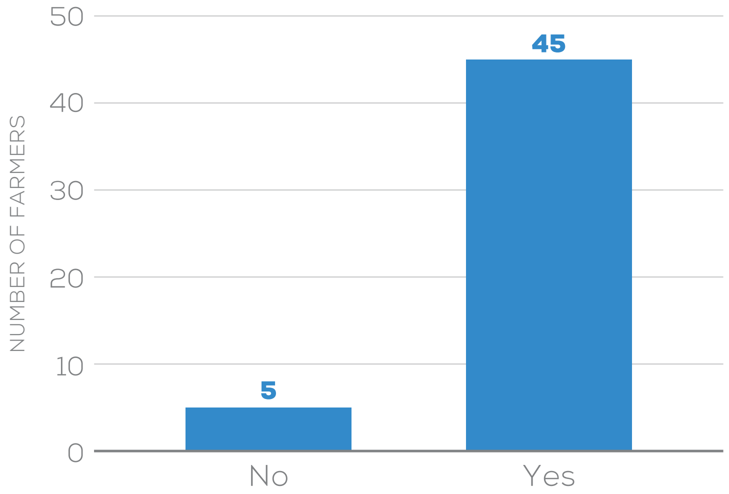
In the first year, 215 farmers adopted use of co-compost from blackwater recycling while183 adopted treated water by grey water recycling. In the second year, 759 adopted co-compost and 201 adopted grey water.

When asked to explain the benefits gained from using co-compost and grey water, most interviewed farmers were positive about the innovation and its various benefits. A few interviewed farmers suggested improvements and other problems they are facing , such as market fluctuation, high electricity usage charges, high cost of seeds and other inputs, transportation and storage difficulties, and access to loans. Overall, farmers experienced multiple benefits from the innovation and have observed greater yields and less usage of water.

Agricultural activities benefit

The innovation's effect on agricultural activities was observed through various questions asked by the innovator. Among the 50 farmers, 90 percent (45) responded positively about using co-compost and 10 percent (5) were not yet using the co-compost (Graph 11). Of these, all intended to use the co-compost generated from the innovation in the next agriculture cycle.

GRAPH 11: NUMBER OF FARMERS USING CO-COMPOST (n=50)



The number of farmers growing a particular crop before and after using the innovation demonstrates the innovation's outcome is substantial diversification (Table 3). Farmers had better yield in terms of vegetable size, color, skin, and taste. Carrot, the golden crop of the Nilgiris, performed well with a 14 percent increase in production after using the innovation. Beetroot has a 12 percent increase while garlic and potatoes only saw a two percent increase. Other crops, including beans, cabbage, radish, cauliflower, broccoli, and zucchini also increased in production. Crops like flowers, strawberry, fenugreek, and capsicum were introduced but were not produced before the access to the innovation. Production of peas was unchanged.

TABLE 3: DIVERSIFICATION IN CROPS AS A RESULT OF USING INNOVATION

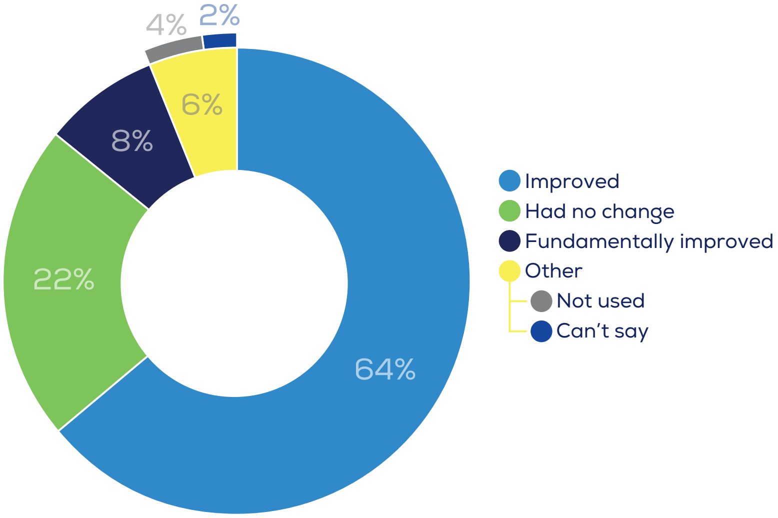
	NUMBER OF FARMERS GROWING CROPS BEFORE INNOVATION	NUMBER OF FARMERS GROWING CROPS AFTER INNOVATION
Carrot	35	42
Radish	2	4
Beetroot	13	19
Garlic	12	13
Peas	1	1
Beans	4	10
Potato	19	18
Cabbage	4	5
Cauliflower	1	2
Broccoli	3	6
Zucchini	1	3
Flowers	0	1
Strawberry	0	1
Capsicum	0	1
Fenugreek	0	1

Water benefits

Water sources ranged from borewells, rivers, ponds, rainwater, and innovation source (grey water) to groundwater. Most farmers used natural sources of water, such as ponds in their lands, nearby rivers, and groundwater, to manually irrigate their crops. They also increasingly relied on grey water because the region's extreme climate change and dry season deprive usual sources of irrigation of water. Few farmers revealed incurring tremendous losses since the last few agri-cycles because of lack of access to water. However, they sometimes invest in water labor costs (cost incurred by farmers to pay daily wage labor to transport water from nearby lands) which leads to high cost of inputs.

Using the innovation, 68 percent of farmers had a major change in access to water (Graph 12). Only eight percent reported significant improvement in accessing water after introduction of the innovation source. Twenty-two percent had no change in access to water after grey water units were constructed. Six percent either not used the innovation or found it too early to see changes.

GRAPH 12: CHANGES IN ACCESS TO WATER AFTER INNOVATION SOURCE WAS INTRODUCED (n=50)

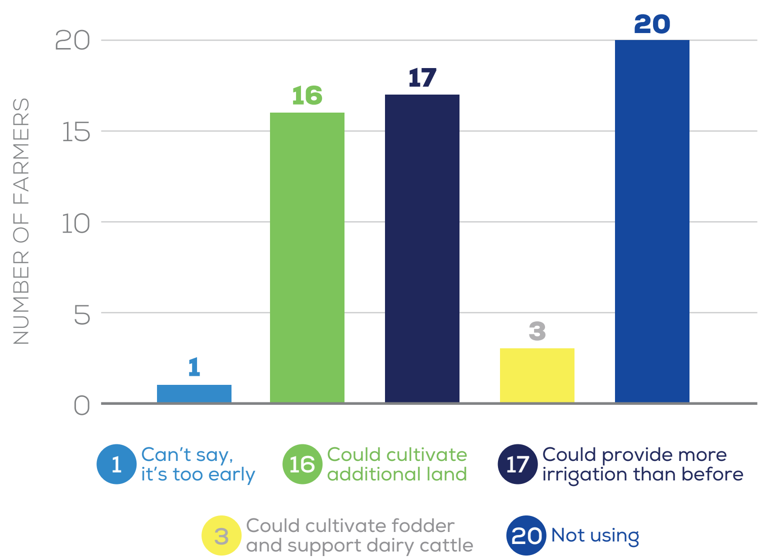


Most farmers complained about water scarcity and requested for more access to grey water. One farmer offered his land to RDO Trust free of charge to construct a grey water unit. Most farmers do not pay for water because they share water from nearby ponds and wells; however, they do incur water labor costs which make the cumulative cost of pre-harvesting practices exuberant.

Grey water unit in Shanthoor Village

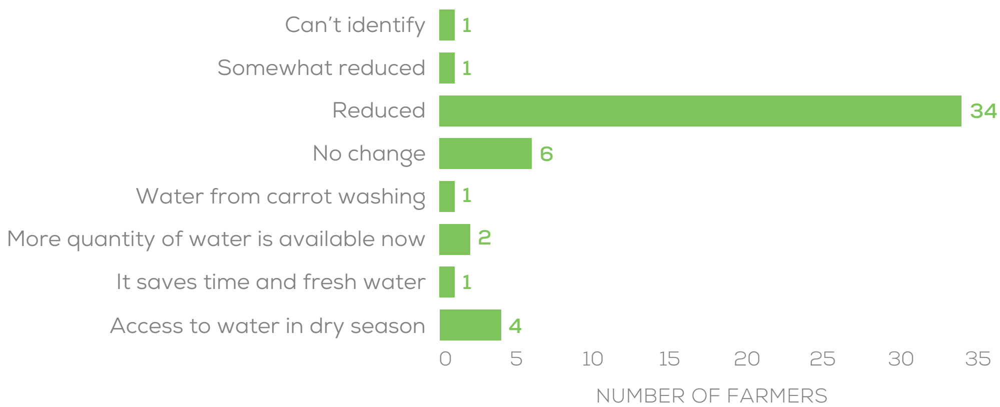
When asked about the result of using grey water, 16 farmers said they could cultivate additional land now (Graph 13). As discussed with the farmer's community leader, it was becoming a common practice to only cultivate one-third to one-fifth of the land because of the area's deprivation of water. The introduction of grey water in some regions, although limited, has allowed farmers to cultivate some additional land. Seventeen of 50 farmers said access to grey water could provide more irrigation than before. Three farmers cultivated fodder and supported dairy cattle apart from irrigation. Due to the high maintenance cost of supporting cattle, many farmers sold their cattle in the past. With access to grey water, this practice is making a comeback. Cattle farming also provides additional income from selling cow dung to be used as a compost in farming.Twenty farmers did not use the grey water facility because the innovation source is not yet in their respective villages. However, all have requested access to the innovation source water. A few villages will gain access in the next phase, although some villages do not have a cluster of households to generate grey water, making it unrealistic to set up a grey water unit. In terms of access to more grey water, households are fewer in number or have not generated enough grey water to meet the demand of farmers. One farmer used grey water recently but could not identify the results.

GRAPH 13: RESULT OF USING GREY WATER



Of 50 farmers, 68 percent (34) have seen a reduction in the quantity of water used for irrigation because the co-compost has increased the soil's moisture retention ,making it viable to use less water (Graph 14). This is an extreme benefit, considering Nilgiris is witnessing its highest recorded dry season in the last decade. There was no change in water usage among 12 percent (6) of farmers, each of whom used the co-compost for one-tenth of their farmland as a trial and said they would use it extensively in the next cycle to see a substantial change.

GRAPH 14: CHANGE IN WATER USAGE AFTER USING INNOVATION (n=50)

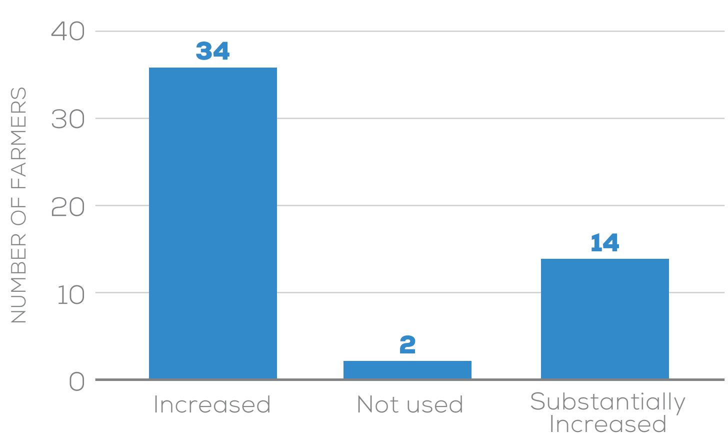


Eight percent (4)now have access to water in dry seasons, something that they did not experience before the innovation was introduced in the region. This allows them to practice farming even in dry seasons. Four percent (2) reported access to more water for irrigation because they are combining grey water with their usual water source for farming. Two percent used water sourced after carrot washing, two percent had a reduction in water usage, and two percent could not identify any changes in access.

Crop benefits

An increase in yield over the period prior to the innovation in Nilgiris was experienced by 68 percent (34) farmers(Graph 15). Those observing a yield increase felt that crops were better quality or had improved survival rates. Twenty-eight percent (14) observed a substantial yield increase while four percent (2) reported not using the innovation.

GRAPH 15: CHANGE IN CROP YIELD AFTER USING INNOVATION (n=50)

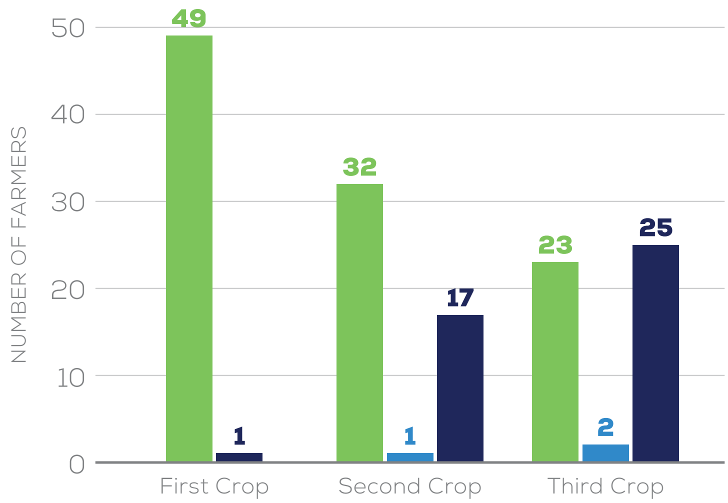


Farmers who have used the innovation for their most important crops observed better quality yield in terms of better, greener, fresher, and qualitative crops after even two months of sowing. Carrot, potato and beetroot are the most important crops across Nilgiris and demand for these crops is insurmountable. Because farming geography facilitates growth and markets allow competitive prices, farmers seem to benefit when growing these crops.

When asked if their three main crops benefited, 98 percent (49) who bought the co-compost (had increased yields, while two percent (1) did not use the co-compost (Graph 16). This shows farmers' confidence in the innovation. With the second most important crop, 64 percent (32) had increased yields, while two percent (1) had decreased yields, and 34 percent (17) did not use the co-compost. It is important to note that the majority of farmers only used the co-compost for their most important crop. They saw merit and wanted to nourish the most important crop as much as possible. This also indicates that farmers see the innovation as an extra quality enhancer agri-input rather than an essential prerequisite for their farming practice. This tendency can be changed by making them more aware of the disadvantage of using chemicals in the soil which essentially speed the process but deteriorate the soil over time. Chemicals are still prioritized over co-compost, which require a solid foundation of education and training to shift farmers to using co-compost permanently. A training and development session can be organized by the innovators as a part of the outreach program. With the third most important crop, 50 percent (25) did not use the co-compost , validating the priority of chemicals over manure behavior. Forty-six percent (23) had increased yields, while four percent (2) saw yields decrease.

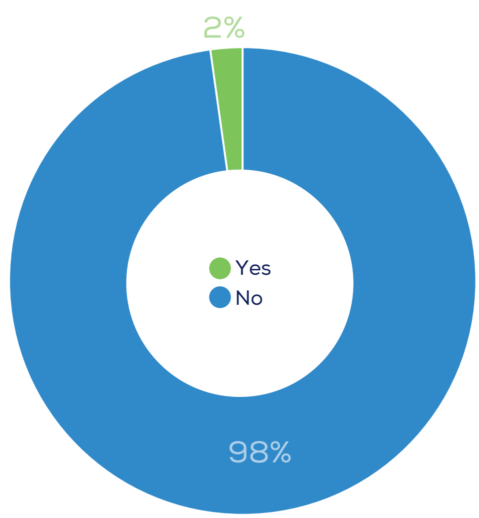
Cultivation of Broccoli using co-compost

GRAPH 16: BENEFITS OBSERVED IN THE FIRST THREE IMPORTANT CROPS AFTER USING INNOVATION (n=50)



Farming knowledge is highly valued and was requested by many of the farmers interviewed. Also, of note is that 98 percent responded "Yes" when asked if they can project the survival rate of the crops (Graph 17). However, two percent answered "No." The majority said they can observe moisture retention in the soil and that using co-compost automatically reduces fertilizer use which enhances crop survival rates. However, an extremely important insight resulted when farmers were asked about crop survival rates.

GRAPH 17: SURVIVAL RATES (n=50)



In Nilgiris District, the government subsidizes electricity usage up to 200 watts, which primarily is for household functions. Farmers utilize this current for fencing to protect the crops from wild animals, which can ruin all the vegetation. For example, a female farmer could no longer cultivate beans and cabbage as supplementary crops despite an excellent yield of beans. The majority of farmers asked for a solar pump to allow them to generate electricity for fencing and use the current provided by the government for the household only. Using the government-supplied current for fencing is more dangerous than using current from a solar pump. . Although this particular insight was out of the scope of the study, it is worth exploring as an extension to the services provided as a part of the innovation.

Income benefits

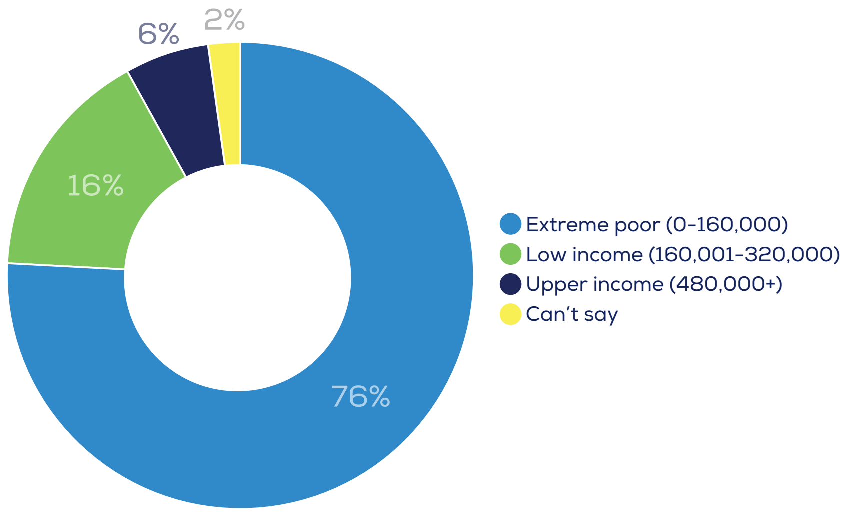
Farmers did not keep close track of their income and expenses. Information was mainly based on what farmers could remember sellingrecently or in the previous year. It was more effective to ask how muchthey would earn for selling one kilogram of each crop and calculate theincome. However, in some cases, farmers stated the total amount they earned in a month or a season.

Prices per kilogram differed depending on the season and market fluctuations and from farmer to farmer. Some farmers managed all transportation and storage logistics themselves and generated a higher profit. In some cases, farmers relied on middle men to eliminate any risk associated with logistical requirements and had less profit.

During the summer, fewer farmers can produce greater yield quantity because of the extreme climate change with no rains and reduced water availability. When asked about the crop prices from last year's production, extreme fluctuations occurred because mandi market is a semi-bondage market where prices are controlled by powerful and wealthy agents. Prices can range from 30 to 60 rupees per kilogram for carrot (the golden crop), depending on the crop, its condition/quality, and the season. Prices for potato ranges from 14 to 40 rupees per kilogram and beetroot is 25 to 40 rupees per kilogram.

Seedling prices ranged from 25,000 to 30,000 per kilogram for one acre. Farmers have started to sell seeds and other inputs themselves because they do not see agriculture as a sustaining occupation due to less rains in the last decade. Farmers were apprehensive about sharing annual income from farming; however, when asked about changes in income due to the innovation, they indicated there was a financial benefit from using the co-compost and grey water. Seventy-six percent are categorized as "extreme poor," 16 percent are "low income," two percent are"upper income" and six percent could not estimate annual income (Graph 18). The exact data is difficult to assess because farmers were not comfortable sharing exact annual income and only gave estimates. Therefore, the income benefit from the innovation can be inconclusive or misleading.

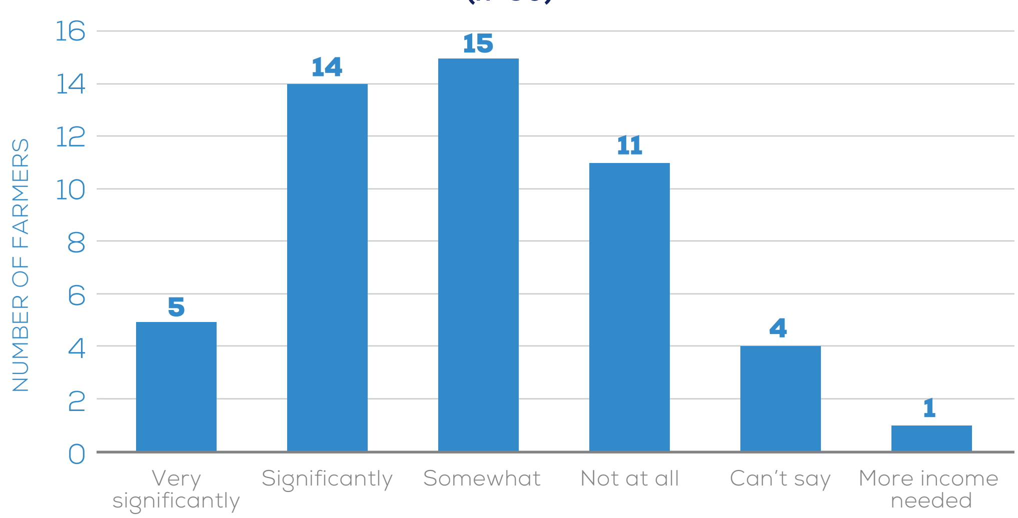
GRAPH 18: CURRENT ANNUAL HOUSEHOLD INCOME AFTER USING INNOVATION (n=50)



The stated income range is broad because farmers referred to either monthly or seasonal income. The smallest stated income was as little as 10000 rupees, while the largest was over 2500000 rupees.

To assess income benefits from the innovation, farmers were asked about any change in income Graph 19).Thirty percent (15 out of 50) reported somewhat increase in income, attributing it to reduction in water labor, quantity of water used, and better quality of yield produced as well as to the farmers' own productivity, price variations, and varying weather conditions. O 50 interviews, 14 farmers reported a significant increase in income, while 11 reported absolutely no benefit in income. Five declared a very significant income change, and four were not able to determine a change in income, while one hoped for better income in the next cycle.

GRAPH 19: IMPROVEMENT IN FAMILY INCOME AFTER USING INNOVATION (n=50)



Thirteen of the 50 farmers responding saw their income increase after the innovation (26 percent), three experienced negative income impact (six percent), and two experienced no change (four percent) (Table 3). Thirty-two farmers (64 percent) could not concretely monitor the change in individual income. Reportedly, farmers believed the income benefit from the innovation was in reducing expensive agricultural inputs, such as seeds and pesticides. Some farmers stated that, since the crops from the innovation were of better quality, it was easier to sell them. The Self Help Group created by the innovators was also considered a benefit, as it provided new knowledge about farming practices which was a contributing factor to their income.

TABLE 3: CHANGE IN INDIVIDUAL FARMER INCOME WITH USING CO-COMPOST

INCOME CHANGE	NUMBER OF FARMERS	% OF FARMERS
Positive	13	26%
Negative	3	6%
No Change	2	4%
Can't Say	32	64%
Total	**50**	**100%**

Poverty reduction benefits

Poverty reduction benefits are estimated by understanding broad farm expenses. To understand the household poverty levels, changes in expenses for transportation costs were investigated before and after introducing the innovation. Before introducing the innovation, almost the entire farmer community of the Nilgiris District used mushroom compost and cow dung as an aggregator for yield. Two types of costs are associated with each aggregator: a transportation cost (generally trucks or a personal vehicle) from the source to a common area where the bulk material is offloaded and the transportation labor cost (human resource cost) from the common areas to the individual farms.

When asked about the transportation cost for cow dung, most farmers owned cattle and only incurred labor cost to individual farms (Table 4). Relative to mushroom compost costs, most farmers are incurring both transportation costs from the composting plant to the common areas and a labor cost from open area to individual farms. Farmers reported higher cost of transportation because the mushroom composting plant is in Coonoor, which is far from the Nilgiris District.

TABLE 4: TRANSPORTATION COST FOR USING COW DUNG AND MUSHROOM COMPOST

INPUTS	TRANSPORTATION COST FOR COW DUNG	TRANSPORTATION LABOR COST FOR COW DUNG	TRANSPORTATION COST FOR MUSHROOM COMPOST	TRANSPORTATION LABOR COST FOR MUSHROOM COMPOST
Number of respondents paying	6	9	35	10
Price paid IIndian National Rupees)	26000	46500	180800	25600
Average (Indian National Rupees)	4333	517	5166	2560

When asked about the transportation costs for co-compost, farmers reported less cost because resource recovery parks are closer to villages in Nilgiris (Table 5). It is difficult to assess the exact change in income and ultimately poverty alleviation, as farmers were not able to recall exact data values. Overall, data reflects a certain reduction in transportation cost but better assessment would take place in coming cycles when farmers start using the co-compost and eliminate the dependence on chemicals.

TABLE 5: TRANSPORTATION COST FOR USING CO-COMPOST

INPUTS	TRANSPORTATION COST FOR COMPOST	TRANSPORTATION LABOR COST FOR CO-COMPOST
Number of respondents paying	28	9
Price paid IIndian National Rupees)	36100	8000
Average (Indian National Rupees)	1289	889

Mushroom compost in farmland.

Difficulty with innovation usage and suggestions

Interviewers asked the farmers if they had problems with the co-compost and grey water or had any suggestions for improvement. Responses included access to grey water, access to more water, reduced prices for co-compost, better road infrastructure, and an increase in the cap of the credit services available to farmers as a part of innovation.

The improvement suggestion related to electricity provision was installation of a solar pump. Pumps are available in the market at a higher cost. Farmers suggested regulating them through a marketplace for agriculture inputs at a nominal price. This would enable them to install electric fencing to save their cultivation from wild animals. Another suggestion was crop insurance facilitated by the RDO Trust to avail benefits under National Schemes. Farmers are apprehensive about applying for crop insurance benefits given their limited knowledge about the schemes or sometimes lack of awareness of the documentation process. Organizations such as RDO Trust can enable the process on behalf of the farmers. Individual loans need to be made available, too, apart from group members.

Another suggestion involved market fluctuations and how farmers are exploited by market agents. Such market variations can be controlled if innovators provide transportation and storage logistical support to farmers. This would reduce their dependence on the agents and, ultimately, market prices can be controlled by farmers.

Farmers requested group mechanisms to buy diesel motors in a group mobilized by innovators. Every group can have six to seven farmers that can use the motor sequentially. This suggestion came to light because of exuberant cost of motor diesel.

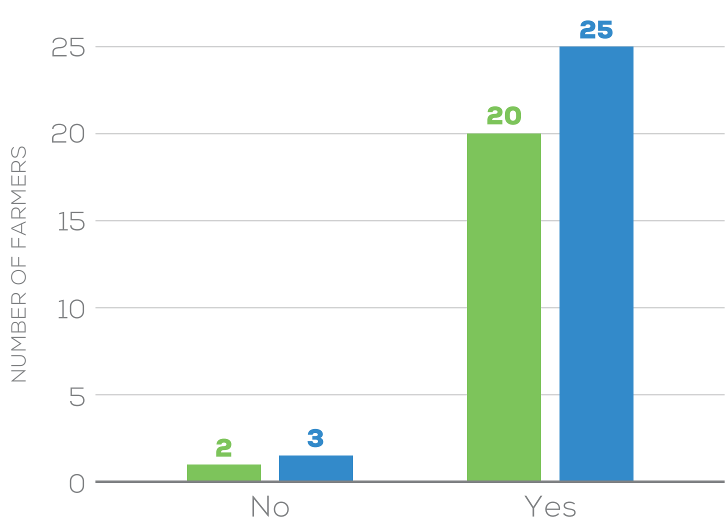
Additionally, farmers suggested that personal loans be made available at lower interest rate, even lower than Ujjivan schemes. They also suggested that they do not want to pay equated monthly installments. Instead, they prefer quarterly payments that would start after four months of the harvesting cycle. Another option would be paying interest every month and the full principle every quarter Farmers reported this is happening through informal sources, and they want it to be channelized through SHG to reduce any further exploitation of farmers through wealthy agents. Also, farmers requested more outreach in terms of SHG loans since some learned of them only recently and could not utilize them in the previous cycle.

Finally, seeds at nominal price needs to be channelizedas prices are extremely high. Framers reported 10 years ago, the price of carrot seeds was 5000 rupees and now is 30000 rupees per kilogram but, interestingly, market prices for crops did not inflate at the same rate. This has resulted in them incurring huge losses every year.

Gender differences and benefits perceived

In terms of usage of co-compost, 20 out of 45 (44 percent) women are using co-compost while 25 out of 45 (55 percent) male farmers used the co-compost(Graph 20). In terms of farmers who have not used the co-compost, two out of five (40 percent) female farmers have not yet used the innovation but both would like to use it in the next cycle. In fact, through this survey, both learned of SHG groups and wanted to become part of it. Three out of five male farmers (60 percent) did not use the co-compost because they heavily use mushroom compost; however, they indicated a desire to use it the next agriculture cycles. Furthermore, women farmers are more likely than men to use co-compost because of two factors: Self Help Group formation and the kitchen garden piloting program.

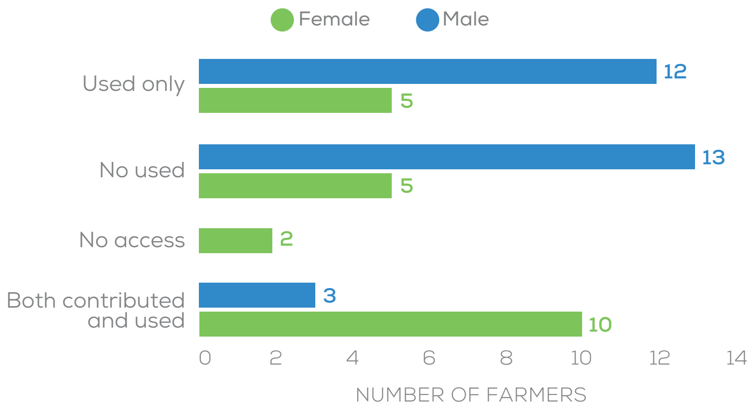
GRAPH 20: GENDER DISPARITY IN USING CO-COMPOST (n=50)



Women farmers removing extra plant while cultivating beetroot.

Women seem to be more enthusiastic about the innovation as they gain farming knowledge and techniques through the innovator's outreach program, making them technically strong since there was limited access to such programs initially. When it comes to using or contributing toward grey water, only 17 farmers used the grey water. Of those, 70 percent were male and 30 percent were female. Eighteen farmers reported not using grey water. Of those, 73 percent were male and 27 percent were female. Two farmers reported no access; both were female. Thirteen farmers reported using both using and contributing toward grey water. Of those, 77 percent were male and 23 percent were female (Graph 21). This poses a challenge to the provision of grey water more generally. This region is already challenged with providing enough grey water to households because the clustering of households is not feasible in many villages geographically. It becomes imperative to educate farmers on the importance of their contribution toward grey water or provide them with the essential means to be able to contribute. Due to limited professions available for women, they tend to work as laborers more often than men. In order to sustain farming as their primary profession, they requested for access to/for more grey water more enthusiastically. Women working as laborers becomes critical to understand the difference in the number of farmerscontributing and using grey water and co-compost, indicating a major gender impact from the innovation.

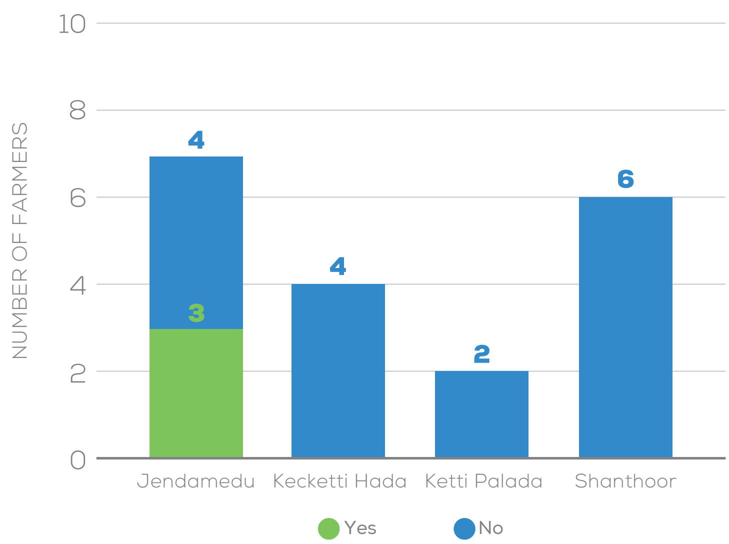
GRAPH 21: GENDER DISPARITY IN USING OR CONTRIBUTING TOWARDS GREY WATER (n=50)



Regional differences

The survey was conducted in eight villages of Nilgiris District where the innovation was active. However, questions related to transport and market availability were asked in only four villages because these questions were added later. The four villages are Jendamedu, Kecketti Hada, Ketti Palada, and Shanthoor, where a total of 19 farmers were interviewed. After conducting the survey, it was clear there were differences between the four villages, especially in terms of logistics of carrying crops to market and negotiating the right prices for the crops. Farmers in different regions had trouble finding markets (Graph 22). Out of 19 farmers, 16 from all four villages reported no trouble finding markets while three farmers from Jendamedu reported trouble in finding the right market.

GRAPH 22: REGIONAL DIFFERENCES IN FINDING MARKETS FOR THE CROP (n=19)

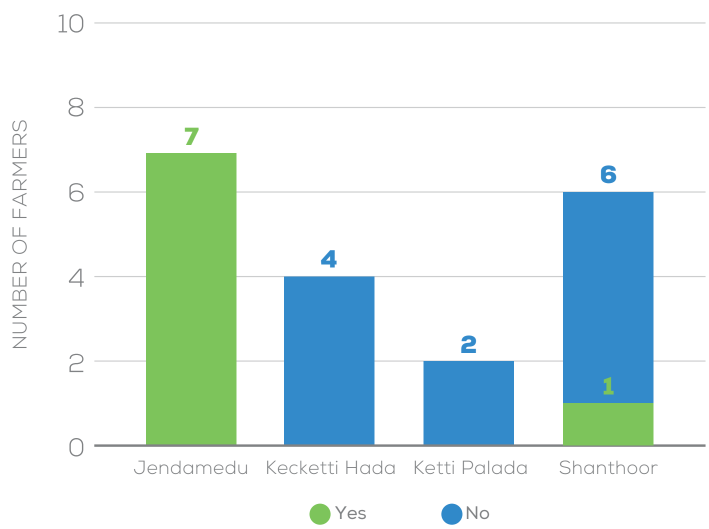


In addition, farmers suggestions and experience with markets brought some insight.

For instance, three farmers who reported trouble finding markets have black color soil in their farmland, which is extremely geographical and found in some parts of Jendamedu village. These farmers could not find markets given the black color of potatoes and other vegetables they cultivate. Most who reported no trouble finding markets share their experiences in terms of dynamic pricing. They operate on the pricing on a particular day and incur huge losses if prices are extremely low. Therefore, timing becomes critical. They try to go as early as possible. Going later means more competition and lower rates, so there is limited time flexibility. Rates are controlled by market-mafias, and farmers have almost no negotiating power in the pricing. Wholesale markets are easily identified ,but quality, size, and color are big variants in setting crop prices in such markets. Hence, manure that increases crop yields becomes an extremely important agent in driving prices in the markets. As part of innovation implemented through the Diamond Model, a key linkage is that female SHG members are fully involved with the farmer's producer company and managing the co-compost supply. The model focuses on developing technical and business capacities of women across the region. Women mainly are dealing with microfinance and are encouraged to move toward agri-business under Farmers Producers Groups. Therefore, the price of produce becomes a critical element in sustaining the entrepreneuring venture of women farmers. If co-compost application helps steer higher prices in the markets, then it becomes a paramount impact resulted through the innovation.

In terms of the regional difference faced by farmers while bringing crops to that market (Graph 23), all seven farmers from Jendamedu villages reported trouble carrying crops to the market, while all farmers from Kecketti Hada and Ketti Palada villages reported no trouble transporting crops. One farmer from Shanthoor village reported trouble, and five farmers from Shanthoor village reported no trouble in carrying the crops.

GRAPH 23: REGIONAL DIFFERENCES IN BRINGING CROPS TO THE MARKET (n=19)



This is because Jendamedu is geographically located far from other villages. The markets and road infrastructure is inadequate, making this village and its farmers inaccessible to various key locations in the district. Roads are narrow, they have to hire two tempos instead of one truck, and, ultimately, pay higher rental. Farmers have to pay higher transport charges every cycle as compared with farmers from other villages. Some farmers suggested they are not comfortable in associating themselves with the risks, so they rely on agents for transportation and labor which eventually leads to agents charging a massive commission. Since prices fluctuate continuously in the markets and farmers aim to get there as early as possible in the day, they must start from their villages at odd hours and take inadequate roads, making them vulnerable to adverse situations.

DISCUSSION

Usage and uptake

The idea has addressed two major challenges of the irrigation sector in one consolidated attempt. This is a definitive example of leveraging opportunities of a circular economy model where solid and liquid waste streams are strategically managed to feed two most crucial input materials (water and fertilizer) into the agricultural sector.

Co-compost from treated waste streams also is cheaper than chemical-based fertilizers; thus, households could increase their annual income using this model. This is due to multiple stakeholders' interest in treatment of wastewater and faecal sludge. As part of various national and state level government schemes, different nodal departments are responsible for treatment of wastewater and faecal sludge, and the outputs of the treatment processes need to be managed by the authorities. This model could help the authorities and the farmers through establishment of a regular and continuous supply chain of the output products in form of co-compost. Farmers have started using co-compost generated using both black water and grey water generated from nearby households. RDO sells co-compost at 5 rupees per kilogram along with lab test results which attracts farmers and gives them certain reliability of the material. Also, the positive experiences of better yield and good quality crops in the region contributes to the higher selling of trusts' co-compost.

Women farmers removing extra plant while cultivating beetroot.

Crop yield and survival

The tables below are mostly for crops grown in the winter of 2019 and harvested in monsoon, and then again sowed in monsoon and harvested in summer. Because of acute climate change and rains still not appearing, many planted crops were in danger of being lost. It should be noted that most farmers alternate crops every cycle, but "carrot" as the golden crop is sown again by the farmers. Carrot has a great market value, has high demand, and offers competitive market prices. Farmers suggested that co-compost helped retain moisture in the soil and strengthen it further so they can grow carrots in the repetitive cycle.

Data on yields of diverse crops grown by farmers before using the innovation (Table 6) and after using the innovation (Table 7)suggest more farmers were growing beetroot, for example, before using the innovation. However, the average yield is higher after using the innovation, suggesting farmers are now growing higher yield crops compared to earlier harvesting. Similarly, better yields can be observed in major crops such as carrot, beetroot, cabbage, zucchini, and cauliflower. Conversely, other major crops such as potato, broccoli, garlic, radish, and peas had a better average before using the innovation. It is essential to note that crop yield are a factor of both the sequence of which crops are sown in a particular cycle and the usage of co-compost. The figures reflect the total produce from all the farmers interviewed.

TABLE 6. FARMERS' CROPS YIELD BEFORE USING INNOVATION

	CARROT	BEETROOT	RADISH	GARLIC	BEANS	PEAS	CAULIFLOWER	POTATO	BROCCOLI	ZUCCHINI	CABBAGE
Number of farmers growing crops before Innovation	23	14	1	9	3	1	1	14	2	1	0
Total kilos harvested before using innovation	109750	49750	2000	23270	6400	1000	2000	70725	3000	500	0
Average	4989	3554	2000	2586	2133	1000	2000	5052	1500	500	0

Crop yield is calculated in kilograms (kg).

TABLE 7. FARMERS' CROPS YIELD AFTER USING INNOVATION

	CARROT	BEETROOT	RADISH	GARLIC	BEANS	PEAS	CAULIFLOWER	POTATO	BROCCOLI	ZUCCHINI	CABBAGE
Number of farmers growing crops after Innovation	35	6	2	10	3	1	3	20	2	1	3
Total kilos harvested after using innovation	278665	40900	3000	15430	1820	500	15000	61070	6000	7000	45000
Average	7962	6817	1500	1543	607	500	5000	3054	3000	7000	15000

Crop yield is calculated in kilograms (kg).

Changes in income

The quantity of inputs used before and after using the innovation. raises some important points (Table 8, Table 9). Quantity of fertilizers, pesticides, herbicides, and seeds remained the same pre- and post-use of the innovation. Water usage remained more or less the same, with six respondents stating they now have better access to water. Respondents could not estimate the reduction in the quantity of water; hence, the data is not quantified. Two farmers relied only on grey water, as they had no access to water before the innovation. Similarly, two other farmers observed reduction in the quantity of water as co-compost retains the moisture in the soil. Another farmer reported better access to water as now she is using the original source of water (in her case, pond) along with grey water provided additionally.

TABLE 8. TOTAL QUANTITY OF INPUTS USED BEFORE INTRODUCING INNOVATION

INPUTS	FERTILIZERS (KG)	PESTICIDES + HERBICIDES (ML)	WATER (1 PER WEEKLY)	WATER LABOR (PER WEEKLY)	SEEDS (KG PER CROP)	COWDUNG (KG)	MUSHROOM COMPOST (KG)
Number of respondents using	48	49	33	23	40	24	35
Total quantity used before innovation	114	18255	663720	66	43	17770	311000
Average	2	373	20113	3	1	740	8886

All quantities are calculated per actuals per acre.

Interestingly, more than water quantity, it was quantity of water labor that changes effectively after the introduction of the innovation. Four farmers reported reducing the water labor as the grey water unit is accessible from their farms, and they can access the water themselves. Two farmers reported using bio-fertilizers and vermicompost and reduced their quantities after using co-compost.

TABLE 9. TOTAL QUANTITY OF INPUTS USED AFTER INTRODUCING INNOVATION

INPUTS	FERTILIZERS (KG)	PESTICIDES + HERBICIDES (ML)	WATER (1 PER WEEKLY)	WATER LABOR (PER WEEKLY)	SEEDS (KG PER CROP)	COWDUNG (KG)	MUSHROOM COMPOST (KG)	CO-COMPOST (KG)
Number of respondents using	48	49	33	23	40	12	22	30
Total quantity used after innovation	114	18255	could not quantify the change	58	43	4470	183750	126760
Average	2	373	NIl	3	1	373	8352	4225

All quantities are calculated per actuals per acre.

Now, coming to the input's usage post-introduction of the innovation, 30 respondents used the co-compost in recent agri-cycle. Introduction of co-compost decreased the number of farmers opting for both cow dung and mushroom compost from 24 to 12 in the case of cow dung and 35 to 22 in the case of mushroom compost. Additionally, co-compost replaced the heavy quantities of mushroom compost used, and farmers are increasingly opting for co-compost because of cheaper prices and better-quality manure. In fact, farmers using bio-fertilizers and vermicompost also reduced their quantities and introduced co-compost in their farming practices. Estimations of the change in income with respect to inputs used before and after the innovation are below (Table 10).

Fewarmers (seven out of 50) have paid for the water, as their own sources of water were depleted and they started buying water where the average price paid by farmers was rupees 7,114 (Table 10). Water labor cost them an average of rupees 1,722. Although, 24 farmers used the cow dung, 50 percent owned the cattle; hence, the remaining 50 percent paid for the cow dung with an average of rupees 25,542. Thirtyfive out of 50 farmers paid for mushroom compost with an average of rupees 62,200.

TABLE 10. TOTAL PRICES OF INPUTS PAID BEFORE INTRODUCING INNOVATION

INPUTS	FERTILIZERS (KG)	PESTICIDES + HERBICIDES (ML)	WATER (1 PER WEEKLY)	WATER LABOR (PER WEEKLY)	SEEDS (KG PER CROP)	COWDUNG (KG)	MUSHROOM COMPOST (KG)
Number of respondents using	48	49	7	23	40	12	35
Total price paid	**34200**	**7302000**	**49800**	**39600**	**1062500**	**306500**	**2177000**
Average	713	149020	7114	1722	26563	25542	62200

All quantities are calculated per actuals per acre.

The change in the price paid for the inputs and eventual impact on the income of farmers is critically important (Table 11). Once grey water was introduced, farmers realized reduction in the quantity of water used but could not quantify by how much; hence, it was difficult to evaluate the prices paid to buy water after the grey water become accessible.

TABLE 11. TOTAL PRICES OF INPUTS PAID AFTER INTRODUCING INNOVATION

INPUTS	FERTILIZERS (KG)	PESTICIDES + HERBICIDES (ML)	WATER (1 PER WEEKLY)	WATER LABOR (PER WEEKLY)	SEEDS (KG PER CROP)	COWDUNG (KG)	MUSHROOM COMPOST (KG)	CO-COMPOST (KG)
Number of respondents using	48	49	33	23	40	6	22	30
Total price paid	**34200**	**7302000**	**Nil**	**34800**	**1062500**	**4470**	**1286250**	**633800**
Average	713	149020	Nil	1513	26563	745	58466	21127

All quantities are calculated per actuals per acre.

Micro sprinklers used as a method of irrigation in farmlands.

Prices for water labor reduced and farmers paid rupees 1,513 on average as compared to an average of rupees 1,722 earlier. Prices paid for cow dung observed a massive reduction after the introduction of co-compost. Post-introduction of co-compost, 50 percent (12 out of 24) fewer farmers used cow dung. Out of these 12, only six paid for cow dung because the rest owned the cattle. Farmers are now paying an average of rupees 745 as compared to an average of rupees 25,542. This explains that farmers observed brilliant yields through co-compost as compared to cow dung and want to shift completely to co-compost in near future. When it comes to mushroom compost, the same trend can be observed. Farmers are now paying an average of rupees 58,466 as compared to an average of rupees 62,200 earlier. Thirty farmers started using co-compost with an average quantity 126,760 kgs used with an average of rupees 21,127 paid by them.

Gender differences

Women do not necessarily own the bigger farm lands in their names, but small-scale agriculture has become a gendered activity where women are seen as the main person responsible for farming even though they do not always have the final decision or legal status of farming land (Table 4). It is important to note that the field evaluator came across more enthusiastic women than men while interviewing about the recent innovation. The innovation, as part of their diamond model, enables women to become agri-entrepreneurs and sustain themselves financially through selling of the innovation to farmers. The innovators have come up with the idea of the Women Self Help Group (SHG) to provide credit services to women (a group of 11 women can avail a credit loan up to 50,000 rupees). This led to ownership of farming practices and a shift of decision making among women which was missing earlier. Women across different regions recommended making the RDO a marketplace for agricultural inputs, such as seeds which are extremely unaffordable, so they could buy them through RDO and pay through EMI services managed by RDO.

After witnessing the success of women SHGs, men are interested in creating all male SHGs with a cap more than 50,000 rupees. Earlier, they were dependent on financing schemes such as Muthoot finance, Impact etc, or through informal sources of loans which are often unreliable. In fact, male farmers are encouraging their wives to be part of these groups to avail maximum benefits.

Even though men had higher technical knowledge in terms of quantity and cost of inputs used in farming, women are increasingly becoming aware of the technical know-how through the innovator's outreach program. They now have access to ask questions or clarify doubts, something that was missing earlier.

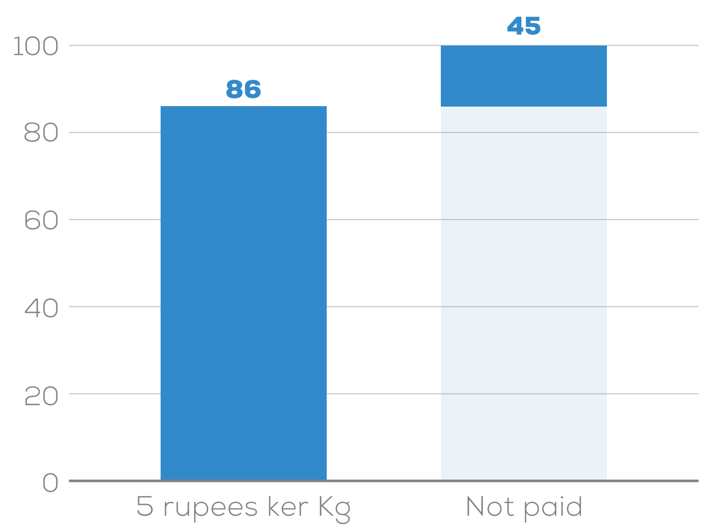
Through this study, many farmers got the cognizance of initiatives taken by innovators, such as formation of SHGs, credit services, benefits of co-compost, and access to grey water facilities. Every SHG is a group of six women who eventually take care of another six women independently. In total, 36 women are part of one group. This model enables complete ownership of circular economy model/innovation to women farmers. Most women farmers showed enthusiasm when they learned about loan services through SHGs and committed to become part of it as soon as possible. One-time fixed cost to join an SHG is 1,000 rupees. Almost all male farmers plan to get their wives to become a part of an SHG going forward. Male farmers observed that their wives are getting heavily invested in the farming practices after joining these groups. A female farmer reported to avail 250,000 rupees under loan schemes in last few years and plans to avail 500,000 rupees more in coming cycles. It was out of scope of this survey to understand gender disparities in terms of knowledge and understanding of techniques related to farming. It is worth exploring deeper how this innovation further benefits women specifically. Also, as previously mentioned, confidence in terms of knowledge, ownerships, and techniques can be observed after the introduction of the innovation, an indirect benefit that also could be better researched to bring more benefits to women. For instance, a one-stop center can be set up to enable women to be trained with newer technologies and practices.

S Shaguntla, Director of SHG Group formed as part of innovation

Affordability

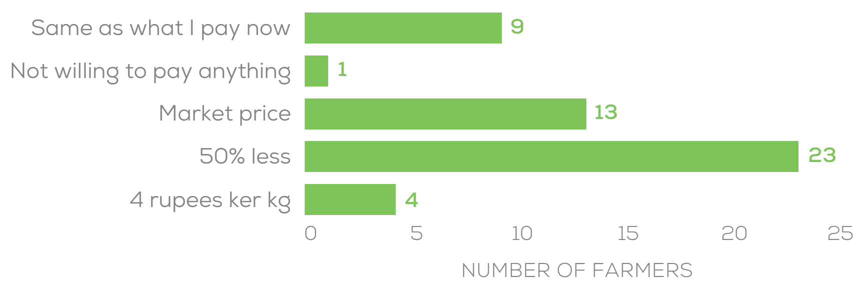
When asking the interviewees how much they pay for the innovation, 86 percent (43 out of 50) of the farmers reported paying Rupees 5 per kilogram for the co-compost. This does not include the transportation cost. Fourteen percent (seven out of 50) reported not paying anything. These farmers have used the co-compost in the kitchen gardens or during the trial phase when it was provided free by extension services (Graph 24).

GRAPH 24: MONEY IN RUPEES PAID BY FARMERS FOR AVAILING INNOVATION (n=50)



When asked about the amount they are willing to pay for the sustained service of the innovation, 46 percent (23 out of 50) immediately continued the answer by saying that they want a 50 percent lower price to afford the service (Graph 25). In fact, 26 percent of the entire sample (13 out of 50) are comfortable paying only the market price for the co-compost. They compare it with the cooperative society compost, which is 4 rupees per kg but comes with a superior transportation cost and no evidence in the form of laboratory test reports. Eighteen percent (9 out of 50) are comfortable paying what they repay now, which is essentially the selling price of co-compost (5 rupees per kg). Eight percent (four out of 50) willingly pay 4 rupees per kg, which is again the selling price of co-operative society compost. One farmer paid nothing for the innovation, as she incurred heavy losses in the last cycle because of market prices and the acute dry season. However, most farmers had a positive attitude toward the innovation and would like it to continue to be active.

GRAPH 25: FARMERS WILLING TO PAY FOR THE INNOVATION (n=50)



Impact on poverty

The innovation had a small impact on poverty alleviation in terms of transport costs, inputs prices, and labor costs since most farmers have used the innovation only three to six months and have yet to see a major income change. They continued with similar practices but reported to qualitatively observe improvement in income. Data shows after the innovation was active, 38 percent of farmers reported increased income while income remained the same for for the majority of farmers (Graph 16). On the other hand, the diversification of the crops assessed, higher yields, and average earnings of farmers after selling their yields showed positive inclination, which also can be seen as beneficial. This is in line with the fact that farmers expect that innovation would direct benefits to them after they completely shifted to co-compost and eliminated other sources of composting. It is interesting, however, that more farmers want to utilize all the benefits of the innovation from grey water to co-compost and credit services from SHGs. The data repeatedly showed that farmers would like to obtain any kind of help to bring them out of their state of deprivation. One farmer stated he "hopes for a better income after every cycle." When asked if they wanted to continue using the innovation, the majority agreed and recommended improvements and supplementary suggestive mechanisms in the innovation. Also, for faster and larger production, a large-scale farmer suggested , he would need to use chemicals and co-compost might not able to replace them completely. It is worth exploring this target segment (upper income) of farmers to make them knowledgeable about co-compost and to develop training modules customized for different target groups.

Benefits of innovation on community

The impact and benefits of WASTE's innovation can be noted confidently for farmers across all regions. Although, benefits on the community are difficult to measure, one can observe tangible community cohesion as a result of the innovation. The grey water unit installed in some villages has allowed small groups of farmers to use the water cyclically, which brought community-level sharing and adeptness to resources judiciously. For instance, farmers reported the quality of grey water is so good that it looks like filtered water. Officials from RDO come weekly to make sure everyone has access to water. Additionally, this cyclic process is community-driven, enabling them to take ownership of general cleanliness in the village.

In most cases, it is observed that women specifically have developed a sense of ownership and pride toward learning about the innovation. They now have an agency to learn new techniques from and can implement them in the field, making them feel empowered. Good quality yields observed after using co-compost are leading to confidence building. For instance, one female farmer said: ***"My sister-in-law has asked for co-compost because the vegetable from my kitchen garden taste. She is from Coonoor. I felt very happy and encouraged to tell about this innovation to my family, friends and neighbors"***

Another farmer stated:

"I plan to use co-compost for tea farming as well now seeing better quality yield from neighbor farmers. This will help me improve my family income and give better education to my children"

It was observed that farmers exhibited a lot of trust and faith in the innovation and started to treat it as a tool for community engagement. Another benefit was recent involvement of youth in agriculture and seeing positive changes, which gives them a sense of hope. They now see farming as a sustained profession, which otherwise was becoming difficult to sustain in the past years because of the acute dry season and climate change.

CONCLUSION

WASTE is a SWFF-supported circular economy project that is intended to help farmers with access to grey water when fresh water resources are increasingly getting depleted. This allows farmers to cultivate better and good quality exotic vegetables with the usage of market quality compost application, enabling an extended crop season to advance bringing soil back to life in the Nilgiris District. The innovation primarily accounts the concern of limited and expensive resources, such as water, seeds, compost, manure, labor, fertilizers, and petrol, and figures out a sustainable, scalable, and actionable route map to produce high quality co-compost from waste water and faecal sludge.

This report analysed the results obtained by the monitoring and evaluation field intern, who conducted an evaluation survey in July 2019 in Nilgiris after the project had been active there for two years. The report provides insight on various parameters which may become essential to track future monitoring and provides insights on various parameters which may become essential to understand the future scope.

- Cost of co-compost should be reviewed, as it is important to monitor the market competition and operational cost to produce co-compost and understand how it can be reduced to meet the farmer's request for a lesser price. The government stakeholders can be lobbied and the horticulture department can come forward to buy co-compost in bulk and eventually sell it at a subsidized price.
- It becomes imperative to learn about the market pricing and fluctuations; hence, questions as to how the market is structured and who controls the pricing of the vegetables become crucial. These can be viewed as an extension to the model, as its would provide insights in the semi-bondage market of Nilgiris which is essentially an insight into the innovation's impact.
- The innovator should consider collaboration with educational institutes to sell the crops cultivated by farmers directly to hostels rather than involving middle men to generate better income for farmers. Seeds are the most unaffordable input, and farmers outrightly declared not being able to afford them in the long run. The RDO Trust, given the trust and their reputation amongst the farmers, can be created like a marketplace where farmers can avail them on subsidised price and through flexible EMI options.
- A service center for farmers can be incubated disseminate information about new technologies, new and sustainable brands of inputs, and scalable methods of sustainable farming. The center would specifically be useful for women farmers who generally are hesitant to learn new technologies or largely do not have access to learn new processes. The center also can enable capacity building of farmers by teaching them a balanced application of fertilizers.
- Most of the farmers requested more grey water. This depends upon the topology of the villages and the contributing number of households. Most farmers wanted to construct a grey water unit in their lands as it brings farm ponds automatically in their land. There seems to be flexibility in terms of designing and costing grey water units. This insight may be explored further.
- Access to grey water on farms had become indispensable to them as they had to reduce the consumption of fresh water for irrigation and divert it for use as drinking water in state of scarcity. Similarly, any region having high depletion of the freshwater sources or seems to be reaching that in the future should adopt this model to make the best use of available resources. As the model involves multiple stakeholders having a shared goal, implementation has become easy and highly impactful.

- A majority of farmers immediately asked for a solar pump to enable them to utilize the electricity generated by the pump for fencing and use the current provided by the government for household use only because using the government current for fencing is more dangerous and harmful than using the solar pump. Farmers are losing their entire vegetation because of wild animals.
- Another extension to the services of note is the recycling of carrot washing water. These recycling units need to developed wherever a carrot washing factory is established. Given the acute dry season Nilgiris is observing, this assessment can be explored in future. There are 16 units of carrot washing alone in Ketty Palada. Private entrepreneurs are majorly operationalizing the unit. A collaboration can be followed to recycle the water used for carrot washing, which can lead its way to farms or the water used for carrot washing should be recycled in the first place. Private sector engagement is crucial in agricultural planning given the shift in available resources.
- When it comes to food security, organic carbon content in soil is essential. Co-compost helps in retaining the carbon and helps to sync carbon in the soil.
- The innovation had an impact on water usage, crops, yields, and farmers' income. To build it further, the capacities of farmer producing companies needs to be strengthened, which would eliminate middle men. An EMI or a quarterly system for agri-inputs can be facilitated. Market has a huge cultural aspect toward crop pricing. Farmers purely rely on agents because they do not want to undergo any stress or risk, thereby willingly losing a massive chunk of profits.
- With respect to the supply of exotic vegetables, marketing initiatives need to be strengthened to promote modern terminals markets that connect to major urban centers.

With a high degree of uncertainty of rainfall as the time progresses, right policy interventions and Government schemes to implement dry land farming, water conservation through precision farming, and diversification of crops become consequential.

When it comes to understanding farmers' perceived benefits from the innovation, there is a positive inclination in totality.

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ANNEX I

TABLE 12. FARMERS' CROPS YIELD BEFORE AND AFTER USING INNOVATION AND PERCENTAGE CHANGE IN THE YIELD

	CARROT	BEETROOT	RADISH	GARLIC	BEANS	PEAS	CAULIFLOWER	POTATO	BROCCOLI	ZUCCHINI	CABBAGE
Average kilos harvested before using innovation	4989	3554	2000	2586	2133	1000	2000	5052	1500	500	Nil
Average kilos harvested after using innovation	7962	6817	1500	1543	607	500	5000	3054	3000	7000	1500
Percentage	60%	32%	-25%	-40%	-72%	-50%	150%	-40%	100%	1300%	Nil

TABLE 13. AVERAGE PRICES OF INPUTS PAID BEFORE AND AFTER INTRODUCING INNOVATION AND PERCENTAGE CHANGE IN THE PRICES

INPUTS	FERTILIZERS (KG)	PESTICIDES + HERBICIDES (ML)	WATER (1 PER WEEKLY)	WATER LABOR (PER WEEKLY)	SEEDS (KG PER CROP)	COWDUNG (KG)	MUSHROOM COMPOST (KG)
Average price paid before innovation	713	149020	7114	1722	26563	25542	62200
Average price paid after innovation	713	149020	NIl	1513	26563	745	58466
Percentage change	NIl	Nil	-100%	-12.13%	Nil	-97%	-6%

ANNEX II: SURVEY

FARMER INFORMATION

NAME ____

AGE ____

DATE ______________________ TIME ______________________

GROUP INTERVIEW? ❑ Yes ❑ No

GROUP INTERVIEW NOTES

____

____

____

HOW MANY FAMILY MEMBERS LIVE WITH YOU? ______________________

GENDER ❑ Male ❑ Female

WHAT IS YOUR PRIMARY OCCUPATION?

❑ Farming
❑ Wage Labor
❑ Seasonal Migrant Labor
❑ Small Enterprise
❑ Other: ____

DO YOU HAVE ANOTHER OCCUPATION?

❑ Farming
❑ Wage Labor
❑ Seasonal Migrant Labor
❑ Small Enterprise
❑ Other: ____

SIZE OF FARM (ACRES) ____

NAME OF VILLAGE ____

HOW MUCH LAND DO YOU OWN? ____

HOW LARGE IS YOUR FARM/PLOT?

❑ Large
❑ Medium
❑ Small
❑ Very Small

HOW MUCH IS LAND RENT? ___________________________

OTHER LAND NOTES

____

____

____

HOW LONG HAVE YOU BEEN USING WASTE STICHTING? ___________________________

DID YOU PARTICIPATE IN AGRICULTURAL ACTIVITIES THIS YEAR? ❑ Yes ❑ No

HOW MANY MONTHS IS THE PRIMARY GROWING SEASON? ___________________________

HOW MANY TIMES DO YOU HARVEST PER YEAR? ___________________________

FARM INFORMATION

WHAT CROPS DO YOU GROW AS A RESULT OF THE INNOVATION? LIST FROM MOST IMPORTANT TO LEAST IMPORTANT:

1. ___________________________
2. ___________________________
3. ___________________________

DID THE MOST IMPORTANT CROP BENEFIT FROM WASTE STICHTING? ❑ Yes ❑ No

DID THE SECOND MOST IMPORTANT CROP BENEFIT FROM WASTE STICHTING? ❑ Yes ❑ No

DID THE THIRD MOST IMPORTANT CROP BENEFIT FROM WASTE STICHTING? ❑ Yes ❑ No

WHAT IS THE WATER SOURCE FOR YOUR IRRIGATION OF CROPS?

- ❑ Own pond
- ❑ River
- ❑ Groundwater
- ❑ Innovation Source
- ❑ Other: ___________________________

WHAT IS YOUR METHOD OF IRRIGATION?

- ❑ Drip feed
- ❑ Flooding
- ❑ Hand watering
- ❑ Rainfed
- ❑ Other: ___________________________

HOW MUCH HAS YOUR WATER USAGE CHANGED SINCE USING WASTE STICHTING, IF AT ALL?

____

HAVE YOU CONTRIBUTED OR USED RECYCLED GREY WATER? ❏ Yes ❏ No

WHAT IS THE RESULT OF THE USE OF GREY WATER? ______________________________

____

____

HAVE YOU BEEN USING CO-COMPOST? ❏ Yes ❏ No

IF SO, HOW MANY YEARS HAVE YOU BEEN USING IT? ______________________________

USING WASTE STICHTING HAS YOUR ACCESS TO WATER:

- ❏ Had no change
- ❏ Improved
- ❏ Fundamentally improved (Improved a lot)
- ❏ Other: ____

PREVIOUSLY GROWN CROPS: DID YOUR FARM PRODUCE DIFFERENT CROPS IN THE PAST THAT ARE NO LONGER GROWN HERE? IF SO, WHICH ONES? ______________________________

____

MASS OF PRODUCE: WHAT YIELDS DID YOU HAVE FOR EACH CROP YOU MENTIONED?

____

____

MASS OF PRODUCE 2: WHAT YIELDS DID YOU HAVE FOR YOUR CROPS BEFORE USING WASTE STICHTING? ____

____

USING WASTE STICHTING HAVE YOU, FOR EACH CROP:

- ❏ Used more water
- ❏ Had no change in water use
- ❏ Used less water
- ❏ Other: ____

USING WASTE STICHTING HAVE YOUR CROP YIELDS (ASK FOR EACH CROP):

- ❑ Declined
- ❑ Remained the same
- ❑ Increased
- ❑ Substantially increased

IS THERE A DIFFERENCE IN THE SURVIVAL RATES OF YOUR CROPS DUE TO WASTE STICHTING?

❑ Yes ❑ No

HOW MUCH OF YOUR PRODUCE DID YOU CONSUME IN YOUR HOUSEHOLD? (PERCENTAGE – NOTE IF DIFFERENT FOR EACH CROP) ______________________________

____

HOW MUCH OF EACH OF THE FOLLOWING INPUTS DID YOU USE BEFORE WASTE STICHTING?

FERTILIZER ____________ (KG)
PESTICIDE ____________ (KG)
HERBICIDE ____________ (L)
CHARCOAL ____________ (KG)
WATER ____________ (TOTAL)
LABOR ____________ (DAYS)
OTHER ________________

HOW MUCH DID YOU SPEND ON EACH OF THE FOLLOWING INPUTS BEFORE WASTE STICHTING?

FERTILIZER ____________ (KG)
PESTICIDE ____________ (KG)
HERBICIDE ____________ (L)
CHARCOAL ____________ (KG)
WATER ____________ (TOTAL)
LABOR ____________ (DAYS)
OTHER ________________

HOW MUCH OF EACH OF THE FOLLOWING INPUTS DO YOU USE AFTER WASTE STICHTING?

FERTILIZER ____________ (KG)
PESTICIDE ____________ (KG)
HERBICIDE ____________ (L)
CHARCOAL ____________ (KG)
WATER ____________ (TOTAL)
LABOR ____________ (DAYS)
OTHER ________________

HOW MUCH DID YOU SPEND ON THE FOLLOWING INPUTS AFTER WASTE STICHTING?

FERTILIZER ____________ (KG)
PESTICIDE ____________ (KG)
HERBICIDE ____________ (L)
CHARCOAL ____________ (KG)
WATER ____________ (TOTAL)
LABOR ____________ (DAYS)
OTHER ________________

HOW MUCH DID YOU SPEND ON EQUIPMENT BEFORE AND AFTER WASTE STICHTING? ________

____

HOW MUCH DID YOU SPEND ON TRANSPORT AND STORAGE BEFORE AND AFTER WASTE STICHTING? ____

DO YOU HAVE PROBLEMS FINDING A MARKET TO SELL YOUR CROPS IN? ❑ Yes ❑ No
PLEASE EXPLAIN. ____

____

DO YOU HAVE PROBLEMS GETTING YOUR CROPS TO THE MARKET? ❑ Yes ❑ No
PLEASE EXPLAIN. ____

____

OTHER FARM NOTES (OPTIONAL).

____

____

____

INCOME AND EXPENDITURES

WHAT IS YOUR ANNUAL HOUSEHOLD INCOME? _________________________________

HOW MUCH INCOME DID YOU MAKE BEFORE WASTE STICHTING? ______________________
AFTER WASTE STICHTING? ____

HAS WASTE STICHTING IMPROVED YOUR FAMILY INCOME? __________________________

WHAT PERCENTAGE OF YOUR INCOME DO YOU GET FROM NON-FARM SOURCES? __________

HOW MUCH PRODUCE DID YOU SELL FOR EACH OF YOUR CROPS IN THE LAST SEASON AND THE LAST YEAR? ____

____

WHAT IS THE PRICE PER KILO YOU RECEIVED FOR EACH OF YOUR CROPS FOR THE LAST SEASON?

____

____

USING WASTE STICHTING HAS YOUR ACCESS TO CREDIT:

- ❏ Not improved
- ❏ Improved
- ❏ Improved and have been able to repay over a short period

HOW DO YOU CURRENTLY FINANCE AGRICULTURAL ACTIVITIES?

- ❏ Own savings
- ❏ Credit and savings scheme
- ❏ Other credit

HOW MUCH DO YOU PAY FOR WASTE STICHTING? ______________________

HOW MUCH ARE YOU WILLING TO PAY FOR WASTE STICHTING?

- ❏ Nothing
- ❏ WASTE STICHTING is free
- ❏ The same as what I pay now
- ❏ 50% less
- ❏ 50% more
- ❏ Other: ______________________________________

HOW HAVE YOU SPENT YOUR NEW INCOME?

- ❏ N/A (if no new income)
- ❏ Send children to school or keep children in school
- ❏ Social functions (like weddings)
- ❏ Investment in farming
- ❏ Improving house
- ❏ Other: ______________________________________

OTHER INCOME NOTES (OPTIONAL)

____

____

____

PERCEPTIONS OF WASTE STICHTING

WILL YOU USE WASTE STICHTING IN THE FUTURE (5 TO 10 YEARS)? ❑ Yes ❑ No

WHY? ____

____

HOW, IF AT ALL, HAVE YOU CHANGED YOUR FARMING PRACTICES DUE TO WASTE STICHTING?

- ❑ No change
- ❑ Introduced new crops
- ❑ Changed irrigation system
- ❑ Reduced water usage
- ❑ It helps me decide when to plant
- ❑ It helps me decide which crops to plant

HAVE YOU FACED ANY DIFFICULTIES OR PROBLEMS USING WASTE STICHTING? ❑ Yes ❑ No

HOW CAN WASTE STICHTING BE IMPROVED? ____

____

HOW DID YOU HEAR ABOUT WASTE STICHTING?

- ❑ Wealthy farmer
- ❑ Neighbor
- ❑ Innovation personnel
- ❑ Extension worker
- ❑ Other: ____

WHAT FACTORS INFLUENCED YOU TO TRY WASTE STICHTING?

- ❑ Demonstration from neighbor's farm
- ❑ Innovation is free from extension services
- ❑ No alternative water source
- ❑ Other: ____

DO YOU SHARE YOUR KNOWLEDGE SKILLS FROM WASTE STICHTING WITH OTHERS? ❑ Yes ❑ No

IF SO, HOW? ____

____

____

WHAT DO YOU FEEL ARE THE BENEFITS OF WASTE STICHTING? ________________________________

____

____

HAVE YOU HEARD ABOUT CLIMATIC VARIATION? HAVE CHANGES IN RAINFALL OR TEMPERATURE AFFECTED YOUR FARMING PRACTICES OR CROP YIELDS COMPARED TO YOUR HISTORICAL RAINY/DRY SEASON PERIODS? ❏ Yes ❏ No

PLEASE SPECIFY HOW. ____

____

____

HOW HAS WASTE STICHTING HELPED YOU? PLEASE RANK THE TOP 3 AND EXPLAIN POSITIVES/ NEGATIVES.

- ☐ Makes water reusable ____
- ☐ Helps women farmers as well as men __________________________________
- ☐ They made a special effort to include women farmers ______________________
- ☐ Helps in producing more of our most important crop ______________________
- ☐ Increases my yield through timely forecasts ____________________________
- ☐ Helps by lowering cost of inputs _____________________________________
- ☐ Improves health and strength of livestock ______________________________
- ☐ Helps reduce labor ____
- ☐ Reduces crop wastage ____
- ☐ Helps me decide when to plant ____
- ☐ Helps me decide which crops to plant ___________________________________
- ☐ Other: ____

WOULD YOU RECOMMEND WASTE STICHTING?

- ❏ No
- ❏ Yes
- ❏ Yes, would strongly recommend

ARE THERE NEGATIVE IMPACTS FROM WASTE STICHTING IN THE COMMUNITY? ❑ Yes ❑ No

PLEASE EXPLAIN IF YES. ____________________

____

____

IF THERE HAVE BEEN ANY NEGATIVE IMPACTS, HAVE EFFORTS BEEN MADE TO RESOLVE THEM?
❑ Yes ❑ No

EXPLAIN. ____________________

____

____

OTHER

INCOME/POVERTY NOTES

____

____

GENDER OBSERVATIONS

____

____

QUESTIONS/REQUESTS

____

____

OTHER NOTES

____

____

____

SECURING
WATER
FOR FOOD:
A GRAND CHALLENGE
FOR DEVELOPMENT

Securing Water for Food has sourced and invested in a portfolio of innovative solutions that aim to help farmers use water more efficiently and effectively, improve water storage for lean times, and remove salt from water to make more food. Our cohort of innovators are helping people in 35 low-resource countries with tools they need to produce more food with less water.

To learn more about Securing Water for Food, visit www.securingwaterforfood.org.