DEVELOPING CLIMATE RESILIENT VILLAGES

Managing Water & Land to Tackle Drought

An Impact Evaluation Study and Proposed Guidelines for Water Tank Desiltation in Maharashtra

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Developed jointly by: The Nature Conservancy – India & Watershed Organisation Trust

Submitted to: Amit Chandra

The Nature Conservancy India

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The Nature Conservancy's India programme has been advancing projects in India since 2015 and aims to work closely with the Indian Government, NGOs, research institutions and citizens to create science-based solutions that support India's efforts at development while conserving the lands and rivers on which all life depends.

We bring strong science, an ability to pilot and scale up on-the-ground programmes, a focus on collaborating with stakeholders and a history of global conservation successes. We are supporting the Indian Government's priorities, particularly the National Mission for Clean Ganga, Namami Devi Narmade, wetland conservation initiatives, air pollution in northwest India, renewable energy goals and the Smart Cities Mission. We envision a vibrant and healthy India that is guided by sound science to manage its natural resources.

Watershed Organisation Trust

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Established in 1993, the Watershed Organisation Trust (WOTR) is a non-profit that engages at the intersection of practice, knowledge and policy across scales and in collaboration with stakeholders from across sectors.

WOTR assists rural communities to assess their vulnerabilities to climate and non-climatic risks. It organises them in a socially and gender inclusive manner to help themselves out of poverty by regenerating their ecosystems in a holistic and integrated manner, conserving and optimising resource use, especially water, and undertaking climate smart sustainable livelihoods.

WOTR as a learning organisation has set up the Centre for Resilience Studies (W-CReS) in Pune with a focus on applied research. It closely engages with institutional and governance actors so that insights and good practices derived from the ground experience contribute towards shaping policies and enabling effective programmes.

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❑ Executive Summary

The state of Maharashtra in India has 36 districts, of which more than 20 (mostly in the north-western, northern and central regions) regularly face droughts. Lack of adequate water has had a cascading effect on socio-economic and environmental conditions in these regions. One of the major problems is the fact that small dams which traditionally stored water during the dry season are in a state of disrepair. The reason behind that is siltation – when particles settle in the water and the tank – a problem compounded by lack of regular maintenance. This is primarily due to human activities in the upper catchment areas and the failure of traditional institutions to maintain these tanks.

But tanks, when desilted, help villagers in multiple ways.

Studies have shown the benefits of desilting water tanks and subsequently using the silt to improve the quality of soil in farmland, on farm productivity and regional hydrology. To assess the effect of desilting, a project was carried out with funds and support from philanthropist Amit Chandra of Bain Capital, implemented by NGOs such as Caring Friends, Manavlok and Dilasa Sanstha. For this, eight reservoirs/dams were desilted in Beed, Jalna and Nanded districts of the Marathwada region in Maharashtra. The silt excavated from the tanks was applied to the soil in farmland. Not only did the water capacity of these tanks/dams increase because of desilting, but it also led to the recharging of groundwater and an improvement in farm productivity.

Encouraged by such positive results, the Maharashtra Government announced a *"Gaalmukt Dharan, Gaalyukt Shivar Yojana"* (literally, silt free water reservoirs and fertile farms) policy in 2017 and set up a "Desilting Policy Committee", which recommended that 31,459 small dams and water tanks be desilted in the state. This initiative has huge potential of improving drought resilience in the state.

To support this initiative, The Nature Conservancy India, in partnership with Watershed Organisation Trust (WOTR), conducted a study on the pilots with the following objectives:

- Provide scientific basis to evaluate impact of desilting along with a cost-benefit analysis.
- Provide science-based recommendations for developing guidelines to upscale this work.

Evaluation surveys were conducted on seven pilot tanks in Beed and Nanded districts. Most farmers interviewed in the survey were small and marginal peasants and were scattered across income ranges.

> THE COST-BENEFIT ANALYSIS SHOWS THE DESILTATION ACTIVITY IS ECONOMICALLY VIABLE, EVEN WHEN ONLY THE FERTILITY OF SILT FROM THE TANKS IS CONSIDERED.

Data was collected by surveying the farmers and NGOs involved in desilting through a structured questionnaire. Two soil samples were collected from farms which had benefited from silt application. Soil samples were also collected from three tanks. A GIS-based analysis was undertaken to assess changes in vegetation and water spread areas. Two indices – Normalised Difference Vegetation Index (NDVI) and Normalised Difference Wetness Index (NDWI) – were evaluated. A cost-benefit analysis was carried out to assess the economic feasibility of tank desiltation. Expenses incurred by the NGOs for excavating silt were considered as the cost. The benefits were calculated on the basis of the then current market prices of fertilisers which would have been needed to replenish the equivalent quantity of nutrients applied through the silt.

KEY FINDINGS OF THE SURVEY

1. The quality of silt varies from tank to tank and, therefore, its impact on farm soil also varies:

There were mixed results on the effect of silt application on soil texture, bulk density and water holding capacity of the farm soil and it varied from tank to tank. Soil samples were collected from silt-applied farms and from control farms (an adjacent farm where silt was not applied). The farms on which silt was applied recorded an increase in water holding capacity and improved organic carbon in the soil as compared to control farms.

2. The impact of desilting and silt application on the farms was positive on agriculture:

The area under cultivation increased, seasonally irrigated area increased, rainfed areas and waste land reduced (due to increased irrigation and improved soil conditions), the gross area under water-saving technologies increased, and some amount of summer cropping was made possible.

- The area under irrigation (of 33 households) increased from 57 acres to 75.3 acres in the Kharif season for the three main crops (cotton, soybean and bajra). The same trend was observed in the Rabi season.
- Area under cultivation increased by 51.5 acre (3 per cent) and seasonally irrigated area increased by 33.8 acre (5 per cent).
- Perennially irrigated area showed a significant increase of 86 acre (112 per cent). Rainfed area and waste land reduced by 7 per cent and 11 per cent respectively.
- A corresponding increase in yield was also observed during this period.
- Between 2015 and 2016, the area under cash crops increased whereas that of food crops reduced.
- An increase in area, production and yield of Rabi crops in the post-intervention period was noted.
- No summer crops were reported in the period before desiltation but in the summer of 2016, about eight farmers reported cultivating groundnut, maize and bajra in an area of 10.4 acre.
- Similarly, fodder crops that were not being cultivated before the desiltation are now being grown by six farmers in an area of about 4.3 acre. The area under sugarcane cultivation has also increased from 13.8 acre to 55.9 acre.
- A positive change was observed for intercropping with an increase of about 300 per cent in area. The gross area under water saving technologies increased from 29.7 acre to 76.3 acre after the intervention period.

3. A slight reduction in per acre cost of chemical fertilisers was observed for major crops:

There was a marked reduction in per acre cost (by 31 per cent) of chemical fertiliser for sugarcane, a perennial crop. The fertiliser use could be much lower, but the farmers were reluctant to reduce their input as they felt they had invested significant money in silt application and feared loss of their investment in case of failed crops. Hence, they applied more fertilisers in farms where silt was applied (even though it was not needed). Farmers were of the opinion that silt application reduces weed growth and that weeding cost had reduced. There was no change observed in per acre cost of pesticides for all crops except Bengal gram and soybean which showed an increase of 10 per cent and

20 per cent respectively. This may be due to increase in pest attacks for these crops. No change was observed in the per acre cost of pesticides.

4. There was an increase in income from the silted farms which was used for a variety of socio-economic purposes by the farmers:

The average gross annual income from the silt applied parcel of land rose from Rs. 37,489 to Rs. 92,855. The income generated from the silted farms was used for a variety of purposes by the farmers. Some common uses were: repayment of loans, education of children, marriages, livestock purchases, investments in agriculture (repairing of farm bunds, levelling, purchase of micro irrigation sets), medical purposes and domestic uses including house repairs.

5. Desilting is economically viable for farmers:

The average benefit-cost ratio of three tanks was 1.31. This indicates that the desiltation activity was economically viable, even when only the fertility of silt from the tanks was considered. However, additional indirect benefits of desiltation such as increased water storage capacity, improved soil texture and water holding capacity are not reflected here.

6. Farmers bear the major portion of the cost of the policy:

The major cost of the scheme – to transport and apply silt to farmland soil – was borne by the farmers. The NGOs helped in organising the communities to manage desilting, along with supervising the excavation of the tanks. The average cost borne by the NGOs was Rs. 2.4 lakh per tank, whereas the average cost borne by the farmers included in the survey was Rs. 23.5 lakh per tank. Of the expense borne by the farmers, about 87 per cent was for transportation of silt. Of all the farmers surveyed, 44 per cent took a loan to fund this. The average distance between the tank and the silted farm was 2.4 km. In general, farmers applied three to six inches of silt on their farm.

7. Farmers faced two main challenges while carrying the silt from tank to the farms:

These challenges are i) funds and ii) timely availability of transportation vehicles. An estimated 300 tractor trollies of silt are required for one acre of land. Some small farmers were not able to raise capital for silt transportation. There is a very small window for silt application on farms before farmers plant the next crop. They need to have immediate access to vehicles to move silt during that window, which makes them vulnerable to higher charges for transportation. With the improvement in soil quality and water availability, farmers also expressed their need for training programmes on agriculture management practices.

<u>Other findings:</u>

- The number of people migrating outward reduced due to a rise in employment opportunities within the village as a result of improved farm productivity.
- The silt application led to an increase in land value (fixed asset) in some areas (as in the case of Moha village as detailed later).

- Farmers believed that silt application helped in increasing biomass which led to more fodder for livestock.
- In the tanks where fishing is undertaken, the fish catch increased and the fishes weighed more as there was water for a longer duration.
- Some people were of the opinion that the greenery surrounding the tanks also increased.
- In one tank (Sagroli), many birds were sighted during field visits.
- Average recharge time of the wells during the Rabi season (November) decreased by four hours and by two hours in the summer season (March).
- Desiltation of tanks coupled with good rainfall helped recharge groundwater tables.
- During group discussions, farmers said the duration of water availability from tanks had increased during summer months.

Picture 1: Traditional water tanks have an important role to play in ensuring water security and building drought resilience in Maharashtra.

The survey findings were supported with satellite data analysis. Three methods were used in GIS analysis to evaluate changes in vegetation and the water situation in a 2-km radius around the tanks. Two years with similar annual rainfall – 2014 (before interventions) and 2017 (after interventions) were compared. There is no clear evidence of improvement in vegetation around the tanks – this may be because the impact was in small pockets and the area covered for the analysis was large. Also, 2014 had more wet days than 2017. On the water situation, there was clear evidence that the desilted tanks had more water in the month of February as in the years before desilting they used to dry up by that month. In the months of February and March, the areas around the desilted tanks seemed to have lower water stress than before but this was also true for the two control tanks that were considered.

THE PROPOSED GUIDELINES

Based on the surveys, interactions with farmers and analysis of the data collected, The Nature Conservancy India and Watershed Organisation Trust recommend specific guidelines to implement the *“Gaalyukt Shivar”* policy across the state.

- Priority may be given to rainfed/degraded farms situated within the village itself and particularly to those in a 500-metre periphery of the dam to be desilted.
- Grant support (partial/full) may be provided to small and marginal farmers for transportation of silt.
- The Village-level Monitoring Committee (VMC) and a representative of the Tahsildar will monitor the desiltation work.
- Evaluation of the activity may be done by an external/third party.
- The tank may be desilted only if the siltation has reduced the height of original water storage by at least 50 per cent, so that the work is economically viable.
- Care must be taken that soil of farmland is not degraded in terms of texture and the other parameters mentioned above by application of poor quality silt.
- Excavation of only silt is allowed while sand excavation is strictly prohibited.
- The Gram Panchayat would implement the project through its VMC under close supervision of the Sub-Divisional Officer of the Revenue Department.
- The Gram Panchayat is to give prior notice to the Tahsildar or the designated officer regarding the tank/s to be desilted.
- Boundary plantation around the desilted areas may be undertaken to maintain biodiversity and increase the greenery.
- For all tanks, the Deputy Engineer should also demarcate the area under submergence.
- The approach road from the tank to the existing public road must be demarcated by the VMC with the help of the Talathi/Tahsildar.
- The structure of the VMC should include women representatives to maintain gender equality.
- The VMC must undertake an awareness campaign in the village.

1. Introduction

A large section of land in India falls in arid, semi-arid and dry climatic zones, where rains brought by the south-west monsoons are the main source of freshwater. These monsoons move over India within a very short period (two to three months) but provide more than 80 per cent of the annual water supply for farming. Consequently, roughly 69 per cent of the land in the country is classified as dry land (i.e. arid, semi-arid and dry sub-humid). Most regions in the dry land area are prone to drought, a situation created not only by climatic conditions but also due to mismanagement of water and land resources. In these regions, water scarcity and land degradation are interlinked and form a negative feedback loop (Gnacadja, 2013). The increased runoff from degraded land and lack of proper rainwater harvesting in these regions leave very little water for the dry season (Aggarwal, 2002) while erosion due to runoff and reduced water availability leads to further degradation of the land. To make matters worse, the weather in India is unpredictable, creating a lot of uncertainty in water resource management.

The state of Maharashtra in India has 36 districts, of which more than 20 (that fall in the north-western, northern and central part of the state) face regular droughts, adversely impacting communities dependent on agriculture. More than 61 per cent of Maharashtra's population depends directly or indirectly upon agriculture for their livelihood. In 2013, all 8,700 villages in the eight districts of the Marathwada region were officially declared drought affected. In 2015, more than 3,000 farmers committed suicide in the state (TOI, 2017) and it is widely recognised that drought was a significant factor in this sad statistic. The lack of adequate water has had a cascading effect on the socio-economic and environmental conditions in the region.

Traditionally, the communities in these regions created small dams to store water in reservoirs or dug out soil to create tanks (Dahagama et al. 2014; Deivalatha et al. 2014; Babu et al. 2008; ADB 2006). Over the last few decades, as India invested heavily in large water infrastructures, these smaller structures have been neglected. Most of these reservoirs and tanks are in a dilapidated condition due to siltation and lack of regular maintenance. Institutions to manage these structures either do not exist or are ineffective. Although large infrastructures have helped in bringing more land under irrigation, these have been inadequate in making communities resilient to drought and climate change.

To make the inhabitants of these lands more resilient to drought, there is a need for improved water and land management in these drought-prone areas (Rockström 2010). Improving the condition of degraded land and increasing productivity of existing agricultural land will require judicious planning and management of water and land resources (Aggarwal, 2002).The interventions need to be easy to implement, sustainable, climate change resilient, involve local communities and have positive return on investments.

Lately, there has been renewed interest in managing small dams and tanks to make communities more drought-resilient. Many studies and pilot projects have shown the importance of decentralised rainwater harvesting structures in countering drought and climate change. Many NGOs have been taking up such projects with the goal of improving the socio-economic status of households in India.

Recent activities carried out by regional NGOs in some of the drought-prone villages of the Marathwada region show that there are simple interventions that can increase water availability in these dry areas.

With funds and support from philanthropist Amit Chandra of Bain Capital, implementation by NGOs such as Caring Friends, Manavlok, Dilasa Sanstha, and project-management from Dasra, eight reservoirs/dams in Beed, Jalna and Nanded districts were desilted to increase storage capacity. Subsequently, the silt recovered was used in nearby farms to improve soil quality and increase productivity. More than 3 lakh tonnes of silt was excavated and applied to over 1,300 farms. Water capacity of these tanks/dams was increased by over 35 crore litres. Not only has the surface water storage capacity increased with the desilting activity, it has also led to groundwater recharge. Now, more water is available during the dry season, allowing multi-season cropping in a year and an increase of the net income of farmers by 150 per cent. The wells, which had been dry for many years, now have water all year around.

These interventions were implemented with close involvement of the local community from the very beginning of the process. The community invested in the process by providing labour and paying for hauling silt from the reservoir to their farms, thereby taking ownership of the desilting work. It also led to improved community relationships and, in general, increased the social capital of the region.

The initial results of these efforts have been very encouraging. The farmers' socio-economic condition has improved in villages where desilting was undertaken. The water situation in the area has also improved considerably. These pilots show that for a small investment, the returns to the local community were huge. They also underline the importance of involving local communities for the success of such programmes. Initial success has encouraged stakeholders, including the Maharashtra Government, to scale up this work to cover other villages and cities across the state.

Maharashtra has over 82,000 small dams and tanks. As a direct result of the successful pilots, the Maharashtra Government declared a *"Gaal Yukt Shivar"* policy and set up a "Desilting Policy Committee," which has recommended that 31,459 small dams and tanks in the state should be desilted. Out of the total projected budget of Rs. 6,236 crore over four years, the government's contribution will be Rs. 1,128 crore. The remaining Rs. 4,664 crore needs to be contributed by local communities. This indicates that the government is pushing for a strong component of local community participation and co-investment in the programme. A project of this scale needs to be supported by strong science with proper analysis of pros and cons for the community. The success story in Marathwada needs to be studied more intensely and scientifically. Along with quantifying the benefits, it is also critical to look at the equitable distribution of these benefits and winners and losers defined. There is also a need to identify institutional and governance setups required for such interventions to be successful. Additionally, to scale up, it is essential to study the practices followed and technical interventions

MORE THAN 3 LAKH TONNES OF SILT WAS EXCAVATED AND APPLIED TO OVER 1,300 FARMS AND THE WATER CAPACITY OF THESE TANKS/DAMS WAS INCREASED BY OVER 35 CRORE LITRES.

implemented – to separate the interventions that are good and contribute to resource conservation from those that may be harmful to the resource base. Finally, these interventions also need to be looked at through the lens of sustainability for their long-term success and associated issues of local capacity and governance need to be analysed. There is, hence, a need to support these interventions with science and develop methodologies to scale these up at the catchment level. The Nature Conservancy India, in partnership with the Watershed Organisation Trust (WOTR), conducted this study with the following objectives:

1. Providing scientific evidence to quantify positive externalities (such as improvement in natural vegetation, improved wildlife, impact of reduced use of fertiliser, enhanced social capital, and other indirect benefits due to improved income), including conducting a cost-benefit analysis; analyse negative externalities such as impact on different groups of landowners particularly the small and marginal and upper catchment farm owners; and identify gaps and best practices.

2. Developing guidelines to upscale this work, including identifying institutions and governance structures that help keep communities engaged in management of land and water resources and to help the Maharashtra government with facilitating the implementation of this scaled-up approach on the ground.

2. Literature Review

Failure of reservoirs and tanks

There are multiple reasons for the deterioration of decentralised rainwater harvesting structures such as reservoirs and tanks. One study (Gireesh, et al., 1997) classifies these as socio-economic, institutional/historic and physical. Socio-economic reasons include increasing non-farm income, lack of own labour, increasing access to groundwater, changing crop pattern and investment by the government. The institutional reasons include lack of community participation, lack of historic institutions and sense of belonging and the degree of community homogeneity. The physical reasons include changes in land use in the catchment area, age of tanks, use of inorganic fertilisers, type of soil in the catchment and size of irrigation tanks.

A more recent study (Raju, 2002) classifies factors for the breakdown in the maintenance of tanks as social and economic. The social factors include control of tanks taken away from the local community and given to a distant administration; shift of authority to an "invisible" government; livelihoods not based on tank water requirement; degradation of tank including siltation; more commodification of water due to wells/tubewells; lack of community interest and breakdown of the value system around tanks. On the economic side, the factors include increased (unmet) expectations from tanks by farmers; the state's focus on major and minor irrigation schemes; subsidy on electricity moving the focus to groundwater; insufficient funds for tank maintenance and lack of rent seeking incentive from tanks.

According to another research (Palanisami, 2006), the reasons for the failure of tanks are lack of farmers' confidence since most of the tanks fail in low rainfall years when the farmers most need the water; negative impact of social forestry leading to reduced forest cover and increased erosion leading to higher silting; reduced flow to the structures due to focus on water retaining such as check dams, bundhs etc.; disappearance of supply channels to the tanks due to encroachment; weakening of institutions due to growing nexus between caste and politics; less interest in maintenance of tanks due to growing reliance on wells; and less interest in improving livelihoods due to availability of cheap food through rations.

Broadly, the failure of tanks can be attributed to:

- *Human activity and changes in land use in the upper catchment:* Deforestation and conversion of upstream land into farms has changed the waterflow coming to the tanks and has led to high siltation. Runoff from agriculture activities and in some areas, industrial discharge, is leading to pollution of these reservoirs and tanks. The choking of supply channels prevents tanks from filling up in the rainy season and reduces groundwater recharge as they do not retain water during the non-rainy season.

- *Ineffectiveness of traditional irrigation institutions leading to non-maintenance of tanks:* The control of the tanks has been taken away from local communities by the government as part of their irrigation and water resource management policies. Thus, the communities lose the sense of ownership on the tanks. The officials responsible have little incentive to maintain these tanks. Also, as more and more farmers have started relying on groundwater, they have lost the connection with nearby tanks. Lack of institutions responsible for the maintenance of tanks has led to encroachment of the reservoirs.

It is evident that the area under tank irrigation systems has been declining for several decades. Within the existing tank irrigation systems, the proportion of small and marginal farmers relying on these tanks for irrigation is increasing as larger and richer farmers move to other sources of irrigation such as groundwater (Palanisami, 2006). Thus, the failure of small reservoirs and tanks is also leading to greater inequality among farmers.

Desilting of reservoirs and tanks

The focus on restoration of small reservoirs and tanks has been on desilting them. Desilting implies removing silt that has accumulated at the bottom of tank over the years due to erosion in the upper catchment. The silt not only reduces the storage capacity of the reservoir but also reduces infiltration into the ground and hence recharge of groundwater. The shallow depth of the reservoir leads to increased surface area, and hence higher loss of water due to evaporation. The silt removed from the tanks has been applied by farmers on their fields to replenish their top soil.

Many studies have recorded benefits of desilting (and subsequent application of silt in the farms) of these tanks. A recent study (Dahagama, et al., 2014) examined the impact of desilting on villages that benefited from the intervention in the region of Telangana. Their analysis showed that the application of silt in the farms led to a substantial reduction in chemical fertiliser application (by 36 per cent, thus reducing GHG emissions), improved the soil's capacity for water retention (thus reducing the need for irrigation), while improving crop yield by at least 50 per cent. The study also found that desilting and application of silt to the farms led to increased employment in the region. According to the authors, there is a need to look at the catchments and control soil erosion upstream to make the systems more sustainable.

Another study (Tiwari, et al., 2014) reported rich composition of nutrients and organic carbon in the silt from the tanks in 13 villages of Chitradurga District, Karnataka, located in the semi-arid belt of the central region of the Deccan plateau. According to this study, the quality of the silt depends upon the land use practices (nutrient addition and management) in the catchment of the tanks. The final nutrient content also depends upon curing of silt, i.e. heaping prior to application to cropland, the amount of silt applied and tillage practices etc.

> RESTORATION OF TANKS IS A COMPLEX PROBLEM THAT NEEDS THE INVOLVEMENT OF ALL STAKEHOLDERS AND AN INTEGRATED APPROACH THAT CONSIDERS NOT ONLY TECHNICAL BUT ALSO SOCIO-ECONOMIC ISSUES.

Another research (Deivalatha, et al., 2014) evaluated the impact of partial desilting of irrigation tanks in Ponpadi village of Thiruvallur district in Tamil Nadu. It found that the cropping area of the main crops grown there had increased along with the irrigated area and cropping intensity. There was a significant increase in crop yield. Improved agriculture led to higher employment among non-farm labour. Similar results were seen during a study (Osman, et al., n.d.) of 12 dams in the state of Andhra Pradesh.

An analysis (Padmaja, et al., 2003) of silt from 21 tanks in Medak district of Andhra Pradesh showed that although there was a large variation in the constitution of silt from different tanks, generally the silt contained 30-70 per cent of silt and clay, high quantity of organic carbon, nitrogen and phosphorus. The nitrogen (N) content in the silt was almost double than that in the surrounding soil. Based on the returned nutrients and carbon to the soil, just from the agriculture angle, the benefit-cost ratio, in general, was positive thus showing that the desiltation of tanks is an economically viable option. The study did not consider indirect and non-agriculture benefits from such interventions.

A 2008 research (Babu & Manasi, 2008) that studied the impact of desiltation of 12 tanks in Warangal district in the mid-Godavari basin of Andhra Pradesh state, listed the following comprehensive list of benefits:

- Silt amendment benefits – improved soil layer.
- Improved soil content – reduced soil bulk density, increased available water content and improved moisture retention.
- Plant nutrients from silt – Improved nutrients and organic carbon. The average benefit-cost ratio was 1.51, when the benefit is nutrient equivalent fertiliser value and the cost is the cost of excavation of silt.
- Increased yield – the productivity of all the crops in the region went up.
- Reduced consumption of pesticides.
- Increased growth of natural predators – such as lady bird beetle (Epilachna beetles), chysopa, spiders, dragonflies and wasps were observed.
- Improvement in other biodiversity such as bird life around the tank area.
- Increase in the area irrigated before and after desiltation.
- Reduction in the extraction of groundwater for irrigation – due to more water available from surface.
- Saving in electric power use.
- Augmented water flow distance – because of the presence of more water in the tank, water flowed a longer distance.
- Improved employment opportunities for landless labourers – due to more land under cultivation and improved agriculture production.
- Boost in fodder production.
- Enhancement in fish production.
- Benefits for the washer people community.
- Decline in migration.
- Reduced drinking water problems.
- Increased water holding capacity of tanks.

Broader role of reservoirs and tank systems

Many studies suggest that desilted tanks become ecosystems in themselves, supporting various wildlife (Bhat & Hosetti, 2003). Due to deterioration these tanks are not only losing their irrigation potential, but also their ecological value. As the tanks are desilted, the objective should be to provide social equity, economic efficiency and environmental sustainability in the region. A similar view is put forth in a policy brief (Babu & Manasi, 2008) which recommends looking at other socio-ecological aspects and not just irrigation when rehabilitating a tank.

The IWMI-Tata water policy research suggests conducting a cost-benefit analysis that includes other benefits before designing a rehabilitation programme for a tank. This is also suggested by another study (Palanisami, 2006). The author suggests that with proper institutions, if all the uses are considered, tanks can generate sufficient funds to cover their O&M costs. Palanisami's analysis of Tamil Nadu tanks concludes that social forestry gives the highest revenue, followed by irrigation and then fisheries. Yet another research (Anuradha, et al., 2014) evaluated three measures of investment appraisals – Internal Rate of Return, Benefit-Cost Ratio (BCR) and Net Present Value (NPV) for desilted tanks. All three were higher for non-farming activity as compared to farming activity. This highlights the importance of considering other activities besides farming to evaluate the impact of tank rejuvenation.

Criticism of reservoir desilting

The research mentioned above look at benefits of silt application by farmers at village level. They do not study extensive changes in hydrology in a region due to desilting of reservoirs and tanks. Rather than focusing only on tank desiltation, there is need to look at sustainable ways to manage the tank system. It needs an approach that considers a hydrological boundary as a unit of operation, involves all stakeholders (farmers, technologists and government) to understand local issues, and design a programme that caters to their requirements (Palanisami, 2006). The programme should include restoring the upper catchment, evaluating the impact of upstream activities on the downstream regions, and monitoring. Focusing only on tank desiltation would not lead to maximum return on investment because it has been observed that a tank reaches its full capacity for only three years in a 10-year cycle. Thus, the restoration of tanks is a complex problem that needs the involvement of all stakeholders and an integrated approach that considers not only technical but also socio-economic issues.

Another criticism (Soni, 2010) is that desilting may result in excavating beyond the deposited silt and hence disturbing the original lake bed. This could lead to heavy seepage losses due to an increased rate of percolation (as happened with Pushkar Lake in Rajasthan). Sometimes the storage capacity of a reservoir is increased without taking into account the water yield from the catchment. The excavation process is expensive and providing more storage than is needed by water generated in the catchment is a waste of resources. Also, it is necessary for the tanks to overflow to allow water to reach the lower part of the catchment. Often the excavated material is just dumped near the tanks and during heavy rains it flows back in. If desilting is done in isolated pockets, it may cut off the water in these pockets from the main storage, thus making it unusable. In some irrigation tanks, digging below the outlet canal level creates inequality in water distribution. The water below the canal level is not available for the farmers but is pumped by the industries for their use.

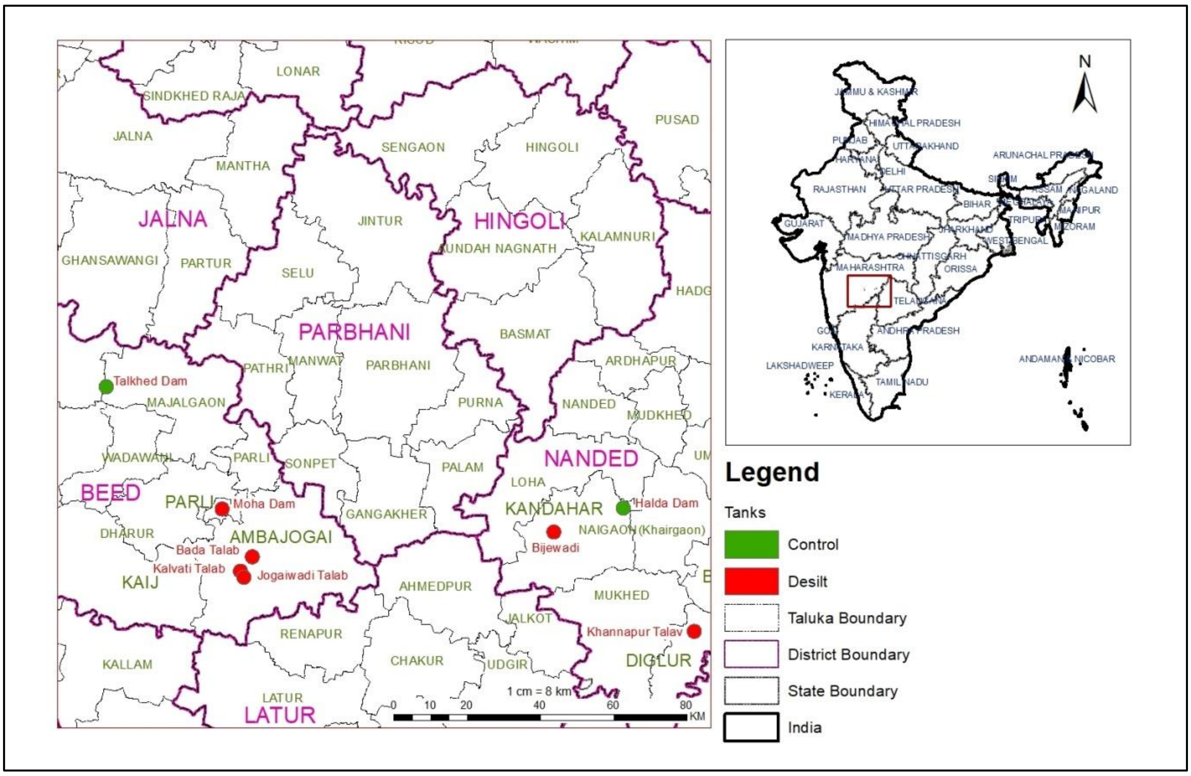
A two-year study (Bhat & Hosetti, 2003) of a tank on the foothills of the Western Ghats in Karnataka showed loss of biodiversity due to human activities to "develop" the tank and its surroundings and changes in the characteristics of the tank.

3. Study Area and Methodology

Location of study

An evaluation study of the pilots was carried out in Beed and Nanded districts of Marathwada. One of the most drought-affected regions in Maharashtra, Marathwada is characterized by recurring droughts, water scarcity and crop losses. The evaluation was done for seven percolation tanks. Four of these tanks are in Beed and three in Nanded district. NGOs Manavlok and Sanskriti Samvardhan Mandal (SSM) initiated the desiltation work in Beed and Nanded districts respectively. For the GIS analysis, two control tanks (i.e. tanks, which were not desilted) were also considered – one in each district. Figure 1 shows the location of the tanks included in the study.

Figure 1: Location map of the study sites



Brief description of the districts

Beed district is located in the west-central area of Aurangabad district. It lies between 18º 28' to 19º 28' North latitudes and 74º 54' to 76º 57' East longitudes. The average rainfall is about 666.36 mm per annum and the temperature ranges from 12º C to 42º C. The geographical area of the district is 10,693 sq km (10.7 lakh ha). Out of the total area, 3.67 lakh ha is under agriculture cultivation and 0.29 lakh ha is under forest. Fallow area accounts for 4.88 lakh ha., 0.78 lakh ha is waste land and non-agriculture land is 0.99 lakh ha. The important Kharif crops in the district are sorghum, pearl millet, pigeon pea, black gram, cotton and groundnut. The main Rabi crops are seasonal sorghum, wheat, chickpeas and sunflower. Sugarcane is cultivated as a perennial crop whereas peanuts and sunflower are grown in summer if irrigation is available. Cotton and sugarcane are the main cash crops in the district.

The total irrigated land in Beed district is 1.77 lakh ha, of which 0.81 lakh ha is under large irrigation projects and 0.94 lakh ha under medium and small irrigation projects. The area irrigated by wells is about 0.40 lakh ha. Godavari is the most significant river that flows on the borderline of Georai and Majalgaon tehsils. Godavari, Manjra, Sina and their tributaries are the major rivers in the district.

Beed is situated in the Deccan black basalt stone region. Rocky and thin layered soils occur in major parts except on the banks of Godavari river, where dark brown to black and clayey loamy to loamy soils are observed. The nutrient levels in almost all the soils are low. (Directorate of Economics and Statistics, 2016) .

Nanded district lies in the Godavari basin, in the south-eastern part of Maharashtra. It is located between 18° 16' to 19° 55' north latitudes and 76° 56' to 78° 22' east longitudes. The average annual rainfall is in the range of 767 mm to 1285 mm. The mean daily minimum and maximum temperatures are 13.1°C and 42° during December and May respectively.

The total geographic area of the district is 10,443 sq km (10.4 lakh ha). The net cultivable area is 7.7 lakh ha. The non-agriculture land and fallow land area is 58,644 ha and 32,461 ha respectively. The total area under forest in the district is 91,748 ha. Total waste land in the district is about 86,994 ha. The land under various irrigation projects is 1.9 lakh ha whereas area under well irrigation is 24,000 ha. The principal crops in the district are soybean, jowar, cotton, pulses, sugarcane, rice and wheat. Cotton, banana and sugarcane are the main cash crops.

Nanded district mainly consists of plain areas with small hills and granite boulders. The soil of the district is black and fertile. There are 10 small rivers with Godavari, Manjra, Manyad, and Penganga being the main rivers. (Directorate of Economics and Statistics, 2016).

Rainfall variation in study area

While analysing the changes in crop production and water availability data because of desiltation activity, the rainfall data of these two districts over the last few years has also to be kept in mind.

Table 1: Rainfall in Beed and Nanded districts during 2015 to 2017

Year	Beed				Nanded			
	District yearly rainfall (mm)	Normal rainfall (mm)	No. of Rainy days	No. of dry spell days	District yearly rainfall (mm)	Normal rainfall (mm)	No. of Rainy days	No. of dry spell days
2012	*461.1*	743.4	43	61	*662.7*	1017.5	61	64
2013	729.9		70	40	*1111.9*		71	35
2014	*423.4*		34	106	*436.5*		38	63
2015	*459.6*		51	58	*599*		61	42
2016	824.7		59	30	*1124.8*		66	38
2017	*706.1*		58	45	*641.8*		56	39

Source: http://maharain.gov.in

As seen Table 1, it was a drought year in 2015 when the desiltation activity was carried out. Beed and Nanded received much less rainfall than in a normal year. In 2016, both these districts received more rainfall than the normal. Again in 2017, there was a deficit in rainfall in both these districts. Similarly, the number of dry spell days was less and the number of rainy days was more in 2016 when compared to 2015 (base year). These changes have an impact on the vegetation growth and water availability and the data needs to be interpreted in this light.

Data collection tools

All the tanks selected for the study were desilted in 2016. The study team obtained a list of all the desilted tanks from the project implementing NGOs and made a preliminary site visit to eight tanks from August 18-22, 2017[1]. The purpose of the visit was to understand the nature of work, processes followed and benefits incurred. The team interacted with the villagers and NGO representatives. Based on the experiences of the preliminary visit seven tanks were selected for the study. The characteristics of these seven tanks are provided in Table 2.

Table 2: Details of tanks selected for study

S.No.	Implementing NGO	Tank Name/Taluka	District	Coordinates	Elevation (m)	Location of Tank in micro-watershed	Year of Construction	Total Storage Capacity (TCM)	Year of desiltation	Total quantity of silt removed (in cu. mar.)	No. of villages benefitted from silt use
1	Manavlok	Jogaiwadi Talab/ Ambajogai	Beed	18.711932° N, 76.380451° E	575.95	Upper	1977	1.564	2016	27882.4	13
2		Kalvati Talab/ Ambajogai	Beed	18.764033° N, 76.401222° E	575.4	Upper	2001	167.79	2016	5446	2
3		Bada Talab (Morewadi)/ Ambajogai	Beed	18.7272° N, 76.371042° E	462	Upper	Nizam period	-*	2016	37217.6	14
4		Moha Dam/ Parali (V)	Beed	18.88169° N, 76.31841° E	514.1	Upper	1979	2.37	2016	65354.8	2
5	SSM	Bijewadi/ Kandhar	Nanded	18.843363° N, 77.192847° E	423.25	Lower	1973	123	2016	23864	1
6		Khanapur/ Deglur	Nanded	18.600965° N, 77.566987° E	394.07	Lower	Nizam period	240	2016	26980	1
7		SSM Sagroli/ Biloli	Nanded	18.69083° N, 77.73444° E	433.74	Lower	Nizam period	210	2016	10948	2

**Data not available*

A sample survey was conducted during the month of December 2017. A total of 292 farmers were interviewed. Information collected from the farmers include: demographic details, land ownership, crop input and production, water sources and availability, economic aspects etc. A structured questionnaire was developed and pretested. Based on the pre-testing experience, the questionnaire was suitably modified. It was translated in the local Marathi language (Annexure 1). An informed consent was taken from the farmer respondents before interviews. The consent was read out verbally and then signed by the surveyed farmers.

The quantitative data was entered in MS Excel and then exported to SPSS. Further analysis was done through descriptive statistics and cross tabulations.

[1] During the preliminary visit, the team also visited tanks from Jalna district. However, these were later excluded from the study due to lack of support from the implementing NGO.

Table 3: Tank-wise surveyed households

Tank name	Total beneficiaries	Survey sample
Jogaiwadi Talab	63	21
Kalvati Talab	23	7
Bada Talab (Morewadi)	63	19
Moha Dam	137	91
Bijewadi	92	57
Khanapur	107	60
Sagroli	78	37
Total	**563**	**292**

Five group discussions were conducted in villages with the farmer beneficiaries and one group discussion was conducted with each of the implementing NGO representatives to understand the intervention details, institutional aspects and benefits of the programme.

Soil sample collection and testing

Two soil samples were collected from farms from each of the seven tanks. The first sample was taken from the farm where silt was applied and the second from a control farm with no silt application. Thus, a total of 14 soil samples were collected. Ideally for testing the effect of silt deposition on physical and chemical properties of soil, sample should be collected from the same farm, before and after silt application, but this was not possible for this study. In addition, soil samples from three tanks[2] – Bijewadi, Sagroli and Jogaiwadi – were also collected.

The soil samples were tested for various parameters, including soil pH, electrical conductivity, organic carbon, soil texture (sand, silt and clay), particle density, bulk density, porosity, water holding capacity, calcium carbonate, available nitrogen, phosphorus, potassium, calcium, magnesium, iron, copper, manganese, zinc and sodicity. The detailed soil test reports are attached in Annexure 2.

Desiltation not just increases the capacity of the tank but also helps increase the fertility of the farm. The nutrients present in the silt act as manure for the farm soil. Of the 16 elements essential for plant growth, seven are required in much smaller quantities and are called micro-nutrients. These are: Iron, manganese, boron, zinc, copper, molybdenum and chlorine. Nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S) are considered macro-nutrients as their requirement by plants is high, particularly the first three (N, P and K). The normal application ratio of macro-nutrients for N: P: K is 4:2:1.

GIS analysis

GIS-based analysis was undertaken to understand the changes in vegetation area and water spread area. Year 2016-17 was chosen to see the changes post-desilting and 2013-14 was chosen to see the situation before desilting. The criteria for choosing the pre-desilting year was based on the rainfall. Mean rainfall was seen from years 2012 to 2017 for the two districts Beed and Nanded, where the

[2] The silt sample from the Kalvati, Moha, Morewadi and Khanapur tanks could not be taken during the survey period (December 2017) as they were filled with water. These samples will be taken when the tanks dry up (probably during the month of May 2018.)

tanks are located (Table 4). The year that had rainfall closest to the year 2016 was chosen for assessing the situation pre-desilting.

Table 4: Total district rainfall in mm

Year	**Beed**	**Nanded**
	(Total district rainfall for year in mm)	
2012	461.1	662.7
2013	**729.9**	**1111.9**
2014	423.4	436.5
2015	459.6	599
2016	**824.7**	**1124.8**
2017	706.1	641.8

Source: http://maharain.gov.in

Composites of Landsat 8 images were taken for five months (Dec 15th to May 15th) for 2013-14 and 2016-17. Taking composites helped in giving a cloud-free image of the study area, although for 2014 all cloud-free images were not available. Landsat 8 images consist of nine spectral bands with a spatial resolution of 30 metres for Bands 1 to 7 and 9. Band information is given in (Table 5).

Table 5: Band information for Landsat 8

Bands	**Band Details**	**Wavelength**	**Resolution (m)**
Band 1	Ultra Blue (Coastal/Aerosol)	0.435 - 0.451	30
Band 2	Blue	0.452 - 0.512	
Band 3	Green	0.533 - 0.590	
Band 4	Red	0.636 - 0.673	
Band 5	Near Infrared (NIR)	0.851 - 0.879	
Band 6	Shortwave Infrared (SWIR) 1	1.566 - 1.651	
Band 7	Shortwave Infrared (SWIR) 2	2.107 - 2.294	
Band 8	Panchromatic	0.503 - 0.676	15
Band 9	Cirrus	1.363 - 1.384	30
Band 10	Thermal Infrared (TIRS) 1	10.60 - 11.19	100 * (30)
Band 11	Thermal Infrared (TIRS) 2	11.50 - 12.51	100 * (30)

Two indices – Normalised Difference Vegetation Index (NDVI) and Normalised Difference Water Index (NDWI) were evaluated. NDVI is related to the health of a plant and estimates its photosynthetic capacity through absorption in the Red band and reflection in Near-Infrared (NIR).

The calculation of NDVI (J.W , et al., 1973) is as follows:

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

The NDWI is used widely to estimate plant water stress. It is calculated using Near-Infrared (NIR) and Short-Wave Infrared (SWIR) bands (Gao, 1996). Higher the reflection in SWIR, lower is the content of water in leaves, hence water bodies are denoted by negative NDWI values.

NIR reflects the leaf internal structure and leaf dry matter content (Anon., 2011). The combination of the NIR with the SWIR improves the accuracy of estimating plant water stress as it removes variations induced by leaf internal structure and leaf dry matter content. The calculation of NDWI is as follows:

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

The NDWI ranges from -1 to +1, depending on the leaf water content. Water stress conditions will be reflected by lower values of NDWI.

NDWI and NDVI were calculated using Google Earth Engine which was then exported as .tif files. After masking the water bodies[3], mean NDVI and NDWI was calculated for a 2-km buffer zone around selected tanks for pre- (2013-14) and post-desilting (2016-17) years using Zonal Statistics in ArcGIS.

Cost-benefit analysis

To assess the economic feasibility of tank desiltation, cost-benefit analysis was carried out (Osman, 2009). The expenses incurred by the NGOs for excavating the silt were considered as the cost. This includes the machine, diesel and operator costs. The value of the silt was quantified in terms of fertiliser equivalent cost of different nutrients (N, P, K, Zn, Cu and Fe) retrieved from it. This was considered as the benefit of desiltation activity.

The benefits were calculated based on the current market prices of fertilisers which would have been needed to replenish the equivalent quantity of nutrients applied through the silt. Straight fertilisers such as Urea (46:0:0) for N, Single Super Phosphate (0:16:0) for P and Muriate of Potash (0:0:58) for K were considered to calculate the price of respective primary nutrient equivalent.

For Zn, Cu and Fe, zinc sulphate (21 per cent Zn), copper sulphate (24 per cent Cu) and ferrous sulphate (19.5 per cent Fe) were considered while calculating prices of respective micro-nutrient equivalent.

Methodological challenges in study

When the NGOs initiated the desiltation work in 2016, they maintained records of machine and fuel usage, quantity of silt excavated and number of farmers who took the silt. However, they did not have the names of the farmers who took this silt for farm application. Hence, when the present study was designed, the NGOs prepared the beneficiary list of farmers retrospectively. As a result, the list was not accurate. Many of the names in the list were not actual beneficiaries or the names were duplicated. Some beneficiaries were not on the list.

In a few cases, farmers from multiple villages had taken the silt from a tank. These villages are spread as far as about 7-8 km from the tanks. For example, farmers from about 15 villages took silt from

[3] Water bodies were masked using NDVI values. All negative values were classified as water bodies. This mask was used to calculate area of water bodies which was then compared for 2014 and 2017.

Morewadi tank. Hence, contacting these farmers spread out over large distances was an issue. Also, farmers residing in Ambajogai town who have agricultural land in the study villages refused to respond to the survey team.

Regarding the soil samples that were tested for various parameters, ideally, they should have been taken from the same farm before and after the intervention period to measure the changes. However, since this study was planned retrospectively, to assess the parameters of the before intervention period, soil was collected from control farms adjacent to the farms where silt was applied.

4. Results and Discussion

Demographic profile

The majority of the farmers covered in the survey belonged to the small and marginal category (58.2 per cent). This was followed by medium farmers and large farmers (Table 6). In 98.3 per cent of the households surveyed, the respondents were men. Responses were provided by women only in five households. About 236 (81 per cent) households reported that at least one household member had completed secondary education.

Table 6: Classification of households according to land ownership

Farmer Category[4]	Number	Per cent
Small & Marginal	170	58.2
Medium	75	25.7
Large	47	16.1
Total	292	100.0

Information on a household's affiliation to village-level organisations was sought to understand if these affiliations are leveraged to procure silt. About 88 per cent households reported no affiliation to any village-level organisation. About 5 per cent households include either a gram panchayat member or a sarpanch. About 4 per cent households are associated with local-level societies. None of the households used their affiliations for getting the silt.

With regards to agricultural asset ownership of the surveyed households, a tractor was found to be owned by 27 households. As seen in Table 7, about 18 households have a four-wheeler which was generally used for transportation of agricultural goods.

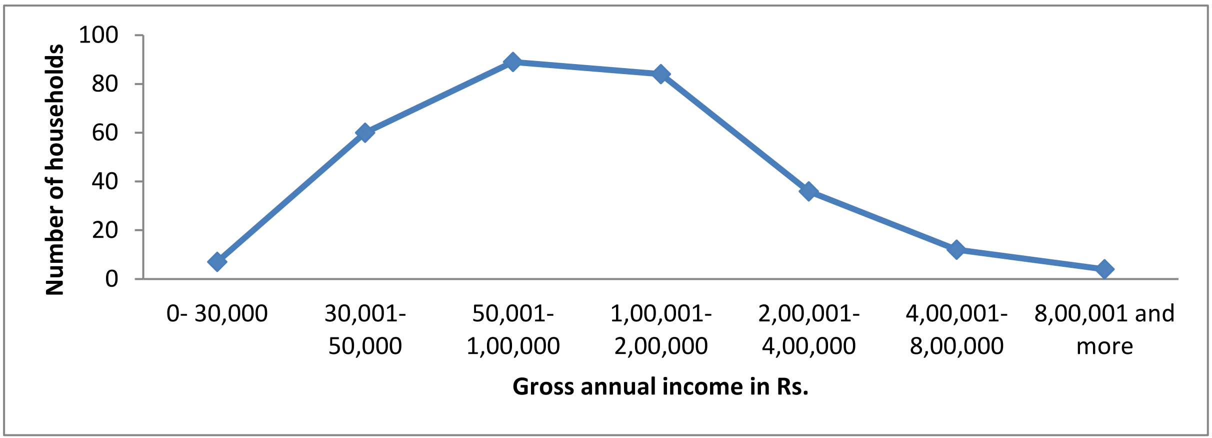
Table 7: Agricultural asset ownership

Agricultural asset	Auto	Bullock cart	Four-wheeler	JCB	Thresher	Tipper	Tractor
Owning Household	1	1	18	2	3	1	27

These households are scattered across all income ranges. However, many of the households (30.5 per cent) have an average annual income in the range of Rs. 50,001 to Rs. 1,00,000 as seen in Graph 1. Seven households have income that is less than Rs. 30,000 whereas four households reported income of more than Rs. 8 lakh.

[4] Farmer classification: 'small and marginal' farmers = less than 5 acres, medium farmer = 5.1 to 10 acres, large farmer = 10.1 acres and more.

Graph 1: Gross annual income of the households



The total land ownership at present as reported by the households (N=292) is 2,165.6 acre. Out of this 151.6 acre of land has been taken on lease by the households.

Economic cost

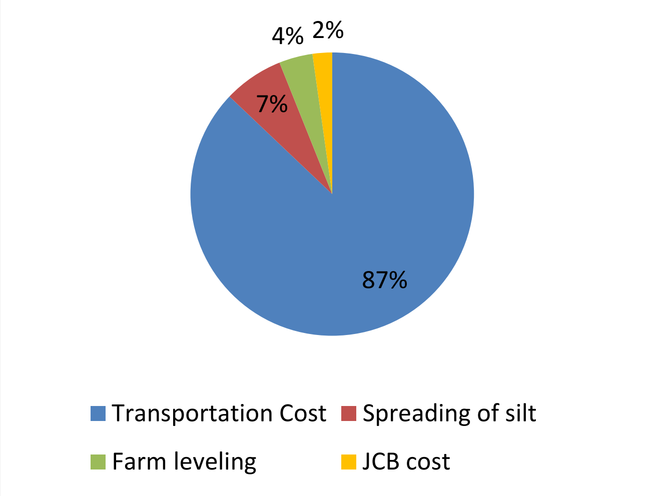
The tank-wise total cost of desiltation is provided in Table 8. This cost was borne by the NGOs and primarily includes diesel and operator costs.

Table 8: Tank-wise cost of desiltation incurred by the NGOs

S. No.	Tank name	Details about days for desiltation		Whether desiltation completed?	Total cost of desiltation (in Rs.)
		Total days available for desiltation	Total days when desiltation work was actually done		
1	Moha	90	81	Yes	4,91,474
2	Morewadi	45	35	Yes	2,61,804
3	Jogaiwadi	60	40	No	2,63,110
4	Kalvati	30	25	No	52,166
5	Bijewadi	90	30	No	2,50,000
6	Khanapur	90	30	No	2,00,000
7	Sagroli	90	20	No	1,50,000

The farmer beneficiaries had to bear the transportation cost and the cost for spreading silt and levelling their farms. The total cost borne by the farmers included in the survey was Rs. 1,64,75,397 (or Rs. 23.5 lakh per tank). Of this, a greater part (87 per cent) was spent on transportation of silt from the tank to the farm (Graph 2). Rest of the amount was spent on spreading silt and levelling the farm. A few farmers had employed JCB machines for excavating the silt.

Graph 2: Break- up of desiltation cost borne by the farmers



Application of silt on the farm is a costly activity and 44 per cent of the farmers took loans for this purpose. Most of these farmers (65 per cent) belong to small and marginal groups and 24 per cent are medium farmers. Only 11 per cent of the large farmers took a loan for this purpose. Most of the loans were taken from banks. A few farmers borrowed from friends, relatives or money lenders. Farmers who did not take loans were self-sufficient. However, five farmers reported selling livestock (goats) or farmland to cover the expenses. Table 9 gives details of loan amounts taken by the households. Most of the farmers have taken loans of less than Rs. 50,000.

Table 9: Loan taken by the farmers for silt application

Loan amount (in Rs.)	No. of HHs	Percentage (%)
≤ 50,000	90	70
50,001-1,00,000	24	19
1,00,001-2,00,000	11	9
2,00,001-4,50,000	4	3

Soil sample tests

During the survey, only 28 per cent of the farmers reported doing soil testing in the past few years. However, only 45 per cent of these farmers got the soil test reports. These farmers used the information to suitably modify the chemical fertiliser usage.

Physiochemical properties of tank soil

The pH range of tank soil was neutral to slightly alkaline and it ranged from 7.19 to 7.82. The electrical conductivity (EC) of soil was in normal range and varied from 0.22 to 0.26 dS/M. The organic carbon (OC) content of Sagroli tank silt was very low (0.09 per cent) while in Jogaiwadi and Bijewadi tanks it was 0.27 per cent and 0.30 per cent respectively – both in the low category. The available nitrogen content in the soil was low and ranged from 63 kg/ha to 210 kg/ha. The very low organic carbon and available nitrogen content recorded in the Sagroli tank soil might be due to a very high sand percentage as compared to silt and clay. The available phosphorus content in the soil was low and it ranged from 12.7 to 13.8 kg/ha (Table 10). The available potassium content recorded was low (102.45

kg/ha) in the Jogaiwadi tank soil. It was very high in the soil of Sagroli and Bijewadi tanks with 534.42 kg/ha and 608.35 kg/ha respectively.

Table 10: **Physio-chemical properties of tank soil**

Tank Name	pH	EC (dS/m)	OC %	Bulk density (g/cc)	Sand (%)	Silt (%)	Clay (%)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	CaCo3 (%)
Jogaiwadi	7.23	0.24	0.27	1.19	43.05	40.52	16.35	189	12.7	102.45	7.63
Sagroli	7.19	0.26	0.09	1.30	76.75	17.67	5.88	63	13.8	534.42	3.88
Bijewadi	7.82	0.22	0.30	1.18	23.71	52.23	22.87	210	12.5	608.35	9.5

Effect of tank silt application on physical properties of soil

The results obtained from soil analysis show that silt application had a mixed impact on soil texture, bulk density and water holding capacity of the farm soil and it varied from tank to tank. In Kalvati and Morewadi tanks, an increase in silt and decrease in sand percentage were observed and this is a positive change. The silt content in farms of Kalvati, Morewadi and Jogaiwadi increased by 33.08, 19.7 and 32.7 per cent respectively. However, silt deposited from Sagroli, Khanapur and Bijewadi tanks have had a negative impact on physical properties of farmland as seen in Table 11. The negative impact may be due the comparison between silt deposited on farm soil and control plot. The silt applied soil from Kalvati, Jogaiwadi and Sagroli recorded an increase in the water holding capacity of the soil. The maximum and minimum water holding capacity was recorded at Kalvati and Sagroli at 28.57 per cent and 2.33 per cent respectively.

Table 11: Effect of silt application on physical and chemical properties of farm soil

Tank Name	Sample Area	pH	OC %	Sand (%)	Silt (%)	Clay (%)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	CaCo3 (%)	WHC %
Kalvati	Silt applied farm	7.44	0.57	42.27	39.71	17.93	399	12.28	57.03	10.13	72.82
	Control farm	7.24	0.18	51.3	29.84	18.79	126	12.06	184.8	12.13	56.64
Moha	Silt applied farm	7.28	0.30	55.81	26.90	17.19	210	11.84	426.6	12.25	60.1
	Control farm	7.20	0.39	37.77	39.44	22.71	273	12.28	594.6	9.38	73.01
Morewad i	Silt applied farm	7.28	0.24	44.82	36.37	17.89	168	11.62	453.0	13.25	58.13
	Control farm	7.29	0.18	51.81	30.39	17.72	126	12.06	463.6	11.38	58.35
Jogaiwadi	Silt applied farm	7.21	0.18	39.14	44.38	16.39	126	12.5	594.6	11.25	65.6
	Control farm	7.48	0.48	16.91	33.45	49.56	336	11.84	453.0	12.13	62.86

Sagroli	Silt applied farm	7.25	0.60	34.01	46.86	19.05	420	12.50	67.59	9.62	70.03
	Control farm	7.55	0.27	16.15	65.1	18.67	189	12.06	637.92	11	68.43
Khanapur	Silt applied farm	7.17	0.30	51.32	32.26	16.24	210	12.72	280.94	9.38	58.23
	Control farm	7.55	0.45	26.15	53.18	20.59	315	12.06	713.96	10.63	78.91
Bijewadi	Silt applied farm	7.45	0.57	48.24	29.82	21.85	399	12.28	421.4	10.75	58.48
	Control farm	7.38	0.30	20.2	58.7	21.03	210	13.16	709.74	7.25	75.84

Effect of tank silt application on chemical properties of soil

Application of silt from Kalvati, Morewadi, Sagroli and Bijewadi tanks improved organic carbon content in soil as compared to control farms. The silt deposited from Kalvati tank recorded maximum organic carbon in soil and the improvement was to the tune of 216.7 per cent.

The pH of silt deposited and control farm soil are neutral to alkaline. The soil pH of silt applied farms from Jogaiwadi, Sagroli and Khanapur decreased from 7.48 to 7.21, 7.55 to 7.25 and 7.55 to 7.17 respectively. Thus, the pH of the soil was not much affected by silt application. The calcium carbonate content in the soil decreased in silt-applied farms in Khanapur, Sagroli, Jogaiwadi and Kalvati. The calcium carbonate decreased from 12.13 to 10.13 per cent in Kalvati. The decrease in calcium carbonate might be due to low calcium carbonate composition in tank silt and quantity of silt applied in a unit area.

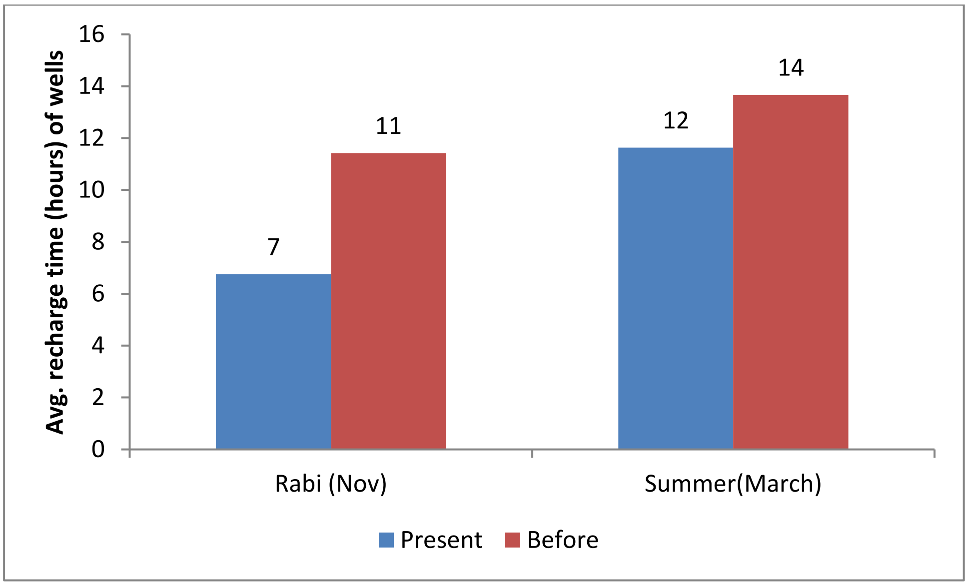
The trends in available nitrogen, phosphorus and potassium content in silt-applied soil were different due to a variation in the composition of nutrients in tank silt. An increase in available nitrogen and phosphorus was recorded in Kalvati and Sagroli. The increase in available nitrogen of 216.6 per cent and phosphorus of 5.57 per cent was recorded in Kalvati and Jogaiwadi. Available potassium in soil was not positively influenced by silt application from tanks except in Jogaiwadi. The available potassium recorded in the Jogaiwadi farm was 594.6 kg/ha and the increase was to the tune of 31.24 per cent over control farm.

Impact on water availability and irrigation

Within the 292 households surveyed, 33 have a well or borewell. All these wells and borewells are located downstream of the tanks, mostly within a 2-km distance. Most of the wells are less than 40 feet deep and the depth of a borewell ranges between 200-400 feet. These wells and borewells are all used only for irrigation.

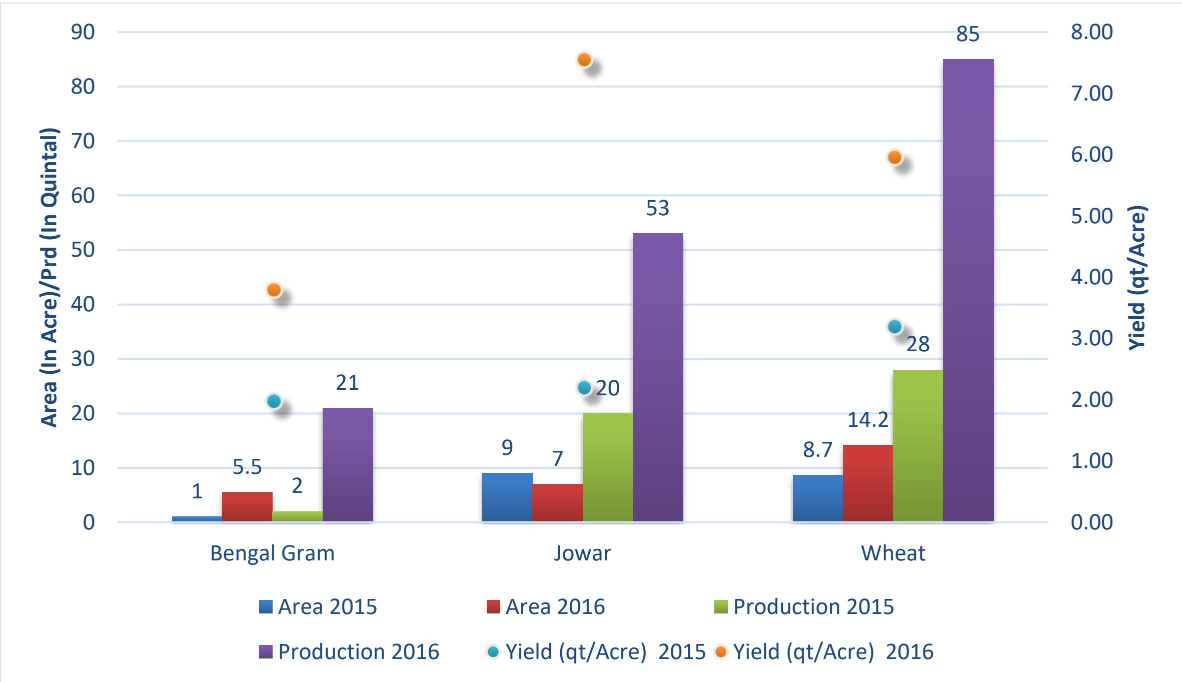
The average recharge time of the wells during the Rabi season (November) has decreased by four hours and for the summer season (March) by two hours as depicted in Graph 3. Desiltation of the tanks coupled with good rainfall has helped recharge groundwater tables. During group discussions also, farmers said the duration of water availability from the tanks had increased during summer months. This is because of the increase in the storage capacity of the tanks,

Graph 3: Changes in average recharge time of wells during Rabi and summer season



The area under irrigation (of 33 households) increased from 57 acre to 75.3 acre in the Kharif season for the three main crops (cotton, soybean and bajra). The number of irrigations provided to these three crops has reduced from 123 to 114. The total production of these three crops also increased from 260 quintals to 546 quintals between 2015 and 2016.

Graph 4: Area and production of main Rabi crops (for irrigated area only)



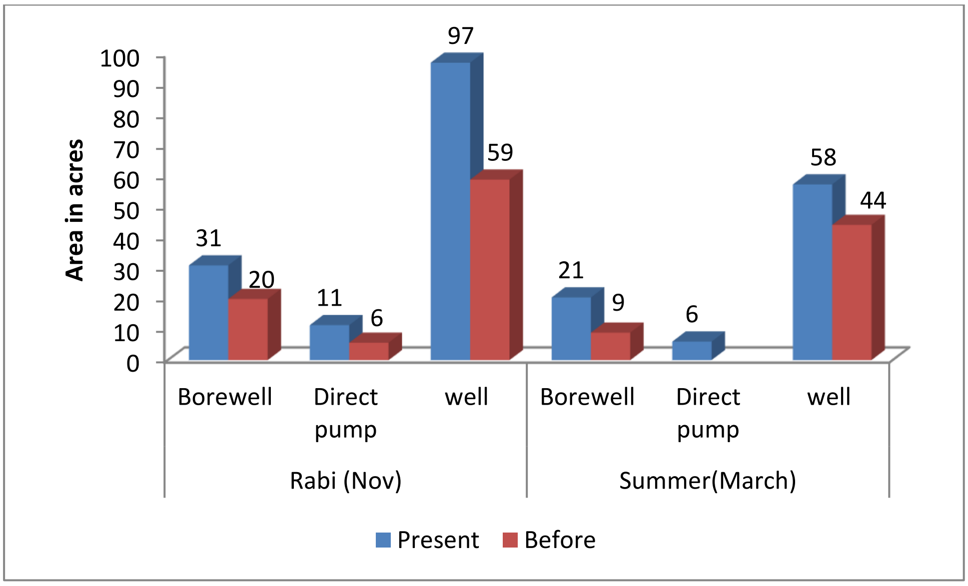
The same trend is observed in the Rabi season where the irrigated area of the three main crops (jowar, wheat and Bengal gram) increased from 18.7 acre to 26.7 acre. The combined production of these three crops increased from 50 quintals to 159 quintals. Crop-wise details are provided in Graph 4. In general, farmers believed the water holding capacity of the soil has increased due to silt application. This increased soil moisture reduces water requirement for the Rabi crops.

Picture 2: Visible change in soil structure after and before mixing with the tank silt

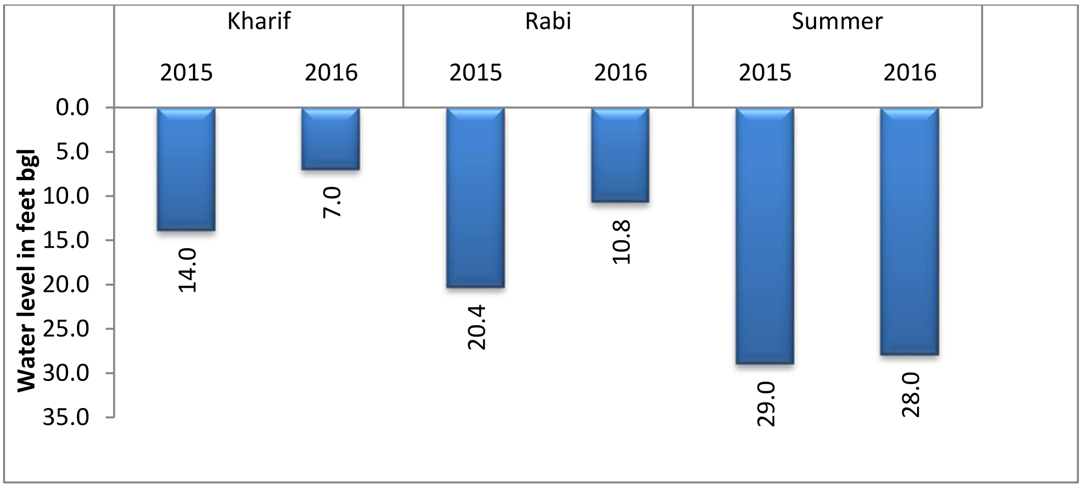
The perennial crop area increased from 11.5 acre to 44.5 acre. Most of this area is under sugarcane cultivation. There was negligible area under irrigation during summer in these 33 households before the desiltation activity. Now summer irrigation is being done in about 1.8 acre of land for bajra and maize crops.

The irrigated area increased significantly post desiltation (Graph**Error! Reference source not found.** 5) in both the seasons, owing to the fact that water levels were higher in dug wells (Graph 6) that access shallow weathered aquifers. The data presented in these graphs are based on recall, since ground data for pre- and post-desiltation was not available. However, good rain in 2016 and desilting have worked in conjunction to show increased water levels in dug wells. To ascertain the direct recharge from tanks, an isotopic study or natural dye test can be employed in the future. Control data points for pre- and post-desiltation for a normal rainfall year and below normal rainfall year are not available for reference to narrow down the role of tanks as recharge structures.

Graph 5: Area under irrigation by sources



Graph 6: Changes in well water level



The same trend is also reflected in the opinions of the farmers. During the group discussions, farmers reported that desiltation has led to an increase in water percolation from the tanks. There is an observable increase in water levels of wells in a radius of about 1-2 km from the tanks. Similarly, farmers feel that irrigated area has also increased due to increased water availability. Increase in well water along with increased storage capacity of tanks has helped farmers cultivate Rabi crops in more areas. In Khanapur, farmers observed that time for pumping the water from the hand pumps near tanks has reduced.

Silt application

In total, the silt was applied on an area of 472.5 acre. On an average, this is about 1.6 acre per farmer household. About half of the households reported that their farm where silt was applied was located downstream of the tank. In 45 per cent cases, it was located upstream whereas in a few cases (5 per cent) the farm was located more than 5 km away from the tank. Most of the farmers (80 per cent) used tractor trollies to transport the silt. About 20 per cent used tippers and only 3 per cent used *hiwa* vehicles for silt transportation. Tractor trollies are mostly used as they are comparatively less costly.

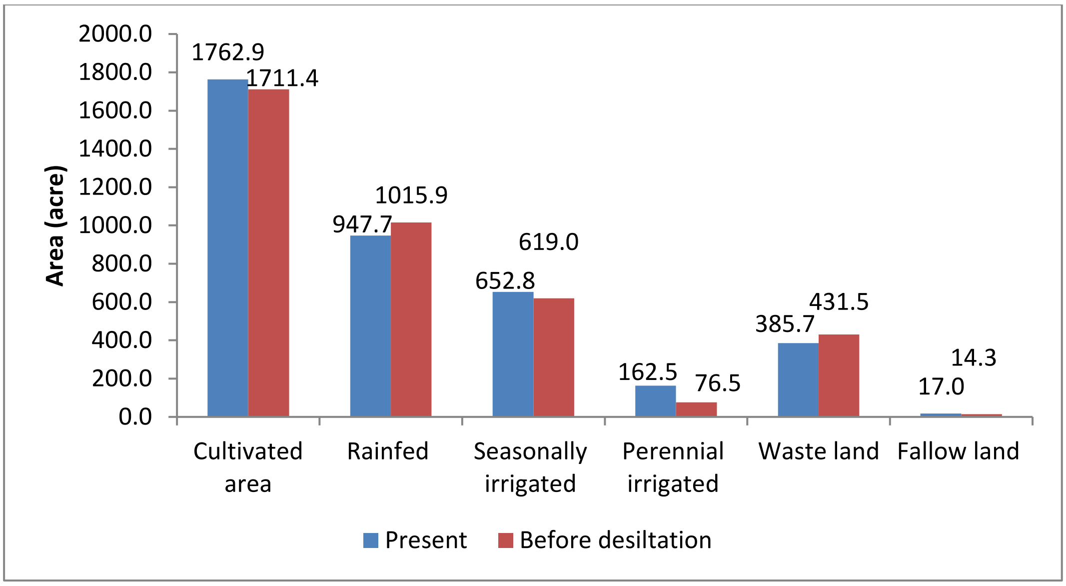
The average distance between the tank and the silted farm is 2.4 km. In total, 50,131 trips were reported, which comes to an average of 172 trips per farmer. In most cases (84 per cent) farmers mixed the silt with existing soil. Tank silt has more clay content than farm soil and hence the silt should be mixed with the existing soil. Mixing of the silt and existing soil also helps crop roots to take hold firmly, farmers felt. Half of the farmers reported an increase of 3-6 inch in the soil layer after silt application. About 44 per cent farmers have farm bunds on their silted land. These farm bunds help in in-situ soil and moisture conservation and prevent future soil erosion. The NGOs also preferred giving silt to farmers who have bunds on their farm.

Impact on land categories

Graph 7 shows the area under different land categories before interventions (2015) and at present (2017). The area under cultivation increased by 51.5 acre (3 per cent) and seasonally irrigated area increased by 33.8 acre (5 per cent). Perennially irrigated area showed a significant increase of 86 acre (112 per cent). Rainfed area and waste land reduced by 7 per cent and 11 per cent respectively.

The use of drip and sprinkler irrigation has increased in the last few years. The number of households using drip and sprinkler irrigation is 29 and 51 respectively. About 77 acre is under drip and 227 acre under sprinkler irrigation.

Graph 7: Changes in area under different land categories



Agricultural production in farms with silt application

The major Kharif crops cultivated by the farmers are cotton, soybean, jowar, black gram and green gram. Pigeon pea, turmeric, marigold, sunflower, seed cotton, sesame and safflower are cultivated by a few of the farmers.

Table 12: Changes in area, production and yield of major Kharif crops

	Area (In Acre)			Production (In Quintal)			Yield (Quintal Per Acre)		
	2015	**2016**	**2017**	**2015**	**2016**	**2017**	**2015**	**2016**	**2017**
Cotton	191.3	202.9	189.4	993.7	1721	908.1	5.2	8.5	4.8
Soybean	134.6	186.8	132.8	525.2	1137	780.3	3.9	6.1	5.9
Jowar	33.2	21.1	23.0	109	99	98.5	3.3	4.7	4.3
Black gram	14.5	19.0	35.2	47.75	34	95.5	3.3	1.8	2.7

Table 12 shows the area, production and yield of the four major Kharif crops for three years. The area growing cotton, soybean and black gram shows an increase of 6 per cent, 39 per cent and 31 per cent respectively in Kharif 2016 as compared to Kharif 2015. A corresponding increase in the yield is also observed during this period. The increase in yield in 2016 is a result of silt application as well as good rainfall. The base year 2015 was a rainfall deficit year and hence the yield was below average.

Between 2015 and 2016, the area under cash crops has increased whereas that of food crops has reduced. From the food security perspective, this is not an encouraging trend.

In 2017, the cotton crop suffered from a pink bollworm pest attack which affected production. A slight decrease in the area of cotton and soybean in the Kharif 2017 season is observed. A decline in yield of black gram is observed even though the cropping area has increased.

During the Rabi season, the main crops cultivated are Bengal gram, jowar and wheat. Apart from these, some farmers also cultivate groundnut, safflower and onion.

Table 13: Changes in area, production and yield of major Rabi crops

Crop	Area (In Acre)		Production (In Quintal)		Yield (Quintal Per Acre)	
	2015	2016	2015	2016	2015	2016
Bengal Gram	49.3	71.4	271.0	397.8	5.5	5.6
Jowar	47.4	55.2	187.0	264.5	3.9	4.8
Wheat	16.5	36.6	72.0	226.5	4.4	6.2

Table 13 indicates an increase in area, production and yield of Rabi crops in the post-intervention period. The area of Bengal gram, jowar and wheat increased by 45 per cent, 17 per cent and 122 per cent respectively. Similarly, the production of Bengal gram, jowar and wheat also shows an increase of 47 per cent, 41 per cent and 215 per cent respectively.

During the group discussions it was observed that the farmers had a positive perception of the benefits of silt application. They felt that silt application increases production by 50 per cent and at the same time reduces the fertiliser cost by about half. The crops also look visibly healthy. Farmers also commented on a change in cropping pattern – there is a shift towards cash crops with more households cultivating soybean and cotton. The area and number of households cultivating jowar shows a slight reduction.

Picture 3: Sugarcane crop in farm with no silt and in farm with silt application

No summer crops were reported in the period before desiltation. In summer 2016, about eight farmers reported cultivating groundnut, maize and bajra in an area of 10.4 acre. Most of this area is under groundnut cultivation. The productivity of summer groundnut was 5.7 quintal/acre.

Similarly, fodder crops were not cultivated before desiltation. Currently, six farmers are cultivating fodder crops in an area of about 4.3 acre.

Sugarcane is the main perennial crop in the area. Very few farmers from Moha village were cultivating sugarcane earlier. Now their numbers have increased from six to 33. Similarly, the area under sugarcane cultivation has also increased from 13.8 acre to 55.9 acre.

A positive change is observed for intercropping. The area under intercropping increased from 48.2 acre to 192.5 acre in the Kharif season. This is an increase of about 300 per cent. Pigeon pea is generally sowed between cotton, jowar, black gram, soybean and green gram. Intercropping helps farmers get an assured income in case of crop failure. It is also beneficial for soil health and prevents soil erosion.

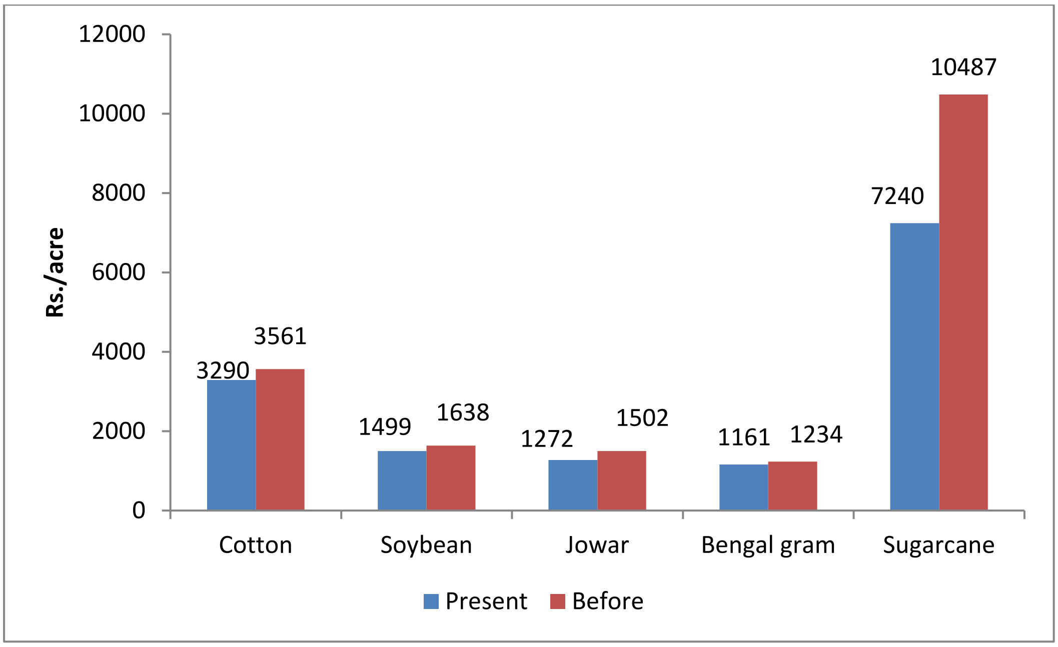
Farms with silt application show an increase in area under water saving technologies (like drip and sprinkler irrigation). The gross area under water saving technologies has increased from 29.7 acre to 76.3 acre after the intervention period.

Impact on fertilisers and income (for silted land)

A slight reduction in per acre cost of chemical fertilisers is observed for the major crops on silt-applied land. The per acre cost of chemical fertiliser usage has reduced by 8 per cent and 9 per cent in case of cotton and soybean respectively for the Kharif season. In the Rabi season, the per acre cost has reduced by 15 per cent and 6 per cent for jowar and Bengal gram respectively as shown in Graph 8.

In case of perennial crop sugarcane, a marked reduction in per acre cost by 31 per cent is reported for chemical fertilisers. The group discussions revealed farmers' anxiety about using silt for the first time. Farmers have invested significant money in silt application and feared if the production was not good it would lead to loss. Hence, they applied more fertilisers in the farms where silt was applied (even though it was not needed). Farmers were also of the opinion that silt application reduces weed growth and hence the weeding cost is reduced.

Graph 8: Change in input cost of chemical fertilisers



There is no change observed in per acre cost of pesticides for cotton and jowar. However, the cost shows an increase of 10 per cent and 20 per cent for Bengal gram and soybean respectively. This may be due to increase in pest attacks.

The average gross annual income from the land with silt application (472.5 acre) changed from Rs. 37,489 to Rs. 92,855. The high value in the post-desiltation period could be a result of silt application coupled with good rainfall. The rainfall in 2015 was below average, resulting in lower production and income losses for the farmers.

The income generated from the silted farms was used for a variety of purposes by the farmers. Some of the key purposes are: repayment of loans, education of children, marriages, livestock purchases, investments in agriculture (repairing of farm bunds, levelling, purchase of micro irrigation sets), medical purposes and domestic uses including house repairs.

Other benefits

In general, migration is not much prevalent in these villages. Before the interventions, 42 individuals had migrated from the villages in the study locations, mostly to work as non-agricultural labour. A few of them also work as agricultural labour or in some business. At present, the number of individuals who migrate (after desilting activity) has come down to 23. In most cases, the migration is within the state for a duration of about of about four to six months. The same trend was reflected during the group discussion. In Kalvati, Moha and Bijewadi, farmers believed that the number of people migrating outside has reduced since they have employment opportunities within the village. In Kalvati, earlier entire families migrated for sugarcane cutting, whereas now only a few individuals from a family migrate out. Increase in Rabi area also means more labour opportunities for landless and marginal farmers within the village.

In Moha, it has been reported that farm prices have doubled as they are more fertile and have increased water availability. Thus, silt application has led to increase of land value (fixed asset) in the region.

Picture 4: Abundance of birds near the Sagroli tank

Farmers believed that silt application helped growth of crops and increased biomass. Hence, the farms are yielding more crop residue. This has led to more fodder for the livestock. In Bijewadi and Sagroli, people were of the opinion that the greenery surrounding the tanks has also increased. In Sagroli tank, many birds were also sighted during the field visits.

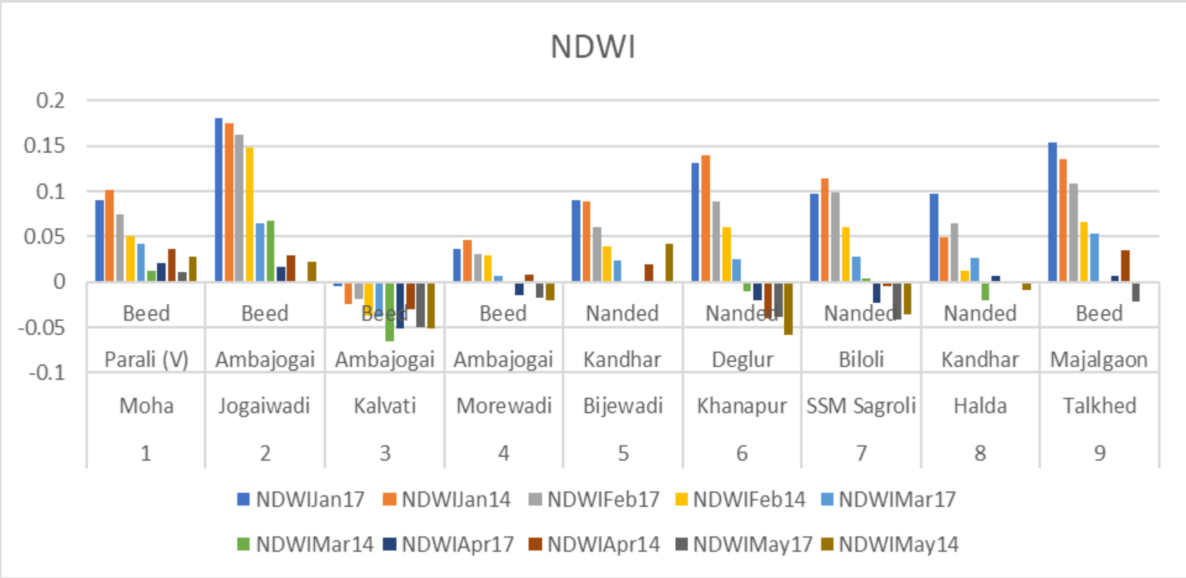
Commercial fishing is being done in the tanks of Moha and Sagroli since the last few years. In Moha, the contract has been given by the gram panchayat to a local fisherman. Similarly, in Sagroli the contract has been given to a local village fisherman by the Zila Parishad for an amount of Rs. 50,000 per year. According to a fisherman awarded a contract in Sagroli, earlier the tank dried up by Diwali (October/November) but now (2017) it has not dried even in February. He has introduced larger quantity of fish in the tank compared to the earlier period. The fish catch has increased and the fishes weigh more as they are in water for a longer duration.

Picture 5: Commercial fishing in the Sagroli tank

GIS-based analysis

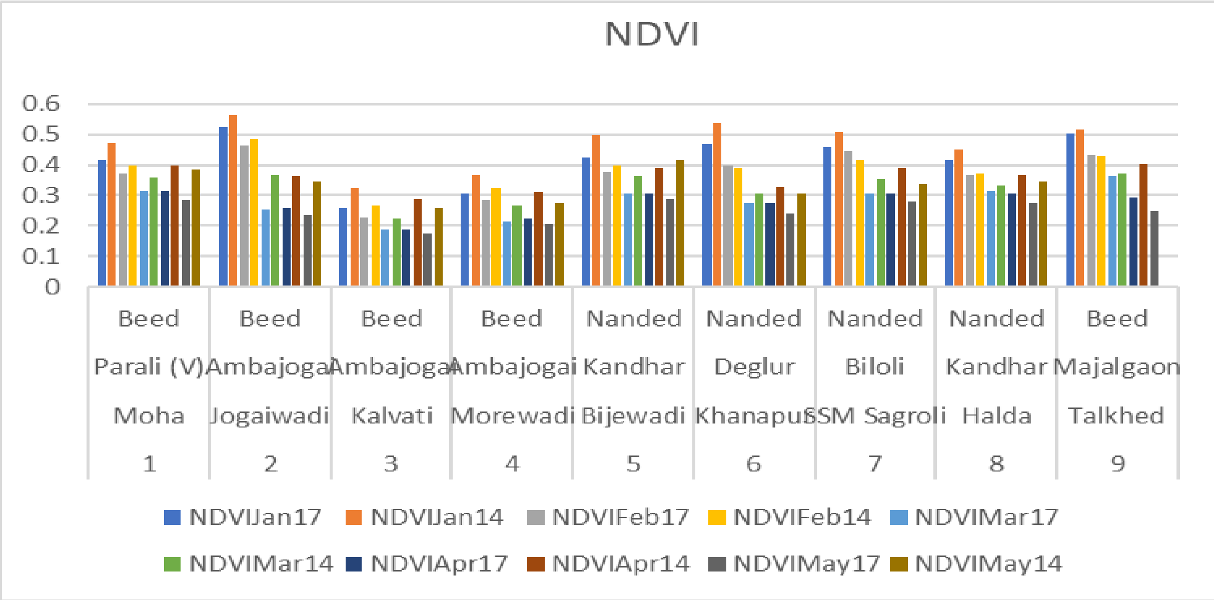
Graph 9 shows NDWI for the months January to May (15th of 1st month to 15th of 2nd month) for 2017 and 2014. In general, Kalvati and Morewadi have higher water stress. From the graph, it is evident the NDWI values are lower in 2014 as compared to 2017, except in the months of January, April and May.

Graph 9: Comparison of NDWI



This implies that the region was less water stressed after desilting in the months of February and March. Although the water stress is much lower in the month of February and March, there is no impact of desilting in January and April and May. One reason for this is that there is usually water available in the month of January even without desilting and there is no water in April and May, even after desilting. The graph shows that the difference between months in 2017 is smaller as compared to the difference between the same months in 2014. This indicates that the region was less water stressed in 2017 and that the transition to a water-stressed situation was more gradual than in 2014. We also note that there is not much difference between the pilot and control farms.

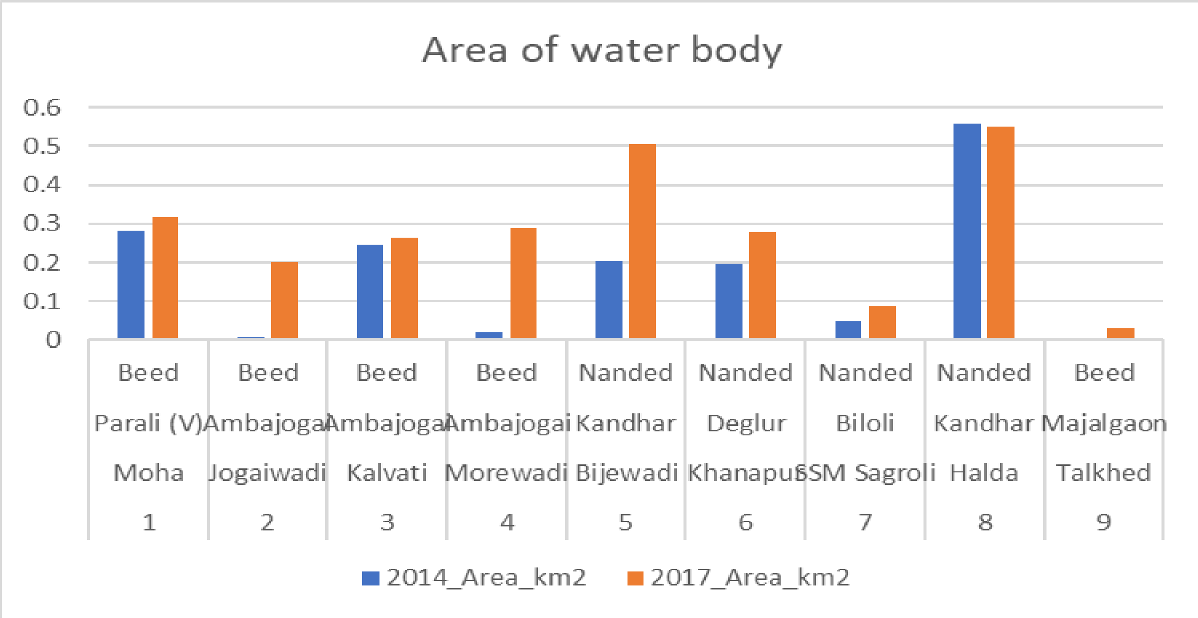
Graph 10: NDVI values for Jan and Feb 2017 and 2014



Graph 10 shows the NDVI values for the same months (January to May, 15th of 1st month to 15th of 2nd) for 2017 and 2014. There are no clear trends seen from this graph and no evidence that 2017 did better than 2014. There may be multiple reasons for this. One reason could be the number of wet days. As seen in Table 1, there are more wet days (in both districts) in 2014 than in 2017. We are also not sure of the number of farmers within a 2-km radius who benefited from silt application. The land may be too small to show any impact in the area selected for this study. Lastly, as noted in the methodology section, it was difficult to get cloud-free images for 2014, which could have also affected results.

Graph 11 provides the surface area of the water in the reservoirs in February of 2017 and 2014.

Graph 11: Comparison of water body area



The graph shows greater surface area in all the pilots in 2017 compared to 2014. There is not much difference in the control farms. One reason is that during monsoons the silted-up tanks store very little water. By February, most of the water has either evaporated or been withdrawn, leaving very little in the tanks. With desilting, as the storage of the tanks increase, they retain more water and even have some water left in February. Graph 11 clearly shows the benefit of desilting, with more water available in the tanks in drier months.

Challenges faced by farmers

Farmers face two main challenges while carrying silt from tanks to farms: money and timely availability of transportation vehicles. The approximate cost of transportation for the first kilometre is Rs. 100, Rs. 200 and Rs. 300 for a tractor trolley, tipper and *hiwa* respectively. For each subsequent kilometre it is Rs. 50. In other instances, a flat rate ranging between Rs. 100-150 per kilometre is charged by the tractor owner.

An estimated 300 tractor trollies of silt are required for one acre of land. The carrying capacity of one trolley is about 1 brass (1.25 brass = 2.83 cubic metre). Thus, an average of about 300 tractor trolley loads (849 cubic metre) of silt create an approximately four-inch layer on one acre of land.

Farmers expressed the opinion that silt application is a costly activity, especially for small and marginal land owners. In many instances the tractor owners prefer to service large farmers who pay them higher than usual charges. Thus, the small and marginal farmers were not able to apply silt even when they wanted to. Many of the small and marginal farmers were not sure about the returns given the high input costs and hence were reluctant to participate in transporting silt. During discussions, farmers said they often did not have ready cash in hand and borrowed money from relatives or took loans from cooperative societies.

Another challenge reported by farmers regarding transporting silt from the tank to their farms was that in the absence of proper roads, the vehicle carrying silt had to travel through another farmer's land. In a few cases, these landowners charged money for allowing the vehicle transit through their farms. This also increases the transportation cost. Since the soil quality and water availability has improved with desilting of tanks, farmers expressed the need for training programmes on agriculture management practices. They want government departments and Krishi Vigyan Kendras to provide such training. Farmers also demanded that the government should subsidise 50 per cent of their transportation costs.

Cost-benefit analysis

Table 14 shows cost-benefit analysis done for the three reservoirs for which the soil test was done.

Table 14: Cost- benefit analysis of tank desiltation activity

Tank	Quantity of silt removed (tons)	Cost of silt removal (Rs.)	Value of nutrients in terms of rupee equivalent							B:C Ratio
			N	P	K	Zn	Cu	Fe	Total	
Jogaiwadi	33180	263110	45823	13279	49250	6094	66499	111231	292176	1.11
Sagroli	14232	150000	5998	5666	100876	2440	19706	10894	145580	0.97
Bijewadi	28160	250000	43578	11186	250305	3682	94501	57724	460976	1.84

(Note: The cost of urea, single super phosphate, muriate of potash, zinc sulphate, copper sulphate, ferrous sulphate is Rs. 600, Rs. 900, Rs. 1,600, Rs. 4,500, Rs. 18,000 and Rs. 2,200 respectively for 100 kg)

The benefit-cost ratio (BCR) of the three tanks ranged between 0.97 and 1.84. The average BCR of the three tanks is 1.31. This indicates that the desiltation activity was economically viable even when only the fertility of silt from the tanks is considered. However, additional indirect benefits of desiltation such as increased water storage capacity, improved soil texture and water holding capacity do not get reflected here. Taking these indirect benefits into account, desiltation would definitely be an economically feasible activity. Table 15 provides a summary snapshot of all the changes in agriculture and water availability discussed above.

Table 15: Snapshot of changes in agriculture and water availability

Indicator	Before desiltation (2015-16)	After desiltation (2016-17)	Change	Per cent change
No. of households =292				
Cultivated area (acre)	1711.4	1762.9	51.5	3%
Rainfed area (acre)	1015.9	947.7	-68.2	-7%
Seasonally irrigated area (acre)	619.0	652.8	33.8	5%
Perennial irrigated area (acre)	76.5	162.5	86	112%
Waste land (acre)	431.5	385.7	-45.8	-11%
Kharif cotton yield (Qtl./acre)	5.2	8.5	3.3	63%
Kharif soybean yield (Qtl./acre)	3.9	6.1	2.2	56%
Kharif jowar yield (Qtl./acre)	3.3	4.7	1.4	42%
Rabi wheat yield (Qtl./acre)	4.4	6.2	1.8	41%
Rabi jowar yield (Qtl./acre)	3.9	4.8	0.9	23%
Summer crops (acre)	-	10.4	-	-
Perennial crop (acre) (sugarcane)	13.8	55.9	42.1	305%
Cost of fertilizer application (Rs. per acre)- Rabi jowar	1502	1272	-230	-15%
Cost of fertilizer application (Rs. per acre)- Kharif Soybean	1638	1499	-139	-8%
Average gross annual income in Rs.(from silted land)	37489	92855	55366	148%
No. of households =33 (well-owning households)				
Average recharge time of wells in Rabi (Nov) (in hours)	11	7	-4	-36%
Average recharge time of wells in summer (March) (in hours)	14	12	-2	-14%

Area under irrigation (acre)	57	75.3	18.3	32%
Yield Rabi wheat (Qtl./acre)	3.2	5.9	2.7	84%
Yield Rabi Bengal gram (Qtl./acre)	2	3.8	1.8	90%
Well water level (feet below ground level) in Rabi	20.4	10.8	9.6	47%
Well water level (feet below ground level) in summer	29	28	1	3%

Other Observations

All seven tanks included in the study were desilted in the summer of 2016 when the Marathwada region was suffering from successive years of a drought-like situation. There was below average rainfall for three years - 2012, 2014 and 2015 - leading to a severe water shortage. In a few villages, desilting was initiated from within the community; in some other villages, NGOs led the work. Since there were no guidelines available (Government of Maharashtra made available a General Resolution in this regard on May 6th, 2017), the NGOs initiated and executed the work according to the immediate community needs and situation. In two villages, a formal committee to implement and manage the desiltation activity was formed (Box 1).

The community perception regarding work execution and management in the two villages was satisfactory as compared to the other villages where there was no such committee. In both the villages, there were no women representatives on the committee. In the villages where such committees did not exist, the implementing NGO deployed JCB machines for excavation and farmers who could bear the cost of transporting the silt to their farms were allowed to carry away the silt. There was no restriction on the quantity of silt they could carry. However, in Kalvati it was reported that private brick kiln owners also took away large quantities of silt, a practice that was not allowed in areas where a committee was in place, as in Moha.

The demarcation of the area for silt excavation was done before work began in two villages – Moha and Bijewadi – by the concerned government department. This prevented accidental damage to the tank wall and prevented water loss because of seepage. In Moha, the area was demarcated at a distance of 10 metres and in Bijewadi, 5 metres from the tank wall.

In Moha, three sample pits at different locations were dug to measure the depth of the silt at the site of the excavation. This helped assess the silt depth and prevented desilting the tank bed. The other villages did not have such sample pits. The excavation at a particular spot was stopped when hard surface or stones were encountered.

Box 1: Institution forming in Moha village of Beed district

The villagers of Moha voiced the need for desiltation, following which a gram sabha was conducted where most people were found to be in favour of implementing this activity. A few of the active community members then approached Manavlok NGO and requested that the work be done. Manavlok held a village meeting and formed a committee, which had five members from the community on it. The NGO provided guidance to the people for building a system for the implementation and management of desiltation.

A public announcement (*dawandi*) was made through the committee and farmers interested in the work were asked to register their names. The committee opened a bank account in a cooperative society. Any farmer who wanted silt had to deposit the money for its transportation in the bank in advance. Registered farmers received coupons which they had to hand over to the tractor driver after every trip made ferrying silt from the tank to the farm. The tractor driver was paid after these coupons were submitted to the bank. The whole process was cashless and was monitored by the committee members. It ensured that all farmers who registered got their share of silt. There was no restriction on the quantity of silt lifted, but each farmer was provided with about 200-300 tractor loads to ensure there was enough for all who had registered.

In Bijewadi village, initially a gram sabha was conducted by the NGO to inform villagers about the work. A seven-member committee representing different wards of the village was formed. The committee was responsible for registering the names of all those interested in taking the silt and managing the work. To ensure that all those who registered got a share of the silt, each farmer was allowed about 200 trips.

The work was carried out in April and May as the tanks were then dry. In Moha and Bijewadi, the tanks were not completely dry at the centre. Hence the excavation work started on the outer boundary of the tank and then moved inwards. There were instances of an excavation machine getting stuck in the wet mud. However, in Khanapur the work started from the centre of the tank and then proceeded outwards. For the rest of the tanks, excavation was started at places found convenient.

Ideally, soil samples from the tank should be tested before being put to use in the farms so as to assess their nutrient content. This would help farmers apply suitable doses of fertilisers. However, soil tests were not carried out in any of the tanks studied.

Only in one village (Moha), soil and water conservation treatments existed in the reservoir catchment when the desiltation work started. Such treatments will reduce soil runoff and delay the rate of silt deposition in the future, thus reducing the frequency at which tanks are desilted.

5. Proposed Guidelines for Tank Desiltation

This section provides recommended guidelines for desiltation of tanks with less than 250 hectares of command area. These guidelines are based on field experiences, discussions with NGO representatives and two Government Resolutions (dated May 6, 2017, and December 6, 2017) by the Rural Development and Water Conservation Department, Government of Maharashtra (GoM). Under the "*Gaalmukt Dharan, Gaalyukt Shivar Yojana*" the Maharashtra government has given permission to desilt water reservoirs with less than 250 hectares of command area. (Note: In the tables below the initial columns contain the points from the existing Government Resolution (GR). The serial numbers mentioned correspond to the serial numbers in the GR. The last column provides the corresponding proposed guidelines.)

The important features of this scheme are as follows:

GoM GR (Government Resolution number 201704101302368426) for Tank Desiltation		**Proposed Guidelines (based on the study findings)**
GR Serial no.	Details	
I.	Involvement of local farmers: The pre-condition for the scheme is that farmers are ready to bear the expenses required for transportation of silt from percolation tank to farm.	Who takes the silt? Priority to be given to rainfed/ degraded farms situated within the village itself and particularly to those in the periphery of 500 m from the dam to be desilted. Even among these farms, small and marginal land holders may be given preference. The sequence of priority may be as follows: 1. Distance from dam: 0-500m; 500m-1 km; 1-1.5 km and more than 1.5 km. 2. Landholding pattern: Small, Marginal, Medium and Large farmers. 3. Farming system: Rainfed, Cultivable waste land and Irrigated. 4. Grant support (partial/full) may be provided to small and marginal farmers for transportation of silt from the tank to their farms. The support could be from government schemes such as MGNREGS or JYSY. This will help improve soil quality of degraded lands, enhance crop productivity and increase the earnings of low-income farmers. 5. A special loan with 'no/minimal' interest rate may be offered to other farmers for transportation of the silt. This would help them avail of the opportunity to improve the land if own funds are not immediately available.

II.	Involvement of private and public institutions: The required machinery and fuel cost for silt excavation will be provided from government and CSR (Corporate Social Responsibility) funds.	*The GoM point seems to be Ok. No change suggested.*
III.	Use of technology: latest technology will be used for geo-tagging and maintaining the record of activities carried out in the project.	*The GoM point seems to be Ok. No change suggested.*
IV.	Monitoring and Evaluation: The work to be done under this policy will be monitored and evaluated by third party agencies.	The village-level monitoring committee (VMC) and representative of Tahsildar will monitor the desiltation work, along with evaluation by external/third party to assess the efficiency and effectiveness of the work carried out.
V.	Priority will be given to percolation tanks which are more than 5 years old and have command area of less than 250 hectares.	(It is suggested that the definition of big and small dams may be based on the catchment area of a dam rather than the command area. The silt load is transported from the catchment area. The villagers would be able to calculate the catchment area easily.) Priority should be given to the oldest and most silted tank in the village. The tank may be desilted only if the siltation has reduced the height of original water storage by at least 50 per cent so that the work is economically viable. This will provide sufficient amount of silt as well as ensure that the storage volume is significantly increased due to silt removal. Method of assessment: (a) Three sample pits at different locations within the selected tank should be dug to determine the actual depth of the silt. (b) Samples of silt from different locations in the silted area and at different depths (<30cm; 30-60cm and >60cm) should be sent for testing to determine the suitability of silt for application on croplands. Farmers need to be made aware of the following: The parameters mentioned below are of utmost importance and should be followed prior to the application of silt on farmland: a. Soil texture: proportion of sand, silt and clay. Soil with sand of more than 60 per cent is to be avoided. This affects the Soil Organic Carbon and available. nutrients such as N, P and K.

		b. pH: Silt with pH of more than 8 is to be avoided. c. Calcium carbonate ($CaCO_3$) of more than 10 per cent may be avoided. d. Exchangeable sodium percentage should not be more than 15 per cent. Care must be taken that the soils of farmland on which silt is planned to be applied do not deteriorate in terms of texture and other parameters mentioned above by the application of poor quality silt. It is advisable that farmers have their soils tested prior to the application of silt. They can even refer to Soil Health Cards provided by the Department of Agriculture. Accordingly, a decision can be taken on the utilisation of the silt for application on the farms or providing the same for other use (e.g. brick kilns) in case the quality cannot be improved by treatment. However, if the soil is deemed unfit for further use, desiltation is still considered as it enhances water storage. In such case, a place for dumping the silt needs to be identified and accordingly a budget may be allocated.
VI.	Only silt excavation is allowed; sand excavation is not permitted.	Excavation of only silt is allowed while sand excavation is strictly prohibited. Only that quantity of silt should be excavated which would help in restoring the original water storage capacity of the dam. The designed storage capacity of the tank should not be increased.
VII.	Sub-Divisional Officer (SDO-Prant) from the Revenue Department will be the implementing officer of this scheme	Gram Panchayat would implement the project through its VMC closely under the supervision of Sub-Divisional Officer of the Revenue Department.

4. Procedure: According to the rules, following is the procedure for implementation:

A) In cases where the farmer/NGO spends own funds to excavate and transport silt.

i. Responsibilities of farmer/NGO:

A.	Prior notice related to tank desiltation activity should be given to Tahsildar/ Talathi/Deputy Engineer (Dams) along with the schedule of work by farmer or NGO.	The Gram Panchayat (GP) is to give prior notice to the Tahsildar or the designated officer regarding the tank/s to be desilted. An individual or NGO approaches the respective Gram Panchayat expressing their interest in tank desiltation/silt. The GP prepares the proposal based on the following procedure:

		a. The GP assesses the suitability of the tank based on parameters given in other section of the guidelines. b. The Govt engineer helps the VMC/GP estimate the tank's suitability for desiltation and the quantity of silt available and gives guidance on area i.e. how much of farmland can covered by the application of the silt. (Refer Annexure 3) c. Accordingly, the GP/VMC prepares the list of farmers surrounding the tank and others of the village. d. The interest/no interest of these farmers and accordingly their consent and quantity required are obtained by the GP/VMC. e. The list of the farmers who apply for the same is displayed in a public place.
B.	If the percolation tank's irrigation potential is between 0 to 100 hectares, initiate the work after 48 hours (2 days) of submitting the Schedule of tank desiltation work to the designated authorities.	*The GOM point seems to be Ok. No suggestions.*
C.	If the irrigation potential is between 101 to 250 hectares then work should start 3 days after submitting the Schedule.	*The GoM point seems to be Ok. No suggestions.*
D.	If the irrigation capacity of tank is 0 to 100 hectares then desilting is not allowed for a distance of 5 metres from the wall. If the irrigation capacity of the tank is 101 to 250 hectares then desilting is not allowed for a distance of 10 metres from the wall.	*The GoM point seems to be Ok but the following points are to be added.* Caution: Changing the topography of silted area through desiltation may impact its flora and fauna. It may affect the habitat for migratory birds. Hence, boundary plantation surrounding the desilted areas may be undertaken to maintain biodiversity and increase greenery.
E.	If the tank is owned by a private farmer or if there is no clarity about ownership, then it should not be considered for desiltation.	A percolation tank owned by any government department or the GP may be considered for desiltation. If the tank is privately owned, or the silt lies within privately-owned land, then written permission from the owners must be taken by the GP prior to submission of the proposal to the Tahsildar.

ii) Responsibilities of Tahsildar:

A.	The Tahsildar should maintain the record of silt excavation applications given by the concerned farmers/ NGOs.	The GP should maintain the documentation of all applications it submits to the Tahsildar for tank desiltation, including the amount of silt lifted and of the benefiting farmers who apply the silt on their land. This is helpful for future studies. The format for the collection of the farmer data is given in Annexure 2.
B.	The Talathi should monitor tank desiltation activity happening within their jurisdiction.	The VMC established by the GP should monitor the desiltation process and the work continuously. The Talathi is responsible for monitoring the work and for giving the final sign-off.
C.	After receiving proposal by the concerned Tahsildar and if they do not reply to the concerned farmer/organisation within a span of 48 hrs or (2/3 days), then the farmers/NGOs can start silt excavation.	*The GoM point seems to be Ok. No suggestion. However, in this proposal, it is the Gram Panchayat that may proceed with desiltation.*
D.	Farmers/NGOs are not allowed to excavate murum/sand from the tank. Desiltation activity should be stopped immediately if someone is found excavating sand.	*The GoM point seems to be Ok. No suggestion.*
E.	A tank with irrigation potential of 0 to 100 hectare will not be desilted on government expenses.	*The GoM point seems to be Ok.* However, small and marginal farmers, as suggested elsewhere in the document, may be supported by govt schemes for desilting.
F.	The Tahsildar will be responsible for uploading before and after photos of tank desiltation work in the allocated online system after completion of the work.	*The GoM point seems to be Ok. No suggestion.*

iii) Responsibility of Deputy Engineer (Dam):

A.	If the irrigation capacity of the tank is 0 to 100 hectares then desilting is not allowed for a distance of 5 metres from the wall. If the irrigation capacity of the tank is 101 to 250 hectares then desilting is not allowed for a distance of 10 metres from the wall. Deputy Engineer should mark boundaries.	The Deputy Engineer should also demarcate the area under submergence of the tank for all types of dams to avoid any dispute with nearby farmers who might have encroached into the submerged area.
B.	The tank selected for desiltation should be inspected regularly by the Deputy Engineer, Junior Engineer and Executive Engineer from time to time.	*The GoM point seems to be Ok. No suggestion.*
C.	The work should be stopped immediately, if desiltation activity threatens the safety of the tank.	*The GoM point seems to be Ok. No suggestion.*

B) In cases where farmers transport silt at their own expense after the government undertakes desiltation of the tank/excavation and transportation of the silt by machinery provided by the NGOs.

i.	In case of the farmers or NGOs submitting a proposal for only transporting silt, the Tahsildar, after technical scrutiny, must send the proposal for administrative sanction to the SDO.	The GP gives prior notice to the Tahsildar or any other designated officer. NGOs or individuals are not allowed to apply directly to government agencies. They are to apply to the respective GP. The GP prepares the proposal based on the following procedure: a. The GP assesses the suitability of the tank based on parameters given in another section of the guidelines. b. The government engineer helps the GP/VMC to estimate the quantity of the silt available for desilting and guides them on farm area that may be covered by application of the silt. (Refer Annexure 3) c. Accordingly, the GP/VMC prepares the list of farmers surrounding the tank and others. d. The consent of the interested farmers in lifting and applying the silt on their farm is procured. e. The list of the farmers who will avail of the silt is to be displayed in a public place.
ii.	Committee chaired by the SDO will provide the administrative sanction for such desiltation proposals.	*No suggestion.*
iii.	Account head for this is 4402 2681.	*No suggestion.*
iv.	Digital photographs taken before starting of desiltation and after the completion of desiltation must be uploaded to the online system. A 50 per cent payment should be made till the work is completed and the rest 50 per cent payment must be done only after uploading of photos of completed works. The concerned agency will have to repay the expenses if the payment is done before uploading of the photos.	*No suggestion.*
v.	This decision of government is not applicable in the Coastal Regulation Zone (CRZ).	*No suggestion.*
vi.	Within one month, a negative list should be created where there is sand available in the structures constructed by Revenue Department (small irrigation scheme/ percolation tank /village tank/storage	*No suggestion.*

	tank). Tanks mentioned in a negative list are not considered under this scheme.	
vii.	It is compulsory for the farmers to use the silt only on their own farmland and must not be sold or used for commercial purposes.	*The GoM point seems to be Ok. No suggestion.*
viii.	Farmers will be responsible for making all the necessary arrangements required for the transportation of silt including approach roads.	The approach road from the tank to the existing public road must be demarcated by the VMC with the help of the Talathi/ Tahsildar. The VMC along with GP and the community forms the guidelines to make temporary roads, if required, through the existing farms without major damage to the farmland. These guidelines will also suggest ways and means to compensate the farmers affected by such roads. Such roads constructed should be demolished after the desiltation is completed and the farmland restored. This would avoid the silt-taking farmers from being charged for the roads at an individual level.
ix.	Involvement of different government departments: i) Major Control Mechanism – Revenue Department. ii) Assistive Mechanism – Department of Rural Development. iii) Technical Assistance Mechanism – Soil and Water Conservation Department, Groundwater Surveys and Development Agency. iv) Machinery Supporting Mechanism – Water Resources Department. v) Promotion and Publicity Mechanism- Directorate General of Information and Public Relations.	*No suggestion.*
x.	Regulatory authorities: For implementation of the project, committees should be formulated at State, District and Block levels. The Committee structure is as follows: A) State level: 1. Chief Secretary – President. 2. General Secretary, Water Resources Department – Member. 3. General Secretary, Agriculture Department – Member. 4. General Secretary, Revenue Department – Member.	*No suggestion.*

	5. Preservation, Soil and Water Conservation Department – Member. 6. Managing Director, Maharashtra Water Resources Corporation, Aurangabad – Member Secretary. 7. Director, Groundwater Surveys and Development Agency – Member. 8. Representatives of NGO – special invitees. B) District level: 1. Collector – President. 2. Sub-Divisional Officer – Member. 3. District Agricultural Officer – Member. 4. Executive Engineer, Water Resources Department – Member Secretary. 5. Groundwater Surveys and Development Agency representatives – Members. 6. Inspection Officer, Land Records Department – Member. 7. Information Officer (District) – Member. 8. Representatives of NGO – special invitees. Scope of work: to ensure pre- and post-desiltation photos are uploaded to the online system. C) Block Level: 1. Sub-Divisional Officer – Chairman. 2. Block-level Agricultural Officer – Member. 3. Groundwater Surveys and Development Agency representatives – Members. 4. Inspection officer, Land Records*** Department – Member. 5. Farmer/Water User Association/Jaldoot – Members. 6. Sub-Divisional Engineer (ZP) – Member Secretary. 7. Representatives of Private Sector and NGO – special invitees. Scope of work: proposal of tank desiltation should verified technically and sanctioned after ensuring availability of funds.	
xi.	Financial sources: the overall implementation cost of tank desiltation	*No suggestion.*

	project is provided in the *"Jalyukt Shivar"* policy. The fund limit is up to Rs. 10 lakh.	
xii.	Ore minerals and Royalties: The Revenue Department agree to wave off the royalty charges on farmers and potters, if they would use silt in their farm or in the pottery business.	*No suggestion.*
xiii. A. B. C. D. E.	Monitoring through electronic media: Facility of online demand letter – Water Resource Department should put demand letters on their web portals so that farmers from any village across the state can fill that form. Geo-tagging: finalized tanks for desiltation are to be geo-tagged as per the tagging process used in the *"Jalayukt Shivar"* policy Unique IDs: to avoid duplication of work a unique ID is to be created for each tank according to its Latitude and Longitude. Mobile Application: for transparency reason, mobile application should be launched where any individual would get information about any tank. Photos of pre-desiltation, during desiltation and post-desiltation should be uploaded on the online system so that it could be used in strengthening internal systems.	*No other suggestions besides those already made.*

The GoM GR (Government Resolution number 201712061616303426) for Tank Desiltation	**Proposed Guidelines (based on the study findings)**
Government Decision: Village-level Monitoring Committee (VMC) needs to be formed. The structure of the committee is as follows: 1) Village President – Chairman. 2) Gram Panchayat member (One) – Member. 3) Farmers Representative – Member. 4) NGO representative – Member. 5) Talathi/Gramsevak – Member. 6) Related Section Engineer – Member Secretary.	Besides those mentioned in the govt guidelines, the structure of the committee may have representation of the following groups as well: 1. Women's SHGs to check the possibility of loans for desilting. 2. Women representatives to maintain gender equality. 3. Society/Bank to check the loan possibilities. 4. Landless households – to make them farmers by offering waste land with application of the silt (if possible). 5. Owners of transport vehicles (tractors, tipper, *hiwa*, etc.) 6. SC/ST/Minority communities.

	7. Representation as per landownership pattern (Small, Marginal, Medium and Large).
Responsibilities of the Committee: 1) To inspire the farmers to participate in the *"Galmukt Dharan and Galyukt Shivar Policy."* 2) To coordinate between the farmers and machine-owners for making the machines available on justified rates. 3) To coordinate among the farmers when demand for silt is more than the availability.	i. The Committee must undertake an Awareness Campaign in the village to motivate farmers to apply silt on their degraded farms. ii. Information about the plan and execution of the desilting activity must be displayed and updated daily in public places, so that people are well informed. iii. In case of big tanks, nearby GPs may also be invited to take away the silt for their farmers. iv. The VMC along with GP and the community formulates the guidelines to make temporary roads where required, through the existing farms without major damage to the farmland. These guidelines are to also suggest ways and means to compensate the farmers affected by such roads, as also removal of roads after the work completion and restoration of the farmland. (This prevents the silt-taking farmers from being charged for the roads by the intermediate farmers.) v. Silt transportation charges are to be fixed in the Gram Sabha after discussions with the vehicle owners/drivers based on the distance for transporting the silt. vi. The VMC must consider and plan to build erosion control measures in the catchment area of the desilted tank to reduce future silting.

6. Conclusions

A scientific study was conducted of seven pilot tanks that were desilted in Beed and Nanded districts of the Marathwada region in Maharashtra. As part of this analysis, 292 farmers (51 per cent of the beneficiaries) were surveyed and desktop-based GIS analyses conducted. Soil tests from the tanks and the silt-applied farms was conducted. The analysis shows silt from the tanks was richer with nutrients and carbon and had better water retention. When applied to the farms and mixed with top soil, it helped improve crop yields and cut down input expenses for the farmers. Desilting also helped improve the water situation in the villages.

Surface water was now available for a longer time in the dry period and the groundwater was recharged. This had a positive impact on crop production. Some farmers ventured into growing summer crops and fodder. Overall, there was an improvement in the socio-economic conditions in the region. There were other indirect benefits, such as reduced migration, improved livestock health, more greenery and more bird sightings. Even when only the fertility of the silt was considered, a cost-benefit analysis showed the economic viability of desilting. The economic gains will be higher if other direct and indirect benefits are considered.

Based on the analysis and field visits, we recommend a set of guidelines to help implement the Maharashtra Government's *"Gaal Yukt Shivar"* policy. We have used the government's GR to provide the guidelines. This will help in their easy implementation in the state.

Box 2: Benefits at a Glance

- Water storage level improved
- Farm soil improved
- Greater participation of community
- Gave boost to women, landless, SCs, STs, others
- Generated employment, such as tractor services
- Improvement in socio-economic conditions
- Reduced outward migration
- Improved livestock health
- More greenery and birds

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Annexures

Annexure 1: Household Survey Questionnaires

Household Questionnaire (Form 1)

IDENTIFICATION PARTICULARS

Before Starting Interview

Household Questionnaire no

Name of District ______________________Name of Taluka________________

Name of the village: ____

Name of Household Head: ____

Contact number of the respondent: ______________________

Time of starting Interview (HH.MM):_____._____ AM/PM

After Ending Interview

Time of ending interview (HH.MM): _____ . _____ AM/PM

Names of Respondents 1: ______________________________

2: ______________________________

Date of Interview (DD/MM/YY): _____/_____/______

Name of Interviewer: ____

Name of Supervisor: ____

INFORMED CONSENT

Namaskar! My name is _________ and I am working with Watershed Organisation Trust (WOTR). Since 1993, WOTR has been working for rural development though watershed development program. So far WOTR has supported and carried out developmental work in over 3500 villages across 7 states of India.

Drought is a recurrent phenomenon in the dry land regions of Maharashtra leading to water shortages and declining agricultural production. Traditionally small water storage structures were built to ensure water availability. However, over the years these structures get silted leading to decreased water storages. Few NGOs in Marathwada region took the initiative to remove the silt from the storage tank to improve water holding capacity and use the silt in farms to increase production. Presently we are assessing the impacts of these desilting activities that were carried out in your village. Since you are the beneficiary of this desiltation activity, we would like to interact with you and gather relevant study data. The information provided by you will be strictly used for research purpose only.

The survey will take about 45 minutes to complete. The information provided by you will be strictly kept confidential and will not be shared with others except the concerned project persons. Your names and other information provided will be kept anonymous and the finding will not relate with names of the informants.

Participation in the survey is voluntary and you may choose to withdraw at any time you want and not to answer any specific question. There are no direct benefits of the study as an individual. However, the data from this study would help in creating guidelines to upscale the desiltation activity on a large scale on a scientific basis. Without this data we will not be able to understand these issues.

Hence, we would like to invite you for the survey and appreciate your participation. Do you have any questions regarding the survey?

(***Answer the questions and clear concerns of respondent, if any***)
Can we begin the interview now?

____
Name of Person Obtaining consent

____
Signature of Person Obtaining consent

____
Date

SECTION A - HOUSEHOLD PROFILE			
Q. No.	**Questions**	**Coding categories**	**Code**
A 1	Name of the Head of the Household: ____		
A 2	Name of the respondent :____		
A 3	Sex of the respondent	Male	1
		Female	2
A 4	What is your caste category?	Schedule Caste (SC)	1
		Scheduled Tribe (ST)	2
		Other Backward Caste (OBC)	3
		Nomadic / Denotified Nomadic Tribe (NT/DNT)	4
		Vimukta Jati Nomadic Tribe (VJNT)	5
		Open	6
		Other (specify) -----------------	88
A 5	Age of the respondent: (in years)	☐☐	
A 6	Total no. of HHs Members:	☐☐	
A 7	Educational qualification of **all the HH members** *(Please circle the relevant responses)*.	Post graduate	1
		Graduate	2
		Diploma/ITI	3
		Professional courses	4
		Higher secondary	5
		Secondary	6
		Primary	7
		Read and write only	8
		Illiterate	9
A 8	What is the average gross annual income of your household?	0- 30,000 Rs.	1
		30,001- 50,000 Rs.	2
		50,001- 1,00,000 Rs.	3
		1,00,001- 2,00,000 Rs.	4
		2,00,001- 4,00,000 Rs.	5
		4,00,001- 8,00,000 Rs.	6
		8,00,001 Rs. and more	7

A9	Is anyone in your household, a member of any of these organizations? (*Please circle the relevant responses*)	Gram panchayat member/ Sarpanch	1
		Zila Parishad/Panchayat Samiti	2
		Cooperative society	3
		Office bearers of political party	4
		Not a member of any organisation	5
		Any other (specify) ___________	88
A 10	Agriculture asset ownership (*Please circle the relevant responses*)	JCB	1
		Tractor	2
		Harvester	3
		Four-wheeler	4
		Other farm equipment (Specify)_______________	88

SECTION B – LAND OWNERSHIP AND CROP DETAILS (HOUSEHOLD TOTAL)

B 1. Total own land — Acres ☐☐ Guntha ☐☐

B 2. Total lease land (if any) — Acres ☐☐ Guntha ☐☐

Type of ownership	Total Land	At Present (in Acres)			Before Desiltation (in Acres)		
		Rain-fed	Irrigated		Rain-fed	Irrigated	
			Seasonal	Perennial		Seasonal	Perennial
Cultivated land							
Waste land							
Fallow land							

B 3. List of ALL crops cultivated during the year 2016- 17

Seasons	**Crop Names**
Kharif	
Rabi	
Summer	

Perennial	

B 4. What is the current total area under water saving technologies?

Water saving technologies	Area (in acre)
Drip irrigation	
Sprinkler irrigation	
Plastic mulching	
Other (specify): ___________	

SECTION C – INTERVENTION DETAILS		
C 01. Month and year when silt applied:	M M / Y Y Y Y	
C 02. In how much farmland did you apply the silt (guntha)?	☐☐☐	
C 03. What is the Gat No. of your land where you applied the silt?	___________________________	
C 04. What is the name of the silted plot (if any)?	___________________________	
C 05. Ownership status of the silted land	Owned	1
	Leased in	2
C 06. Location of silted farmland.	Upstream	1
	Downstream	2
C 07. Have you done any soil/ water conservation practices in silted farmland?	Yes	1 → go to C 08
	No	2 → go to C 10
C 08. If Yes, When did you have done?	After desiltation	1
	Before desiltation	2
C 09. What soil/water conservation practices done in silted farmland? (Specified it)	_________________________ _________________	

C 10. What is the name of the percolation tank from where silt was used in your farmland?	____________________
C 11. What is the distance of the silted farmland from the desilted percolation tank? (in meter)	☐☐☐☐

C 12. How did you transport the silt from percolation tank to your farmland? (*Please circle the relevant responses*)	Tractor trolley	1
	Tipper	2
	Hiwa	3
	Bullock cart	4
	Other (specify): ____________	88

C 13. How many trips of tractor trolley/tipper/Hiwa/bullock cart were made to transport the silt to your farmland?	☐☐☐☐

C 14. Was the silt mixed with the existing soil?	Yes	1 → go to C 15
	No	2 → go to C 16

C 15. What was increased thickness of soil layer due to silt application in the farmland? (in inch)	☐☐

C 16. Cost of application of silt in the farm

Sr. No.	Particulars	Cost (In Rs.)
1.	Transportation (diesel/hired vehicle cost)	
2.	Cost of spreading silt	
3.	Cost of leveling farm	
4.	Other cost (specify) ____________________	
5.	**Total cost**	

C 17. Did you take a loan for applying silt in your farm?	Yes	1 → go to C 19
	No	2 → go to C 18
C 18. What is reason for not taking the loan?	____________________ ____________________	
C 19. How much loan have you taken? (In Rs.)	____________________	
C 20. From where you have taken Loan?	____________________ ____________________	

C 21. Did you repay the loan amount?	____________________________________ ___________________________________

SECTION D – CROP INPUT AND PRODUCTION DETAILS (OF SILTED FARMLAND)									
D 1. Crop Production Details									
At Present of silted farm (in guntha) 2016-17					**Before Desiltation (in guntha) 2015-16**				
Crops	Area (in guntha)	No of irrigations (if any)	Irrigation method (Flood=1, Drip=2, Sprinkler=3)	Prod. (In Qnt.)	Crops	Area (in guntha)	No of irrigations (if any)	Irrigation method (Flood=1, Drip=2, Sprinkler=3)	Prod. (In Qnt.)
A) Kharif 2016					A) Kharif 2015				
B) Rabi 2016					B) Rabi 2015				
C) Summer 2017					C) Summer 2016				
E) Kharif 2017									
D) Perennial (sugarcane, fruit crops etc.) 2016-17					D) Perennial (sugarcane, fruit crops etc.) 2015-16				

E. Grass /Fodder crop					E. Grass /Fodder crop				

D 2. Cost of inputs for agriculture (for the entire year) for Present (in silted farmland).

Sr. No	Component	Crop 1 name ____________ Area: _____guntha			Crop 2 name __________ Area: _____guntha			Crop 3 name __________ Area: _____guntha		
		Quantity/ Number	Unit	Cost (Rs.)	Quantity/ Number	Unit	Cost (Rs.)	Quantity/ Number)	Unit	Cost (Rs.)
1	Land Preparation (tilling, harrowing etc)									
2	Farm yard manure									
3	Seeds									
4	Organic fertilizer									
5	Chemical fertilizer									
5.1	DAP (Kg.)									
5.2	Urea (Kg.)									
5.3	**Other_________**									
6	Pesticides (liter)									
7	Insecticides/weedicides (liter)									
8	Labour activity (hired and family both)									
9	Irrigation (electricity/fuel cost)									
10	Hiring of Agriculture equipment (tractor, thresher bullock etc.)									
11	Crop Harvesting									
12	Transportation to market									

D 3. Cost of inputs for agriculture (for the entire year) for before desiltation (in silted farmland).

Sr. No	Component	Crop 1 name ___________ Area: _____guntha			Crop 2 name _________ Area: _____guntha			Crop 3 name _________ Area: _____guntha		
		Quantity/ Number	Unit	Cost (Rs.)	Quantity/ Number	Unit	Cost (Rs.)	Quantity/ Number)	Unit	Cost (Rs.)
1	Land Preparation (tilling, harrowing etc)									
2	Farm yard manure									
3	Seeds									
4	Organic fertilizer									
5	Chemical fertilizer									
5.1	DAP (Kg.)									
5.2	Urea (Kg.)									
5.3	**Other_________**									
6	Pesticides (liter)									
7	Insecticides/weedicides (liter)									
8	Labour activity (hired and family both)									
9	Irrigation (electricity/fuel cost)									
10	Hiring of Agriculture equipment (tractor, thresher bullock etc.)									
11	Crop Harvesting									
12	Transportation to market									

D 4. Details about labours hired (In silted farmland).

	At Present		**Before Desiltation**	
Season	**Number of labours**	**Number of days**	**Number of labours**	**Number of days**
Kharif				
Rabi				
Summer				
Perennial				

D 5. Total gross annual income from silted land	**At present (in Rs.)**	**Before Desiltation (in Rs.)**
D 6. What did you do from the total income of last year?	______________________________ ______________________________	

SECTION E – OTHER INFORMATION

E 1. Livestock Detail

Do you own livestock?		
	Yes	**1 → go to E 2**
	NO	**2 → go to E 3**

E2. Livestock	**At Present**		**Before Desiltation**	
	Number	Yearly Milk Production (unit)	Number	Yearly Milk Production (unit)
Local cow				
Cross bred cow				
Buffalo				
Goat				
Sheep				

E 3	**Had any household member/whole family migrated out of the village temporarily / at times?**			**Yes**	1 → go to E 4
				No	2 → go to E 5
E 4	How many members?	Migration Where (1- within district, 2- within state, 3- outside state)	Duration of migration (in months)	Type of work for which you Migrated? (1 Agriculture labour/ 2 non agriculture wage labour/ 3 Service/4 business)	
At Present					

Before Desiltation				

E 5. Did you do soil testing?	Yes	1 → go to E 6
	No	2 → go to E 9
E 6. If yes, then when?	M M / Y Y Y Y	
E 7. Did you get the report? (*if yes, take a picture/ photocopy of the report*)	Yes	1 → go to E 8
	No	2 → go to E 9
E 8. If yes, how did you use the information from the soil health card?	______________________________	
E 9. Did you have any other benefits of applying sit on your farmland (apart from an increase in crop production)?	______________________________	
E 10. Did you observe any loss of applying silt on your farmland?	______________________________	
E 11. Does your well/bore well come under the influence area of the desilted tank or do you directly lift water from the desilted tank?	**Yes**	**1 → Go to E 12**
	No	**2 → End the interview**
E 12. If yes, then what are the observed benefits? (*Please circle the relevant responses*)	Increase in well water level	1
	Increase in bore well water availability	2
	Direct pumping water through desilted tank	3
	Water availability from canal	4
	Other (Specifiy) : ___________	88
Instruction: Please fill survey form number 2 for those households who respond "Yes" in E11		

Household Questionnaire (Form 2)

IDENTIFICATION PARTICULARS

Before Starting Interview

Household Questionnaire no

Name of District ______________________ Name of Taluka ________________

Name of the village: ____

Name of Household Head: ____

Contact number of the respondent: ______________________

Time of starting Interview (HH.MM): _____ . _____ AM/PM

After Ending Interview

Time of ending interview (HH.MM): _____ . _____ AM/PM

Names of Respondents 1: ______________________________

2: ______________________________

Date of Interview (DD/MM/YY): _____/_____/______

Name of Interviewer: ____

Name of Supervisor: ____

INFORMED CONSENT

Namaskar! My name is _________ and I am working with Watershed Organisation Trust (WOTR). Since 1993, WOTR has been working for rural development though watershed development program. So far WOTR has supported and carried out developmental work in over 3500 villages across 7 states of India.

Drought is a recurrent phenomenon in the dry land regions of Maharashtra leading to water shortages and declining agricultural production. Traditionally small water storage structures were built to ensure water availability. However, over the years these structures get silted leading to decreased water storages. Few NGOs in Marathwada region took the initiative to remove the silt from the storage tank to improve water holding capacity and use the silt in farms to increase production. Presently we are assessing the impacts of these desilting activities that were carried out in your village. Since you are the beneficiary of this desiltation activity, we would like to interact with you and gather relevant study data. The information provided by you will be strictly used for research purpose only.
The survey will take about 45 minutes to complete. The information provided by you will be strictly kept confidential and will not be shared with others except the concerned project persons. Your names and other information provided will be kept anonymous and the finding will not relate with names of the informants.

Participation in the survey is voluntary and you may choose to withdraw at any time you want and not to answer any specific question. There are no direct benefits of the study as an individual. However, the data from this study would help in creating guidelines to upscale the desiltation activity on a large scale on a scientific basis. Without this data we will not be able to understand these issues.

Hence, we would like to invite you for the survey and appreciate your participation. Do you have any questions regarding the survey?

(***Answer the questions and clear concerns of respondent, if any***)
Can we begin the interview now?

____
Name of Person Obtaining consent

____
Signature of Person Obtaining consent

____
Date

SECTION A - HOUSEHOLD PROFILE			
Q. No.	**Questions**	**Coding categories**	**Code**
A 1	Name of the respondent :______________________________		
A 2	Sex of the respondent	Male	1
		Female	2
A 3	What is your caste category?	Schedule Caste (SC)	1
		Scheduled Tribe (ST)	2
		Other Backward Caste (OBC)	3
		Nomadic / Denotified Nomadic Tribe (NT/DNT)	4
		Vimukta Jati Nomadic Tribe (VJNT)	5
		Open	6
		Other (specify) -----------------	88
A 4	No. of HHs Members:	☐☐	

SECTION B – WATER SOURCES		
B 01. How many of your wells/ borewells/pumps come in the vicinity of the desilted tank? (***Please write the number of wells or borewells***)	Well	☐
	Borewell	☐
	Pump lifting water directly from desilted tank	☐
B 02. Did you increase the depth of exiting well after tank desiltation?	Yes	1 → go to B 03
	No	2 → go to B 04
B 03. How much was the increase in the depth?	Original depth (in feet)	
	Increased depth (in feet)	
B 04. Did you take horizontal borewell in the dug well after tank desiltation?	Yes	1 → go to B 05
	No	2 → go to B 06
B 05. What direction and at up to what depth?	Direction (*as per location of desilted tank*)	
	Depth (in feet)	
	Yes	1 → go to B 07

B 06. Did you take any new well or borewell in the vicinity of desilted tank after the desiltation work?	No	2 → go to B 09
B 07. In which year and at what depth?	Year	Y Y Y Y
	Depth (in feet)	
B 08. At what depth you get water while digging?	Depth (in feet)	

B 09. Well and borewell information

Component	Borewell		Well		Direct Pumping through desilted tank
	B1	B2	W1	W2	P1
Location - Upstream (US)/Downstream(DS)					
Depth (feet)					
Distance from desilted tank (in meter)					
Use- Irrigation/ Drinking (I/ D)					
No. of farmers using water					
No. of pumps (own)					

B 10. Average hours of water pumping per day (Take cumulative hours of your own pumps on a well)

		At Present							Before Desiltation						
		Horse Power of the Pump	Avg. Pumping hours per day	Avg. time to recharge (in hours per day)	Discharge Lit/hr (if Known)	Operational Days in Season	Area irrigated (in acres)	Water available days	Horse Power of the Pump	Avg. Pumping hours per day	Avg. time to recharge (in hours per day)	Discharge Lit/hr (if Known)	Operational Days in Season	Area irrigated (in acres)	Water available days
Bore Well B1	Rabi (Nov)														
	Summer (March)														
Bore Well B2	Rabi (Nov)														
	Summer (March)														

Well W1	Rabi (Nov)														
	Summer (March)														
Well W2	Rabi (Nov)														
	Summer (March)														
Direct Pump P1	Rabi (Nov)														
	Summer (March)														
Direct Pump P2	Rabi (Nov)														
	Summer (March)														

B 11 Depth of water level below ground level

Well	At Present (Water level in feet)				Before Desiltation (Water level in feet)				
	Kharif 2016 (Aug)	Rabi 2016 (Dec)	Summer 2017 (Apr)	Kharif 2017 (Aug)	Summer 2014 (Apr)	Summer 2015 (Apr)	Kharif 2015 (Aug)	Rabi 2015 (Dec)	Summer 2016 (Apr)
W1									
W2									

Note – Water level below ground level.

SECTION C – LAND OWNERSHIP AND IRRIGATION DETAILS (HOUSEHOLD TOTAL)

C 1. Total own land (in acres) Acres [|] Guntha [|]

C 2. Total lease land (in acres) (if any) Acres [|] Guntha [|]

Type of ownership	Total Land (in Acres)	At Present			Before Desiltation		
		Rain-fed (in Acres)	Irrigated		Rain-fed (in Acres)	Irrigated	
			Seasonal (in Acres)	Perennial (in Acres)		Seasonal (in Acres)	Perennial (in Acres)

Cultivated land							
Waste land							
Fallow land							

SECTION D – PRODUCTION DETAILS (Only Irrigated Area)									
D 1. Crop Production Details									
At Present (in guntha) 2016-17					Before Desiltation (in guntha) 2015-16				
Crops	Area (In guntha)	No of irrigations (if any)	Irrigation method (Flood=1, Drip=2, Sprinkler =3)	Prod. (In Qnt.)	Crops	Area (In guntha)	No of irrigations (if any)	Irrigation method (Flood=1, Drip=2, Sprinkler =3)	Prod. (In Qnt.)
A) Kharif 2016					A) Kharif 2015				
B) Rabi 2016					B) Rabi 2015				
C) Summer 2017					C) Summer 2016				
E) Kharif 2017									

D) Perennial (sugarcane, fruit crops etc.) 2016-17					D) Perennial (sugarcane, fruit crops etc.) 2015-16				
E. Grass /Fodder crop					E. Grass /Fodder crop				

Observations -

Annexure 2: Detailed physio-chemical properties of soil

Tank Name	Sample Area	Cu (PPM)	Fe (PPM)	Zn (PPM)	Mn (PPM)	pH	EC (mS/cm)	OC (%)	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	$CaCO_3$ (%)	Mg (Mille %)	Ca (Mille)	Particle density (gm/cc)	Bulk density (gm/cc)	Porosity (%)	WHC (%)	Sand (%)	Silt (%)	Clay (%)
Kalvati	Silt applied Land	6.58	7.92	0.8	12.82	7.44	0.45	0.6	399	12.28	57.03	10.13	16.45	35.96	2.55	1.18	69.24	72.82	42.27	39.71	17.93
	Without Silt applied Land	7.36	8.84	2.16	14.62	7.24	0.24	0.2	126	12.06	184.83	12.13	4.81	46.49	2.32	1.35	60.8	56.64	51.3	29.84	18.79
Moha	Silt applied Land	5.54	9.54	0.54	12.4	7.28	0.19	0.30	210	11.84	426.69	12.25	15.65	28.51	2.7	1.27	65.57	60.1	55.81	26.9	17.9
	Without Silt applied Land	3.94	35.1	0.72	15.08	7.2	0.26	0.4	273	12.28	594.62	9.38	25.27	25	2.35	1.08	67.69	73.01	37.77	39.44	22.71
Morewadi	Silt applied Land	5.58	15.9	1.26	14	7.28	0.2	0.2	168	11.62	453.09	13.25	17.25	27.63	2.37	1.33	61.74	58.13	44.82	36.37	17.89
	Without Silt applied Land	4.58	24.86	0.7	18.26	7.29	0.24	0.2	126	12.06	463.65	11.38	17.65	30.7	2.37	1.26	62.19	58.35	51.81	30.39	17.72
Jogaiwadi	Tank	3.18	35.36	1.02	21.1	7.23	0.24	0.3	189	12.72	102.45	7.63	12.03	34.21	2.33	1.19	64.1	65.43	43.05	40.52	16.35
	Silt applied Land	3.56	10.32	5.92	19.36	7.21	0.11	0.2	126	12.5	594.62	11.25	15.24	34.21	2.38	1.22	64.63	65.6	39.14	44.38	16.39
	Without Silt applied Land	3.48	8.58	1.2	14.9	7.48	0.86	0.5	336	11.84	453.09	12.13	26.48	28.07	2.57	1.23	66.73	62.86	16.91	33.45	49.56
Sagroli	Tank	2.4	8.82	1.04	24.74	7.19	0.26	0.1	63	13.82	534.42	3.88	8.02	16.23	2.41	1.30	54.05	44.97	76.75	17.67	5.88
	Silt applied Land	7.06	10.46	0.86	16.9	7.25	0.45	0.60	420	12.50	67.59	9.62	19.26	28.95	2.47	1.21	68.06	70.03	34.01	46.86	19.05
	Without Silt applied Land	8.98	9	2.52	17.2	7.55	0.79	0.27	189	12.06	637.92	11	11.63	10.96	2.62	1.26	69.99	68.43	16.15	65.1	18.67
Khanapur	Silt applied Land	5.14	10.34	0.7	13.42	7.17	0.24	0.30	210	12.72	280.94	9.38	15.24	29.39	2.52	1.32	63.95	58.23	51.32	32.26	16.24
	Without Silt applied Land	3.88	8.64	0.96	15.94	7.55	0.18	0.45	315	12.06	713.96	10.63	28.88	37.28	2.35	1.19	68.8	78.91	26.15	53.18	20.59
Bijewadi	Tank	5.28	21.44	0.72	14.1	7.82	0.22	0.3	210	12.5	608.35	9.5	9.23	15.35	2.46	1.18	69.28	72.34	23.71	52.23	22.87

	Silt applied Land	0.26	11	1.3	17.72	7.45	0.9	0.57	399	12.28	421.4	10.75	6.02	43.42	2.71	1.32	66.44	58.48	48.24	29.82	21.85
	Without Silt applied Land	3.4	5.66	2.38	29.3	7.38	0.19	0.30	210	13.16	709.74	7.25	10.83	38.6	2.33	1.16	68.42	75.84	20.2	58.7	21.03

Annexure 3: Estimation of Silt available in the Tank

To estimate the quantum of siltation in the tank over a period of time, one must have the original design document of the tank. This document may be procured from the department which had built the tank. The original storage capacity of the tank is part of such a document. You might also assess the level survey of the storage area at the time of tank construction.

Method 1: The siltation reduces the storage capacity. The accurate way is to undertake the auto-level survey of the storage area when the tank is dry. The difference between current storage capacity and designed storage capacity gives the actual amount of silt accumulated in the tank.

Method 2: The storage area as per the design document must be marked on site so that there is no dispute. We may take at least three sample pits in the tank at specified distances and scattered, to take out silt sample for testing as well as the depth. The sample pits need to be in the silted area to find out the depth of the accumulated silt in different pits. The average of the depth measurements need to be taken. The average length and average width of the silted area is measured. We can use the following formula to calculate the amount of accumulated silt.

$$Total\ Silt\ (cum) = Average\ Length(m) \times Average\ Width(m) \times Average\ Depth(m)$$

It might happen that some part of the silt is not useful for applying to farmlands. We can calculate the quantity of silt available for farm application by measuring average length, width and depth for only that part of the silted area which is suitable for farm application.

Estimation of area of farmland

The requirement of the silt i.e. thickness of silt to be applied at a farm depends on the present depth of the soil, type of the soil, availability of irrigation facilities, farmers' plan for the crops and ability to pay for transportation. The quantity of the silt required for a farm is calculated by the following formula:

$$Quantity\ of\ Silt\ reqd\ for\ a\ farm(cum) = Farm\ area\ (ha) x\ Thickness\ of\ Silt\ applied\ (cm) x 100$$

If the farmland is already under a rainfed farming system then a silt layer of about 15-cm depth would be economical as well as sufficient to enhance crop productivity. By using the above formula, the quantity of silt required for one hectare of the farmland would be 1500 cum i.e. 530 brass. One acre of farmland will need 600 cum, i.e. 212 brass of silt, to put 15 cm layer of silt on it.

In the first step, we have estimated the suitable quality of silt available for applying on the farmland. Then the area of the farms that can be covered is calculated by the formula:

$$Farm\ Area\ that\ can\ be\ covered\ (ha) = \frac{Quantity\ of\ Silt\ Available\ from\ Tank\ (cum)}{Thickness\ of\ Silt\ to\ be\ applied\ (cm)x100}$$

If a tank has 10000 cum of the silt suitable for farm application and the farmers in the village decide to apply on an average a 15-cm layer then an area of 6.7 ha i.e. 16.6 acre can be covered with the silt. A simple ready reckoner is provided below:

Total amount of Suitable Silt Available in a Tank (cubic metre)	**Total Area of the farm that can be covered (rounded-approx.) (acre)**
5,000	8
10,000	16
20,000	32
30,000	48
40,000	64
50,000	80
60,000	96

Preparation of Farmers' List

Once the VMC/GP calculates the area that can be covered by the desiltation of the tank, a survey may be conducted to identify the farms and farmers that would need the silt application. The GP/VMC will make the list of these farmers and prioritise them based on the following criteria. The sequence of priority to be followed is given below:

1. Distance from dam: 0-500m; 500m -1 km; 1-1.5 km and more than 1.5 km.
2. Landholding pattern: Small, Marginal, Medium and Large farmers.
3. Farming system: Rainfed, Cultivable Waste Land and Irrigated.

The matrix of the priority looks as below:

Distance from dam	**A - Less than 500 m**		**B - 500 m to 1 km**	
Small & Marginal	Priority - A1	Priority - A2	Priority - B1	Priority - B2
Medium & Large	Priority - A3	Priority - A4	Priority - B3	Priority - B4
Farming System	*Rainfed & Cultivable Waste Land*	*Irrigated Farms*	*Rainfed & Cultivable Waste Land*	*Irrigated Farms*

Distance from dam	**C - 1 km to 1.5 km**		**D - More than 1.5 km**	
Small & Marginal	Priority - C1	Priority - C2	Priority - D1	Priority - D2
Medium & Large	Priority - C3	Priority - C4	Priority - D3	Priority - D4

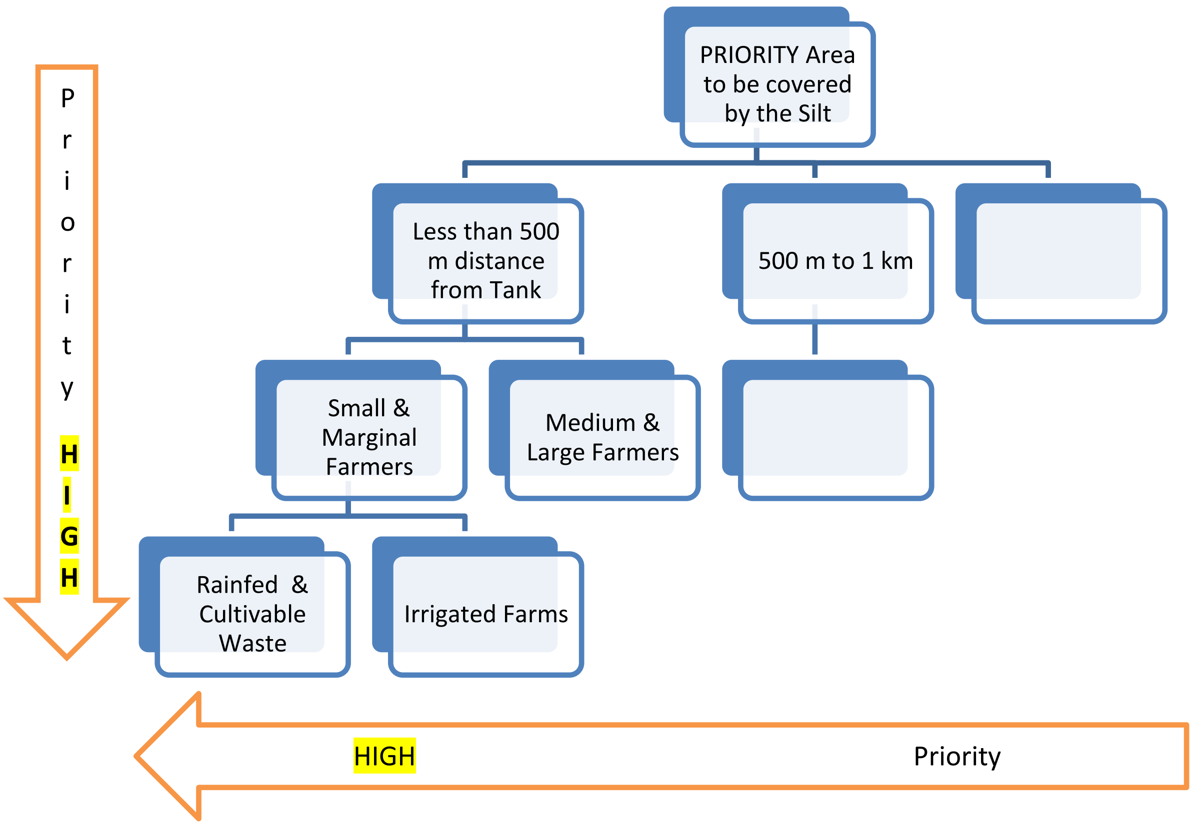
Farming System	*Rainfed & Cultivable Waste*	*Irrigated Farms*	*Rainfed & Cultivable Waste Land*	*Irrigated Farms*

First Priority - A	**Second Priority - B**	**Third Priority – C**	**Fourth Priority - D**

Illustration: Highest priority is given to the small and marginal farmers having rainfed/cultivable waste land situated at a distance less than 500 m from the tank to be desilted. They will fall in Box A1 in above matrix. Thus the names of these farmers will be placed on top of the list. The farmers falling in Box A2, A3 and A4 follow them respectively. The sequence continues as B1, B2, B3, B4, C1, C2, C3, C4, D1, D2, D3 and finally D4.

The GP/VMC must call a meeting of farmers as per the priority list and brief them on the desilting project. The farmers would then give their consent or refusal in writing to the GP/VMC to participate in the project.

The prioritisation system can also be depicted in a diagram as given below.



Annexure 4: Proposed format for maintaining beneficiary list of silt-taking farmers

Name of Beneficiary: ____

Total Household Number:

9	9

Total Income: ______________Rupees/Annual

Card Holding: *BPL/Antyodaya/APL/White/Annapurna*

Caste: __________________

Gender: Male/Female

Aadhaar Card Number:

1	2	3	4	5	6	7	8	9	0

Mobile Number:

1	2	3	4	5	6	7	8	9	0

Total land holding: __________Acre_________Guntha

Silt application on land: ________ Acre ________Guntha Gut Number of Silt applied Land: _________

Soil & water conservation measures in silt-applied Land:_________________

Numbers of trips made:

9	9	9	9

Bullock cart/trolleys/tipper/*hiwa*______(mention)

Total cost of silt-application: _________________Rupees

Loan taken for the silt application: *Yes/No* From where have you taken loan: - ______________

Irrigation facility on silt-applied land*: Furrow Irrigation/Drip Irrigation/Sprinkler Irrigation*

Water-saving technology in area: _________ Area _________Guntha

Borewell/ Well affected by the tank: Bore well___/ Well____