


Water to Economy

A regional footprint analysis of Sadguru's work in Dahod, Gujarat

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Preface by Tushaar Shah

INREM Foundation
Anand, Gujarat

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Preface

In the late 1980s, Robert Chambers and I visited scores of development initiatives around India to understand what works best for improving the livelihoods of poor people. Sadguru Foundation in Dahod was one of those NGOs with which we spent quite sometime especially because all of Sadguru's work targeted poor Adivasi communities. The book that we co-authored in 1987, *"To the hands of the poor: Water and trees"* (Chambers, Saxena and Shah 1987) was deeply influenced by our Sadguru experience. It put into bold relief how community-based management of common property natural resources can improve livelihoods of the poor through sustainable intensification of hitherto rainfed agro-ecosystems.

The present study which documents the economic impact of Sadguru Foundation's work in Dahod district validates the hypothesis we advanced over 25 years ago. The Dahod district, where Sadguru Foundation began its work first, has been a prime beneficiary of the Foundation's labours. And this study shows that the results have been amazing. In several small river basins, the Foundation has created distributed storages, in the form of check dams, to capture and hold over 20 million cubic meters of flood water from monsoon. Scores of lift irrigation systems established on these checkdams directly irrigate some 6500 ha; in addition, some 4000-5000 ha downstream get benefited through well irrigation from groundwater recharge. Because of these efforts, Dahod has emerged to be by far the best irrigated district of Gujarat, even better than districts like Anand and Surat in the core command areas of large irrigation systems. Sadguru Foundation has not stopped at just providing means of irrigation; it has also pursued an 'irrigation++ strategy' by helping Adivasi farmers to move up the agricultural value chain by growing high value crops such as flowers, fruit and vegetables.

Arguably, as striking as the impact on agriculture has been the impact of Sadguru's work on the forest economy. The study estimates that the current value of trees that Sadguru helped to plant years ago is well over ₹ 14,000 crore. Annuity of these assets at a 8% discount rate

would make Sadguru's impact on Dahod's forest economy as significant as its impact on irrigated agriculture!

Many in the development community bemoan the fact that, in many areas, single-minded focus on irrigation has resulted in serious loss of other eco-system services, often leaving the communities worse-off in overall terms. Sadguru's work stands out as an example of agricultural intensification that is sustainable and mindful of enhancing eco-system resilience.

It is a pleasure for me to welcome this study as a fitting tribute to the lifetime's work of Sharmishtha and Harnath Jagawat who devoted some 40 years of their lives to creating this outstanding model of development. To them, and their colleagues, also goes the credit for building and nurturing a remarkable institution that has opened up opportunities for scores of young development practitioners to become partners in this endeavour. It is an honour for me to have been associated with them. I compliment INREM Foundation for undertaking this timely and much-needed assessment.

Tushaar Shah
December 2014

Executive Summary

Dahod district of Gujarat is mainly a tribal area, at the western edge of central tribal India, hilly and located on eastern part of the state. Mainly it is a place where farmers have always taken a single rainfed crop. Today, we see that the Gross irrigated area / Net irrigated area (GIA/NIA) ratio of Dahod is 1.96, which is far more than any other district of Gujarat. The magnitude of this ratio is clear when we see that the second highest GIA/NIA in Gujarat is that of Kheda district with 1.46, and then Anand with 1.43 and so on, until districts such as The Dangs with GIA/NIA equal to 1.0. How has this happened?

Now when we look at a satellite generated map of cropping intensity in Dahod, we see that most of the irrigated areas are close to the small rivers which finally flow into the Mahi River. When we overlay the locations of check dams in this district, we see that most of the high CI (Cropping Intensity) areas are the command areas of the LI (Lift Irrigation) systems which access irrigation water from these check dams and the 5-10 km stretch close to these command areas.

Now, when we look at the five small river basins within Dahod district, we see intense rain water harvesting in these river basins contributed by the work of Sadguru foundation over the past four to five decades of work. Totally put together a capacity of 403 Mcft (11.42 MCM) has been generated in Dahod district with these check dams and our estimate for year 2011-12 is that a total volume of more than 1100 Mcft has been stored in these dams by virtue of filling several times during the monsoon and also being able to store water which is flowing off from the upstream locations. Also, the benefit of this LI based irrigation is being transmitted within the command areas and also outside of them through groundwater based irrigation by wells upto distances of 5-10 kms as observed through the Cropping Intensity map of Dahod district i.e. twice the distance beyond the LI command areas. By virtue of this groundwater based benefit, apart from 6479 Ha having direct irrigation benefit from the LI schemes, a total of around 4000-5000 Ha of additional agricultural land gets benefitted in the district indirectly through groundwater recharge. This increases the equity of farmers' access to river water even if field locations are farther away.

Apart from Dahod district, looking at Sadguru interventions as a whole in the remote tribal areas of three states – Gujarat, MP and Rajasthan, we see a total of 356 check dams with a total storage of 2011.7 Mcft, i.e. more than the size of a medium scale irrigation reservoir, but spreading the benefits in a distributed manner to tribal farmers irrigating 55,236 acres (22348 Ha) of agricultural land.

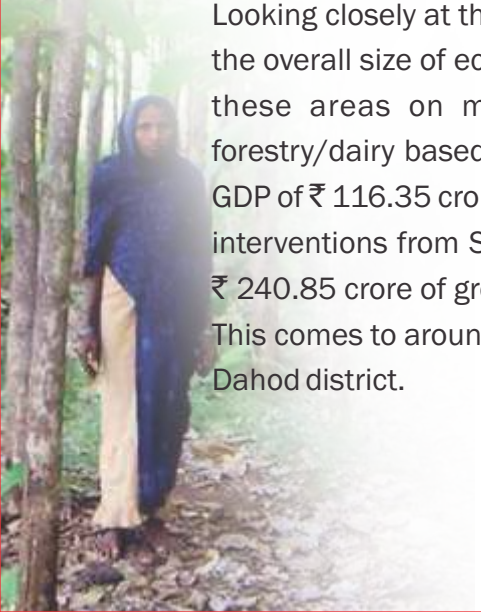
Then we further see that in Dahod district, the LI systems numbering a total of 125 have utilized up to 27.68 MCM of irrigation water from these check dams. This amounts to 277 mm irrigation water per unit area, which facilitates a highly intense cropping system practiced in these command areas. This total water usage also amounts to around 1.59 times the total check dams' water storage in the district which means that recycling and refilling of water helps in more water storage in the check dams.

The above situation explains the high GIA/NIA ratio of Dahod district, keeping in mind that the rest of the district would have GIA/NIA close to 1.0 such as prevalent in other tribal districts, the actually GIA/NIA of these command areas would be even more than 2.0.

Analysis of cropping data from these LI command areas and other such areas with interventions show a wide diversification of cropping systems. We see that a mix of cereal crops (irrigated and hybrid), non food commercial crops (cotton, oilseeds, etc), horticulture, vegetables, floriculture, agroforestry and other sectors such as Dairy based livelihoods have occupied these villages which are either on or close to these command areas.

When we look at Dahod district as a whole, we see an economy which is mainly driven by the traditional cereal based cultivation. But due to this diversification over the past decade or so, these has been a growth in the economy and newer commodities such as rose and mango and trellis based vegetables have now started being produced from this district. All these have now contributed to an agricultural economy that is diverse and growing with contributions from a variety of sub sectors. Consequently, the overall agricultural value GDP of Dahod district is now estimated to be close to ₹ 2047 crore and net agriculture GDP is ₹ 1568 crore. The question is what are these new interventions and diversifications contributing to this agricultural economy.

Looking closely at the areas of intensive cultivation and agricultural activities, we estimate the overall size of economy of these locations. We are able to observe a greater reliance in these areas on more irrigated/hybrid/non-food-cash-crops/horti/flori/vege/agro-forestry/dairy based livelihood which are together now amounting to an Agriculture value GDP of ₹ 116.35 crore and net agriculture GDP of size ₹ 79.47 crore annually contributed by interventions from Sadguru foundation and a possible multiplier effect of 2.07 leading to ₹ 240.85 crore of gross GDP impact ₹ 164.5 crore of net GDP impact to the local economy. This comes to around 5.68% and 5.07% respectively of the total gross and net agro GDP of Dahod district.



Above this, we estimate the natural asset base from agro forestry interventions of Sadguru as ₹ 14,637 crore, which if sustainably harvested annually at 8% rate could provide an annual economy contribution (annual annuity) of ₹ 1171 crore. This contribution would be much greater than the agro economy contribution, and this fact needs to be studied in further detail. The foundation of this economy and contribution to the economic growth of Dahod district is definitely water for irrigation. The entire asset base of water based systems starting from check dams to LI systems are the basic foundation on which this entire economy rests. We estimate a replacement cost of more than ₹ 72 crore for this asset base (check dams only) and an inflation adjusted, depreciation based size of asset base of ₹ 32 crore. Along with this the groundwater based irrigation is furthering the capacity of these LI irrigation systems by acting as a buffer and supplemental value, along with extending the benefits to a wider area, much beyond the LI command area. The replacement cost for the LI system in Dahod comes to ₹ 70.8 crore. This gives a total current replacement cost of check dams and LI systems in Dahod district as ₹ 142.8 crore.

These along with the people's institutions of LI cooperatives, federations, market based linkages, capacity building, and other interventions such as for better seeds and other inputs are together holding this new economy.

The system of agricultural growth and intensification we see in Dahod district of Gujarat is unique. This is because of a unique local atmosphere seeded by the community based institutions promoted by the Sadguru Foundation who have partnered with the various government and formal institutions such as Panchayats, tribal development depts., agri-extensions, agri- universities, agri-companies, research institutions, dairy cooperatives and institutions, to create this overall environment that has now furthered this economy.

Such an environment also holds hope for many other 'Dahods' of Gujarat and more importantly in other such districts of India.

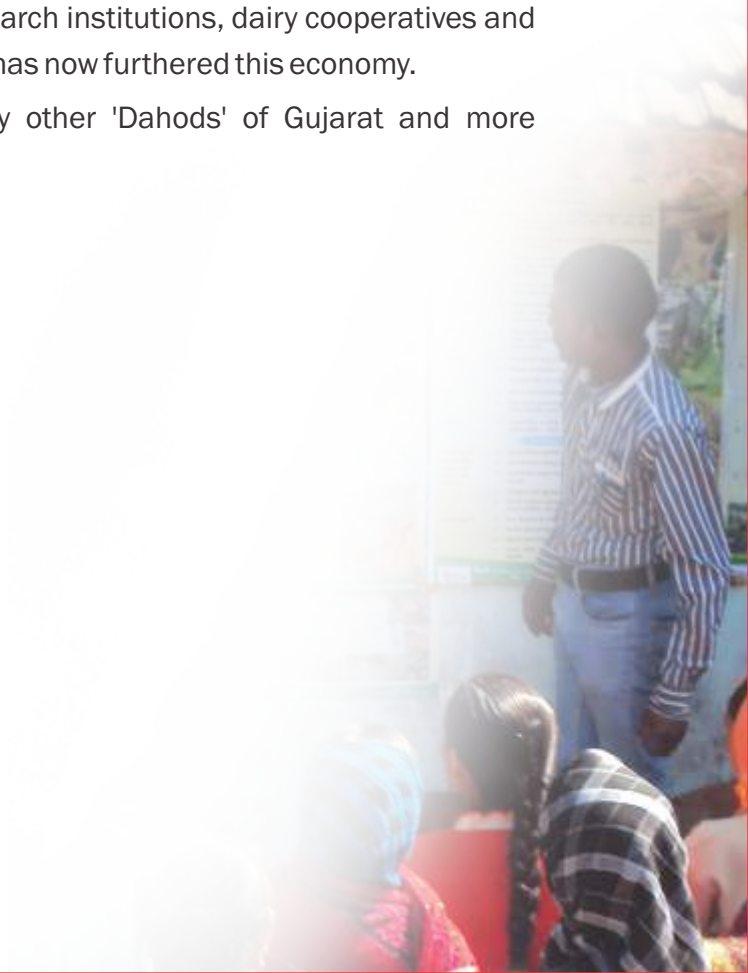
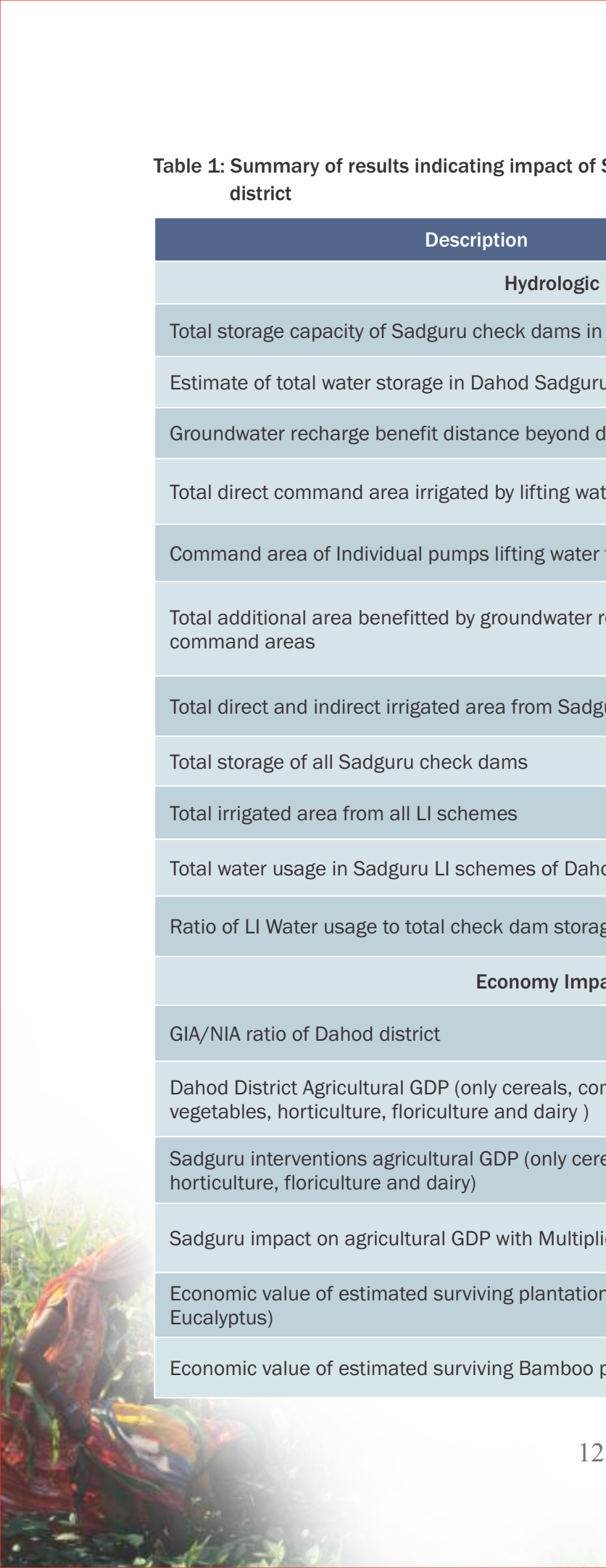


Table 1: Summary of results indicating impact of Sadguru Foundation interventions in Dahod district

Description	Result
Hydrologic Benefits	
Total storage capacity of Sadguru check dams in Dahod district	544.5 Mcft
Estimate of total water storage in Dahod Sadguru check dams	1100 Mcft in 2011-12
Groundwater recharge benefit distance beyond direct command area	5-10 kms
Total direct command area irrigated by lifting water from check dams	6579 Ha
Command area of Individual pumps lifting water from check dams	3975 Ha
Total additional area benefitted by groundwater recharge from LI command areas	8161 Ha
Total direct and indirect irrigated area from Sadguru check dams	18715 Ha
Total storage of all Sadguru check dams	2011.75 Mcft
Total irrigated area from all LI schemes	22348 Ha
Total water usage in Sadguru LI schemes of Dahod district	27.68 MCM
Ratio of LI Water usage to total check dam storage in Dahod	1.79
Economy Impacts Benefits	
GIA/NIA ratio of Dahod district	1.96
Dahod District Agricultural GDP (only cereals, commercial crops, vegetables, horticulture, floriculture and dairy)	₹ 2036.8 crore (gross), ₹ 1568 crore (net)
Sadguru interventions agricultural GDP (only cereals, vegetables, horticulture, floriculture and dairy)	₹ 116.35 crore (gross), ₹ 79.47 crore (net)
Sadguru impact on agricultural GDP with Multiplier effect of 2.07	₹ 240.85 crore (gross), ₹ 164.5 crore (net)
Economic value of estimated surviving plantation (Teak and Eucalyptus)	₹ 13,727 crore
Economic value of estimated surviving Bamboo plants	₹ 910 crore



Description	Result
Total estimate natural asset base	₹ 14637 crore
Potential benefit to economy at 8% annual harvesting	₹ 1127 crore
Per cent share of agricultural GDP by Sadguru in Dahod District	5.68% (gross), 5.07 (net)
Replacement Costs	
Inflation and Depreciation adjusted cost of check dams in Dahod district from Sadguru's work	₹ 31.98 crore
Estimated Price/Mcft for Replacement	₹ 13.32 lakhs /Mcft
Replacement cost of Check dams asset base in Dahod district from Sadguru's work with unit cost/storage analysis	₹ 72 crore
Replacement cost for Sadguru Lift Irrigation Infrastructure in Dahod district	₹ 70.8 crore
Total replacement cost of Sadguru check dams and LI schemes in Dahod district	₹ 142.8 crore

Background

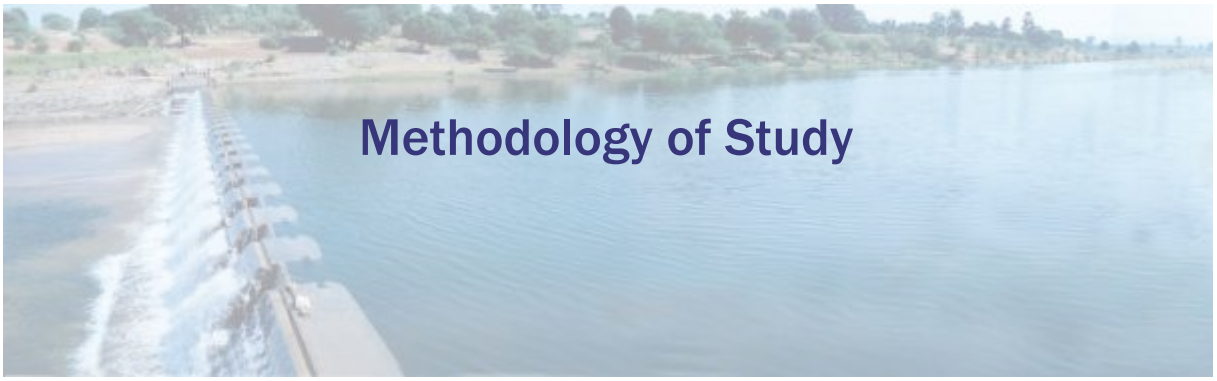
This study looks at the linkages between hydrologic changes to river basins in Dahod Gujarat leading to several decades of sustainable socio-economic development. These changes have also been sustained by the action of local institutions developed by Sadguru foundation. Together, they go from strength to strength and now place the region at the cusp of greater progress.

The NM Sadguru Foundation was established in Dahod, Gujarat in 1974. Sadguru's work has aimed at improving the lives of tribal people by making better use of available natural resources, suatain these resources and break away from the viscous cycle of extreme poverty. It is one of the pioneering organizations in India that have shown the way out of poverty through better management of water resources by improving the quality of watersheds, having community managed lift irrigation systems that are highly equitable and founded upon excellent engineering design of local check dam structures. Also quite unique about Sadguru's work is that instead of fighting along a lonely path, this organization has been able to take along with government significantly in its work thereby making better use of government funds and schemes. Here we aim to explore the impact that these four decades of work has brought upon to the people of Dahod and the agricultural economy which has benefited from it.

At the very root of Sadguru foundation's work in Dahod, Gujarat is – Water. Starting from lift irrigation and large sized checkdams, the work of Sadguru has now expanded to reap the benefits of these basic activities of resource conservation, storage and equitable distribution.

Most of the work of Sadguru lies at the marginal areas of three states – Gujarat, Rajasthan and Madhya Pradesh, comprising the most impoverished areas of these states. These border areas where Sadguru mainly work lie primarily within the Mahi river basin, but Sadguru also works in areas which lie within the Chambal river basin too.

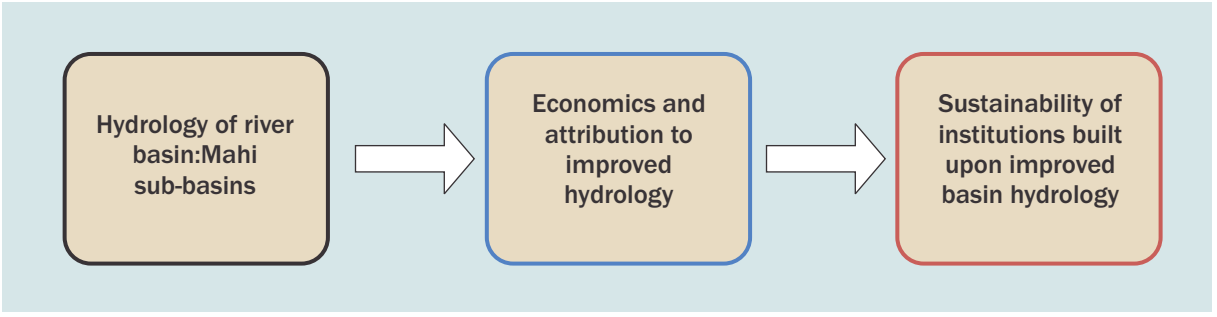
Since the scope of Sadguru's work is massive – right from the size of check dams, number of lift irrigation cooperatives, and now, activities such as horticulture and market linkages – the overall impact on regional hydrology as well on the economy is a significant one. Though the work of Sadguru has been documented well over the years through numerous studies, the element of cumulative regional impact on hydrology of rivers and aquifers has not received much attention. Capturing this larger picture can then help us to connect the dots and link as a chain, from a drop of water, right up to an increase in regional GDP.



Methodology of Study

The study is summing up the overall impacts of Sadguru work in terms of water as well as agricultural economy. For this, two main directions of work i.e. understanding the overall water storage related to Sadguru interventions and how these have contributed agriculture based economy have been undertaken.

Figure 1: Linking hydrology with improved economy and institutional sustain ability



1.1 Methodology: Hydrology of River Basin: Mahi Sub-basins

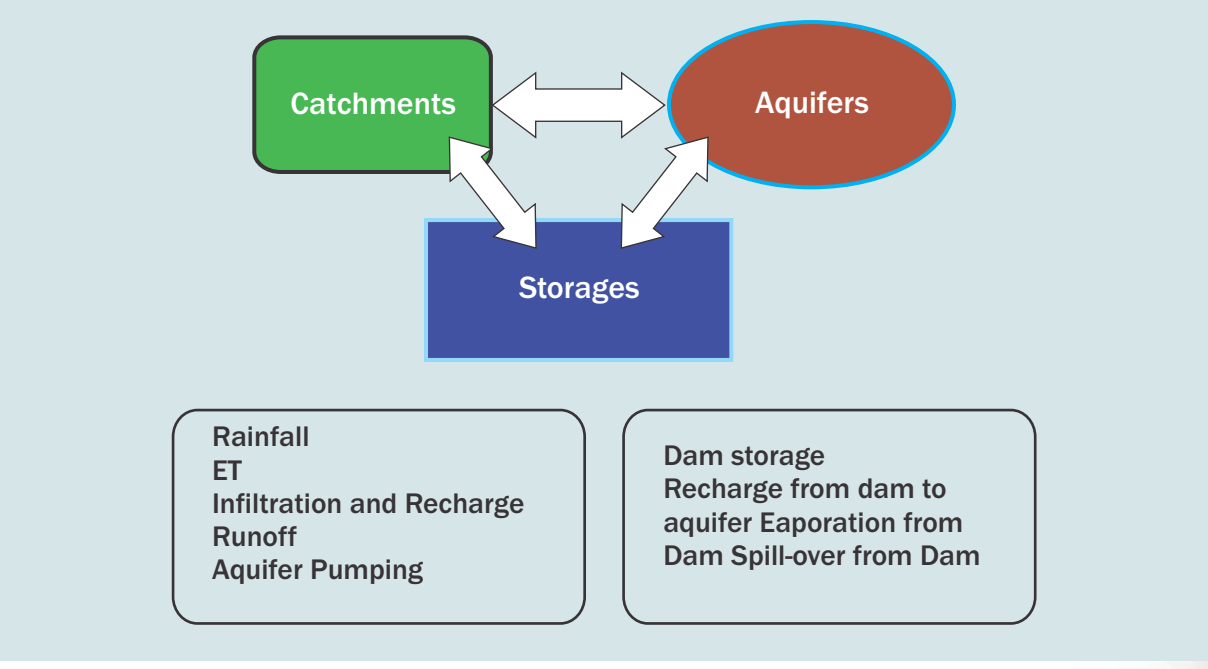
First, information on dam storages, and lift irrigation have been collected and summarized.

The Figure 2 shows the concept diagram of the Hydrologic model used here, referred to as RiverBasinSim (Verma and Krishnan 2012). Three main entities are explicitly represented here i.e. the catchments, the aquifers and the storages. Rainfall drives the entire process over catchments. This is distributed for every time step into ET loss, runoff and infiltration. The infiltration develops as aquifer recharge if the aquifer has storage less than its capacity. The runoff flows into storage. Within the storage, for every time step, there is evaporation, infiltration into aquifer (again developing as recharge if aquifer storage is less than capacity) and when the storage is beyond capacity, it flows downstream into other storages. The aquifers have pumping specified for every time step, if there is sufficient storage in the aquifer.

Over this model can be used for:

1. Basin level simulation of stream flows with daily water balance of catchment, aquifers and storages
2. The behaviour of check dam storages in terms of evaporation, infiltration and overflows
3. Recharge into aquifer and impact of pumping
4. Looking at optimal level of storages in the basin in terms of upstream-downstream tradeoffs
5. Predicting longer term behavior of the basin due to climatic changes and land use or water interventions
6. The Basin Hydrology Model, River Basin Sim, described here has been developed in the Matlab simulation package. Developed as a single code with subroutines for recharge, runoff, etc., it is available for further development for academic and research purposes. The model can be modified for further refinement as including rainfall-runoff, hydrographs, utilizing stage-discharge relationships, internal calibration with runoff data, etc.

Figure 2: The conceptual picture of river basin hydrologic model



1.2 Methodology: Attributing Socio-economic growth to Improved River Basin Hydrology

The hydrological improvement achieved in Dahod district has contributed to socioeconomic development of tribal communities of the area. How much of this socioeconomic development can be attributed to this improved hydrology?

Attribution is always a difficult task since it involves causality which is theoretically tough to establish. However, we will go by the route of establishing alternative means of attribution which are relatively independent. Together, they give us a combined picture of attribution of hydrologic benefits.

Here we have taken Agriculture GDP as a measure to compare and calculate impact. The objective is to look at the overall Agriculture GDP of Dahod district and determine what contribution is provided by Sadguru's water based interventions to this overall GDP of the district.

We have used a ready reckoner from the Directorate of Economics and Statistics, Gujarat, Sector – 18, Gandhinagar (Ref: Guidelines to compute agricultural GDP in *Gujarati*).

We tried to compute only the GDP of agriculture sector of Dahod district that is confining our analysis within the boundary of agriculture products. It is the total money-value of agricultural products during the period of one year calculated without duplication as far as possible. This is known as the 'value of production' of the sector that is “production approach”. The procedure:

- Quantity of goods produced (x) Price of goods = Value of goods
- Value of goods (-) cost of production = Domestic output of goods
  For example, total cotton production in a district (x) price at farm level = total value of cotton
- Value of cotton (-) cotton production cost = domestic product generated through cotton
  Like this, value of all products of agricultural sector is calculated to get the value of gross domestic products in agriculture
- In general this procedure is followed for estimating GDP in agriculture known as 'production' method[1]. “The 'production' approach to estimating GDP looks at the contribution of each economic unit by estimating the value of an output (goods or services) less the value of inputs used in that output's production process.” [2]

Computing GDP (Gross Domestic Products) is a very complex task. There is no such straight cut and comprehensive method available for computing GDP. The GDP is a good indicator for understanding the overall 'growth' of development of an economy. This tool was introduced

[1]Ref: District Income Estimate – GoG, Box 1, p 6 – *in Gujarati.*

[2]Ref: http://www.ons.gov.uk/ons/guide-method/method-quality/specific/economy/national-accounts/gva/relationship -gva-and-gdp / gross-value-added-and-gross-domestic-product.html - accessed on 27 March 2014.

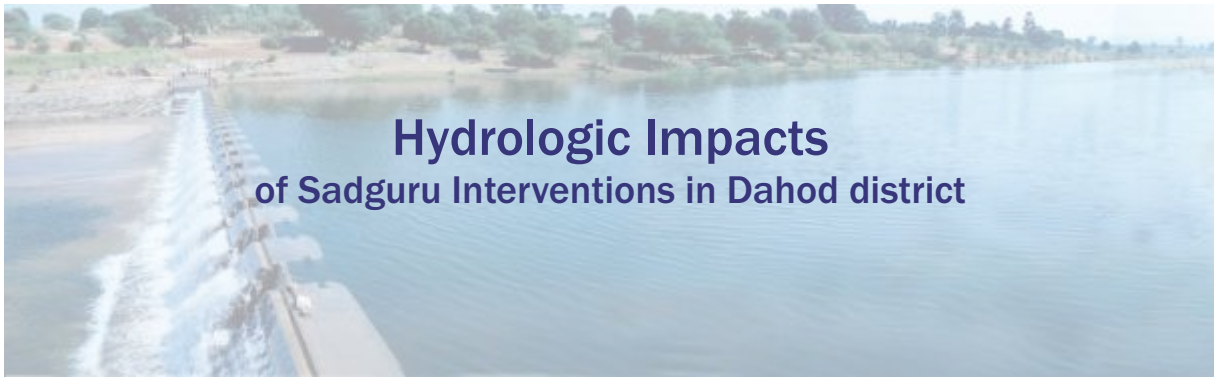
and explained by economist Simon Kuznets in 1930s. It is a *"de facto"* measure of national progress. But it has its own limitations to explain many aspects of development. It has two basic limitations, one, in its process of computation, it excludes some important economic activities – eg., measuring volunteer work, and depletion of natural resources etc.; and two, the way it is used and interpreted[3].

- We tried a simple way of calculating it for "agricultural products only" considering that 'water that has been harvested' is mainly used for agriculture. This we have computed for one year mainly 2011-12 and for some items for 2012-13 or 2014. This includes cereals, pulses, vegetables, fruits (mainly mango) and flowers (mainly rose, marigold, and chrysanthemum) and income from dairy. The agro-forestry is an asset for a geographical location. It generally comprises of perennial trees, so it is better not to include in computing "agri-GDP" for one year income. Here in Dahod as agro-forestry we found eucalyptus, teak trees and bamboo plants in general. Agro-forestry has its special values in the society for its capacity of huge bio-mass. Its cost of cultivation and income should be analyzed in a different way since it is a long term investment and intermittent income in an economy. Agro-forestry is more of an asset than a regular source of income like in crops.
- We focussed only on Dahod district's agriculture GDP – we have shown both for gross agri-value GDP and net agri-GDP [product value (-) cost]. This may reflect the major change that has taken place due to the huge water brought into use by engineering technology of check dams and later using Lift irrigation. Further the lift irrigation has been managed so well and efficiently by evolving co-operative system among the community. We have shown gross value and net value of agri-GDP.
- There is also pump-irrigation from the wells of those whose water table has been improved and also from the check dams. So the area covered and production of those pump-irrigated areas has also been taken.
- Sadguru foundation imparts different kinds of training for enhancing the beneficiaries' knowledge and expertise. They also help their beneficiary farmers for selling their products in the market. Thus a total development in agriculture has happened to the beneficiaries. This engineering and technological innovation of check dam has developed a "spiraling" impact in the total economy. Many a time, a technological change has brought multi-fold changes in a society as we have seen in North Gujarat when they introduced "water-saving technology" of drip and sprinkler, in early 2001 (Indu, Borkar and Dave, April 2008). However there are non-beneficiary farmers in Dahod. Their income from agriculture is included in total Dahod district's agriculture production. So for

[3]Ref: http://post2015.org/2014/01/04/its-eighty-years-since-gdp-was-first-developed-time-for-a-different-measure-of-national-success/ - accessed on 17 March 2014]

getting non-beneficiaries' agri-income one has to deduct the Sadguru's agri-GDP from the total Dahod's agri-GDP. Similarly, this way one can see the Sadguru's contribution in agriculture development and development in total economy.

- We have not done 'before-and-after' or 'with-or-without' analysis in this study, and we also have not done any micro level study. We simply wanted to look into the massive work done by Sadguru and its contribution in the agriculture development through its GDP in Dahod district during a year out of their more than 40 years of intervention, using a simple way by computing GDP values. Also wanted to understand the 'ripple', 'multiplier' or 'spillover' effect of agri-development took place during the last three years mentioned above.



Hydrologic Impacts
of Sadguru Interventions in Dahod district

The primary mechanism of water harvesting in Sadguru interventions is through check dams from where water both recharges into the neighbouring aquifers and is also lifted for irrigation through Lift Irrigation (LI) schemes. When we look at the scale of water storage in Dahod district, the cumulative contribution of Sadguru check dams are quite significant.

Inset 1

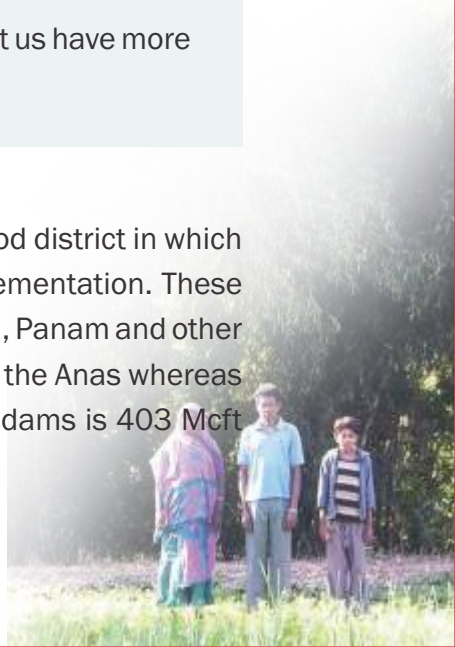
A river coming to life

The Khan river as any in this part of western to central India would have gone completely dry within two or three months of the monsoon, i.e. by December or January. It is rare even in high rainfall years to find water in these rivers. But seeing is believing! This photograph taken in June of 2013 just before the monsoon which arrived later that year is an affirmation of what we see predicted by the hydrologic model of Khan river basin.

If rivers can survive, they bring with them a whole ecosystem to life! Let us have more such river basins across India.

Check dams and LI schemes of Dahod district

A total of 152 check dams are reported to have been constructed in Dahod district in which Sadguru foundation has had some participation in the design and implementation. These dams are across the Kali (I and II), Khan, Macchan, Hadaf, Kharad, Khobdi, Panam and other rivers and rivulets. All of these except the Hadaf and the Panam flow into the Anas whereas the former flow into the Panam River. The total capacity of these check dams is 403 Mcft



(11.42 MCM) with an average of 2.65 Mcft of storage. As compared with this, the total storage of a single medium scale reservoir in Dahod district – Pata Dungri – is 1449.1 Mcft i.e. around 3.5 times this distributed storage. The benefit with these smaller check dams is that they distribute the storage widely across the district and also, as shown here, take advantage of the storages contributed by the larger dams.

The Lift irrigation schemes operated by Sadguru in Dahod number 125 totally. These schemes together have a total irrigation design command of 18,996 acres in the year 2011-12 and have achieved a total of 16015 acres of irrigation i.e. 84% of the total capacity.

The average rate of irrigation is ₹ 59.3 / hour or ₹ 432 per acre of irrigation. One way of estimating the total water used by the LI schemes for irrigation is by looking at the area under irrigation for different crops. Assuming 425 mm, 3000 mm, and 500mm of irrigation respectively for wheat, gram and maize, and average of 408 mm for other crops, we get a total of 27.68 MCM as the total irrigation water usage from LI in Dahod district.

Inset 2

A symbiosis of large and small dams

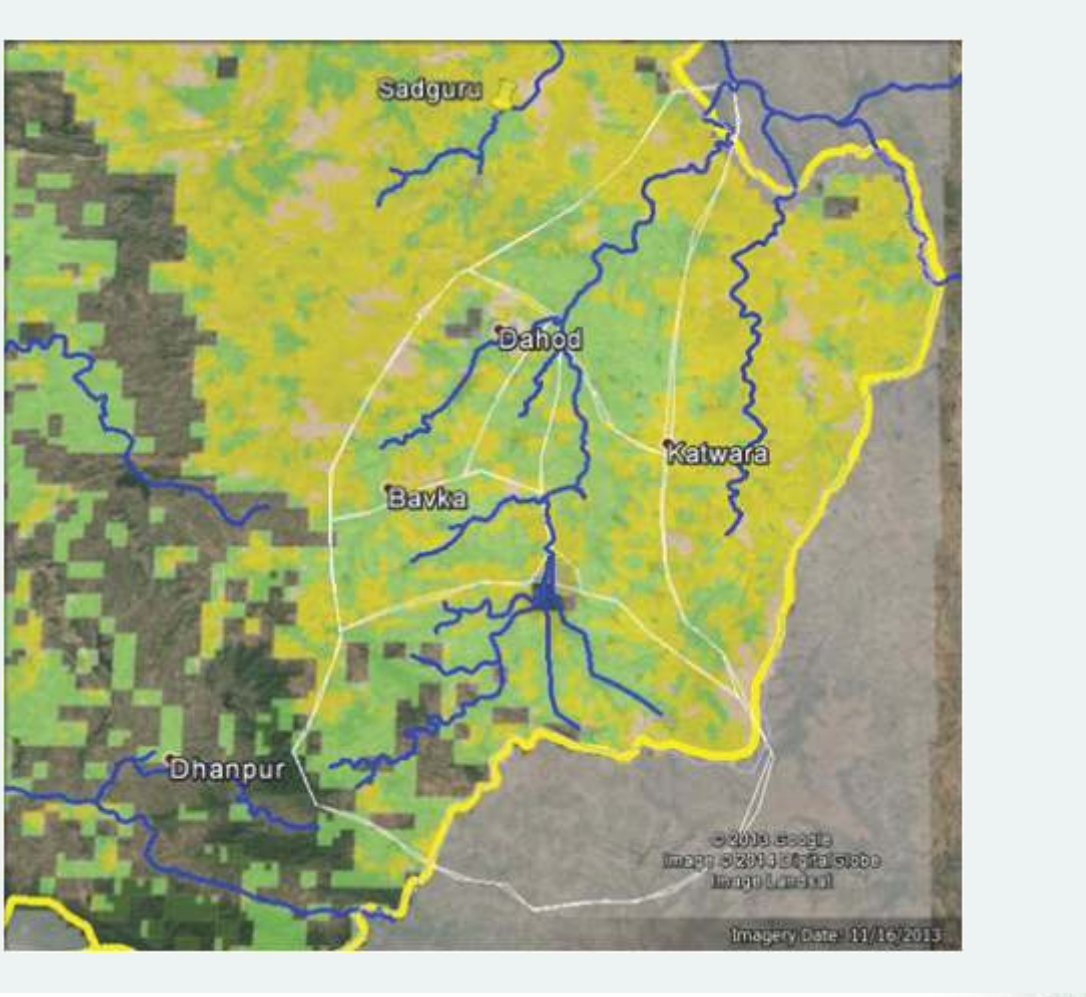
The debate of large vs small dams seems frivolous when we see the situation of Dahod. In India and worldwide, this question keeps arising as to which is of more value: large or small. The Dahod river basin hydrology would convince anyone about capturing the right opportunities and bringing in people's participation to get the benefit of large dams through smaller dams.

The Pata Dungri dam (photo here) and other dams in Dahod district such as the Kali dam and Macchan dam all have smaller dams downstream which capture the baseflows and subsurface flows from the larger dam throughout the year. The smaller dams also capture return flows from irrigation, thereby creating a symbiotic system between the larger and smaller dams. In terms of efficiency, and buffering against climatic extremes, this system is much better than reliance on any one option. Sadguru's work in Dahod shows that this combination is possible and we should try to achieve it where possible.

Comparing this 27.68 MCM total water usage from LI with the total check dam storage of 11.42 MCM, we have an average of 1.57 times water usage as compared with check dam storage volume. We will have a better description of this in with a more detailed analysis of the Khan river basin. The Khan river basin is reflective of typically most other river basins in Dahod district, with combination of larger government constructed medium scale reservoirs and the series of check dams constructed using Sadguru's work. Understanding of this river basin provides us insight into the functioning of river basin hydrology and thereby benefits contributed by these interventions.

The attempt here is to capture overall interconnections between dams, aquifer and water users.

Figure 3: Hydrologic model of Khan river basin



Khan river basin boundaries, streams, and cropping intensity map

This is an attempt to model the Hydrology of the Khan river sub-basin which flows into the Anas, and then into Mahi river. The Khan river basin is located in Dahod, Gujarat and Jhabua, MP (Figure 3). It has a highest elevation of around 1300 ft above MSL and flows into Anas at around 900 ft above MSL with the main flow of river about 40-42 kms in length. This is an

important river for Dahod since the city is located inside this river basin and the main reservoir supplying water to the city is the Thakkar Bapa Reservoir, also known as Pata Dungri is located in the Khan river basin.

Both upstream and downstream to the Pata Dungri dam, there is intensive activity of small to medium size dam storage with check dams (Figure 4). There is lifting of water straight from the dams and used through lift irrigation (LI) cooperatives promoted by Sadguru foundation.

Also, a small canal command area lies downstream of the Pata Dungri dam. Interesting fact is that water seepage from the dams flows onto the river flow and the water drainage out of Dahod city also connects back to the river before it joins the Anas.

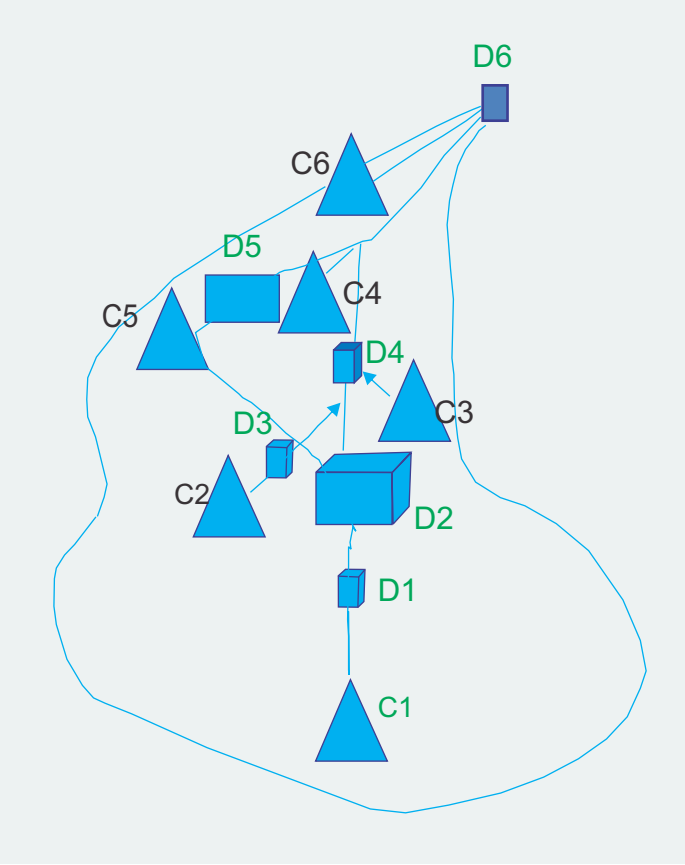
As a result there is intensive recycling of water within the Khan river basin. This recycling of water also acts like a system which is benefitting farmers through the check dams and LI cooperatives. If not for these dams, this water would have flown by to the Anas and then downstream.

The cropping intensity (CI) map (a 1 sq km scale) of the river basin shows intensive agriculture (CI : 2-2.5) close to the river , where check dams are located. As one extends farther from these areas, the CI drops to 1.5 to 2, which is also on the higher side, thereby meaning that there is a groundwater based irrigation system being practiced in this zone (Figure 7).

The overall river basin area is roughly 620 sq kms. Out of this, the Pata Dungri catchment is 276 sq kms in area, final Anas sub basin 116 sq kms, Bavka sub-basin 59.25 sq kms, Devdha sub-basin 64.59 sq kms, Kharaj sub-basin 22.34 sq kms, Dahod sub-basin 74.67 sq kms.

Figure 4: Satellite map of Khan river basin, Dahod

Figure 5: Conceptual picture of Khan river basin model



Conceptual Model for Khan River sub basin

With this, we build a conceptual picture model of the Khan river basin (Figure 5). The triangles above represent catchments and cubes represent storages. The single square is Dahod city. The linkages represent the various natural and manmade flows from catchments to storages and habitations.

The river basin model constructed using this conceptual picture was run using rainfall data available in the river basin, for both daily rainfall (1996 till 2012) and annual rainfall (1950s till now) to build a 15 year rainfall model for daily rainfall for the river basin (Figure 6). A six catchment model was used and results generated for storages, groundwater recharge, baseflows, aquifer deficit and other hydrologic parameters.

What we see very interestingly is the interaction between the large and small dams in this river basin (Figure 10). For small dams which either lie upstream of the large dam or in other catchments, there is certainly no influence of the large dam. But for other check dams which lie downstream below this larger dam, we see the influence of subsurface flows which result in check dams being substantially full throughout the year and consequently, the related aquifers having lesser deficits in the leaner seasons (Figure 11). This is also reflected by observations in the basin, showing the combination of larger and smaller check dams to be highly effective in providing a buffer to hydrologic fluctuations.

Rainfall data, as in many other places of India, is available in different forms. Especially, since a dedicated measurement of daily rainfall is being performed by Sadguru foundation since 1996, it was possible to obtain 16 years of daily rainfall records. Also along with this, government records from the dam in Khan river basin maintain annual rainfall for the past 60-70 years. Both of these rainfall records have been used here to produce an assimilated rainfall record. The benefit of this generated rainfall record is that we can generate

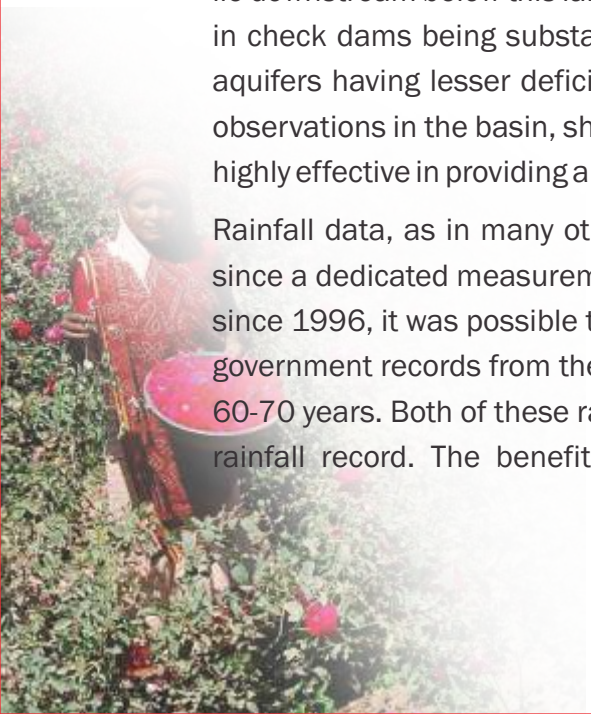
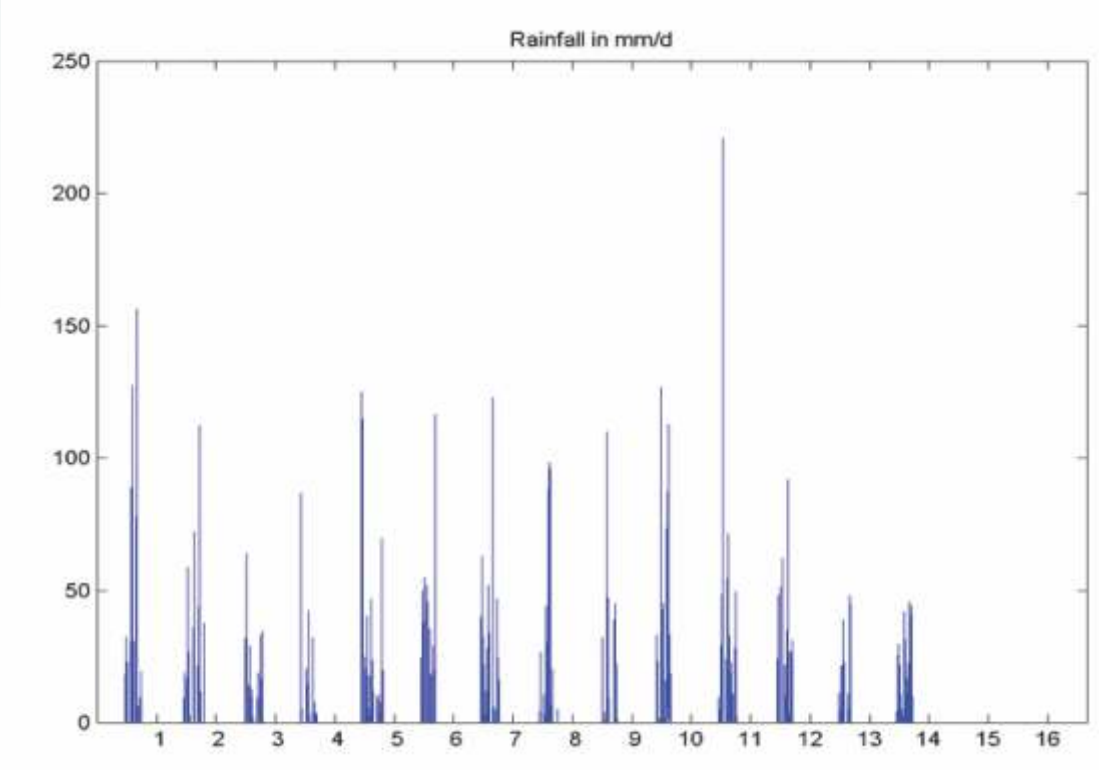


Figure 6: Generated Rainfall model over 14 years



representative rainfall distribution that reproduces the behavior of both data sets – yearly rainfall and daily rainfall record (Figure 6).

The agricultural intensity of the catchment areas in Dahod was determined using satellite-based information (Figure 7, 8). Forested areas and water bodies were first removed from the images using a classified map of Gujarat. Seasonal cropped areas were then calculated using peak season NDVI images i.e. monsoon- 29 Sept., rabi- 2 Feb. and summer- 23 April when the vegetative stage of crops is at its maximum value. These were from the MODIS sensor with resolution of 250 m x 250 m. NDVI values for agricultural sample sites were used to apply a threshold on the images to assign a value of 1 (cropped) or else 0 (non-crop) on each of these three peak season dates. For example, pixel is cropped in monsoon and assigned a value 1 if NDVI >= 0.40 or else 0 (non-cropped). The sum of these binary images from the specified three seasons of the year 2010-11 led to the creation of a yearly cropped area measure of each pixel. Finally the cropped areas were labelled as non-crop, monsoon crop, monsoon + winter crop and all year cropped. These analysis have been performed by Mr Gourav Misra of IWMI.

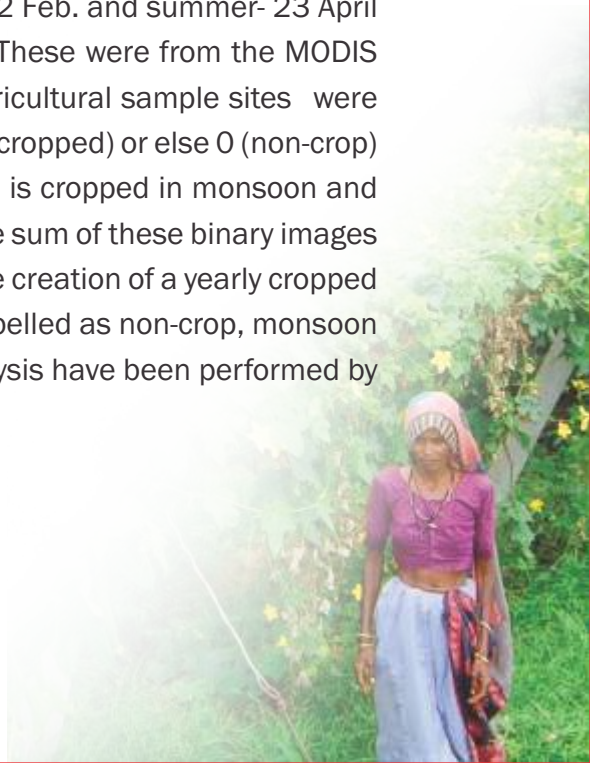
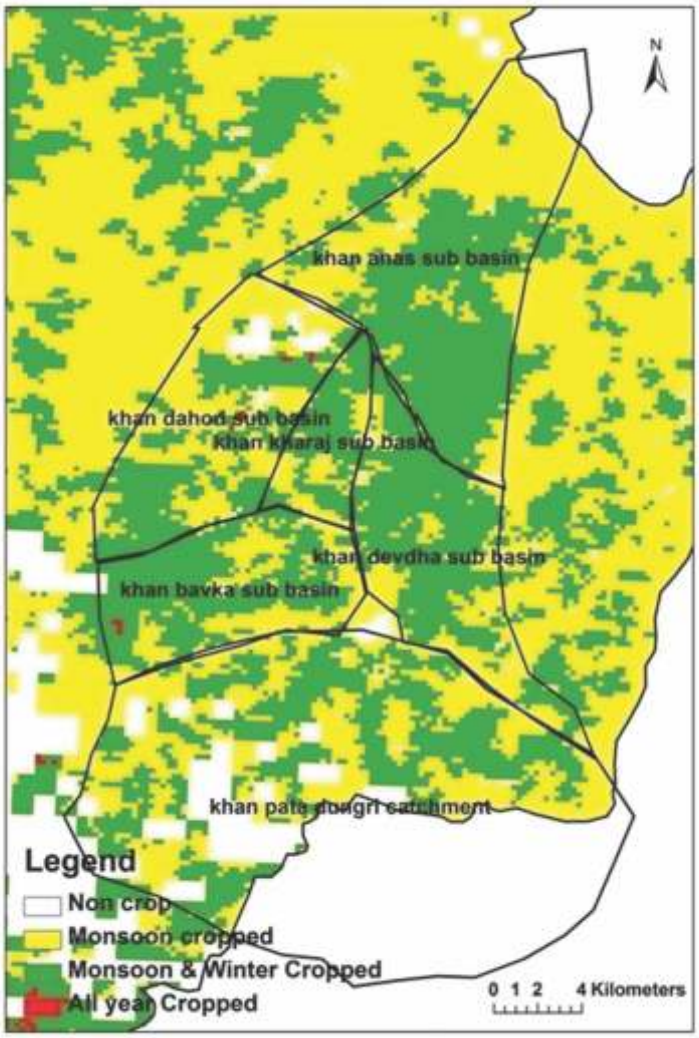


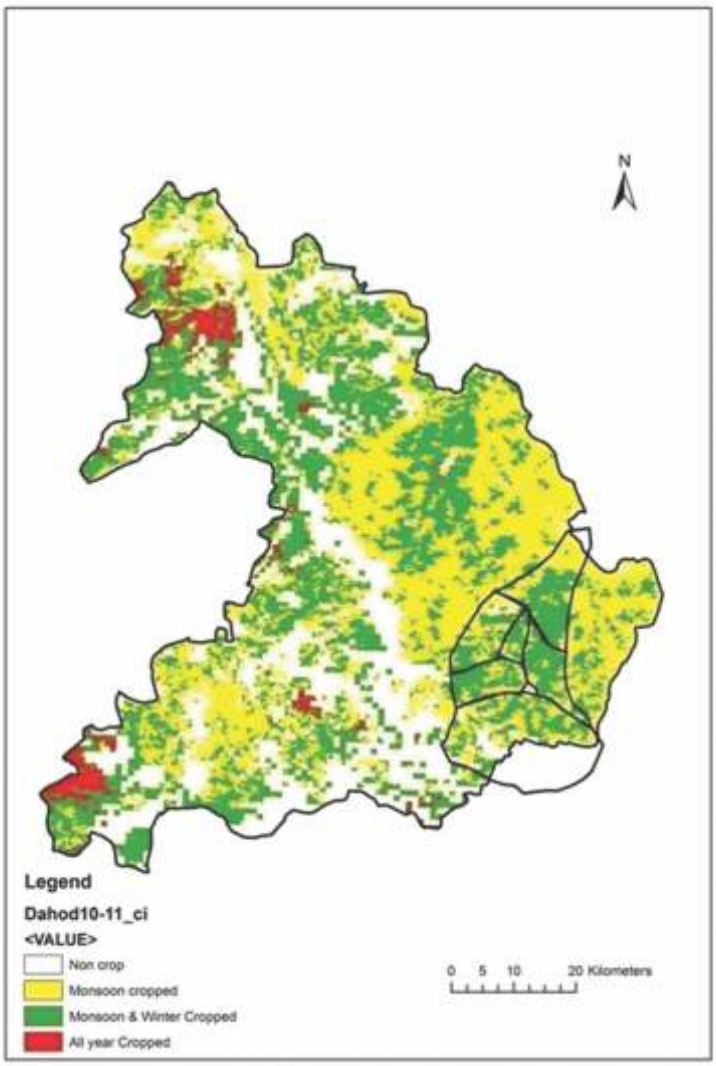
Figure 7: Agricultural Intensity pattern in Dahod district



Groundwater recharge

The six dam sets have average annual recharge of 0.6683 MCM 23.5162 MCM 0.1407 MCM 0.6500 MCM 1.4001 MCM and 0.3398 MCM respectively (Figure 12, 13). This caters to additional irrigation area which is based on groundwater based irrigation through wells. Apart from the larger dam, we have a total average of 3.19 MCM every year as recharge from the Sadguru check dams in Khan river basin. Taking an estimate of Ha/MCM from the LI commands as 22348 Ha for 27.68 MCM, we get 807.3 Ha/MCM of unit irrigated area per MCM of irrigated water. Using this, we get a potential groundwater irrigated area of 2249 Ha in Khan river basin alone using groundwater irrigation from Sadguru check dams.

Figure 8: Agricultural Intensity Pattern in Khan river basin



Similar analysis needs to be done for other such river basins in Dahod such as Kali 1, Kali 2, Macchan and Hadaf which are also intensely rainwater harvested. These river basins together have an overall catchment area of 161 sq kms, which assuming similar behavior such as the Khan river basin would possibly have a groundwater recharge irrigated area of another 5912 Ha adding to the 2249 Ha above from Khan river basin.

This extrapolating to the other intensively harvested river basins in Dahod, shows us the total groundwater irrigated area possibly attributed to Sadguru check dams as around 8161 Ha which is quite significant.

Figure 9: Seasonal irrigation requirement

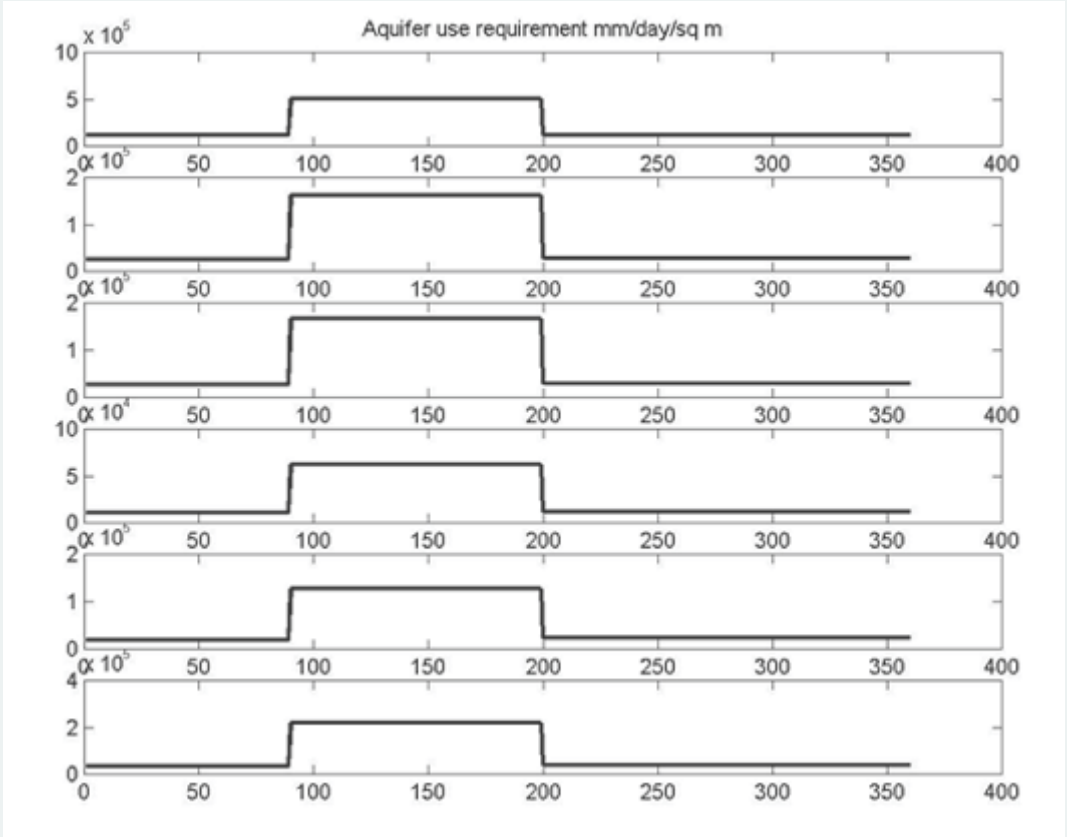


Figure 10: Storages in Dams

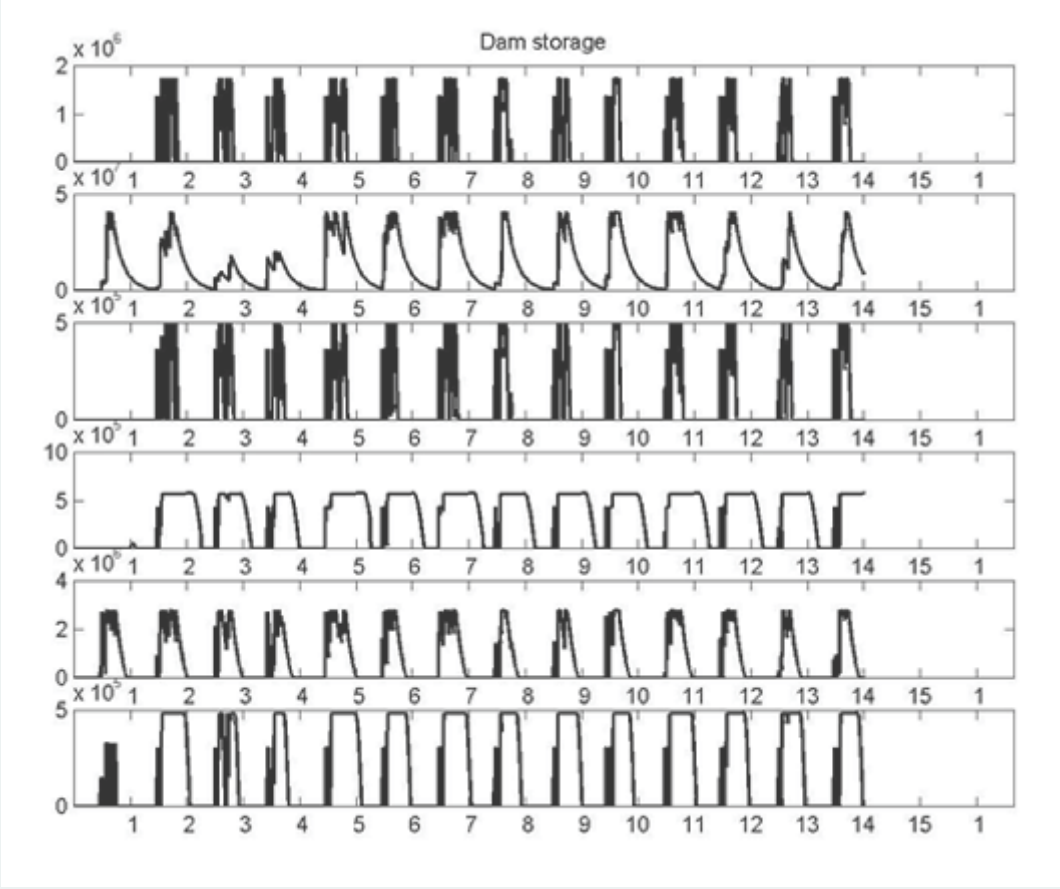


Figure 11: Catchment base flows

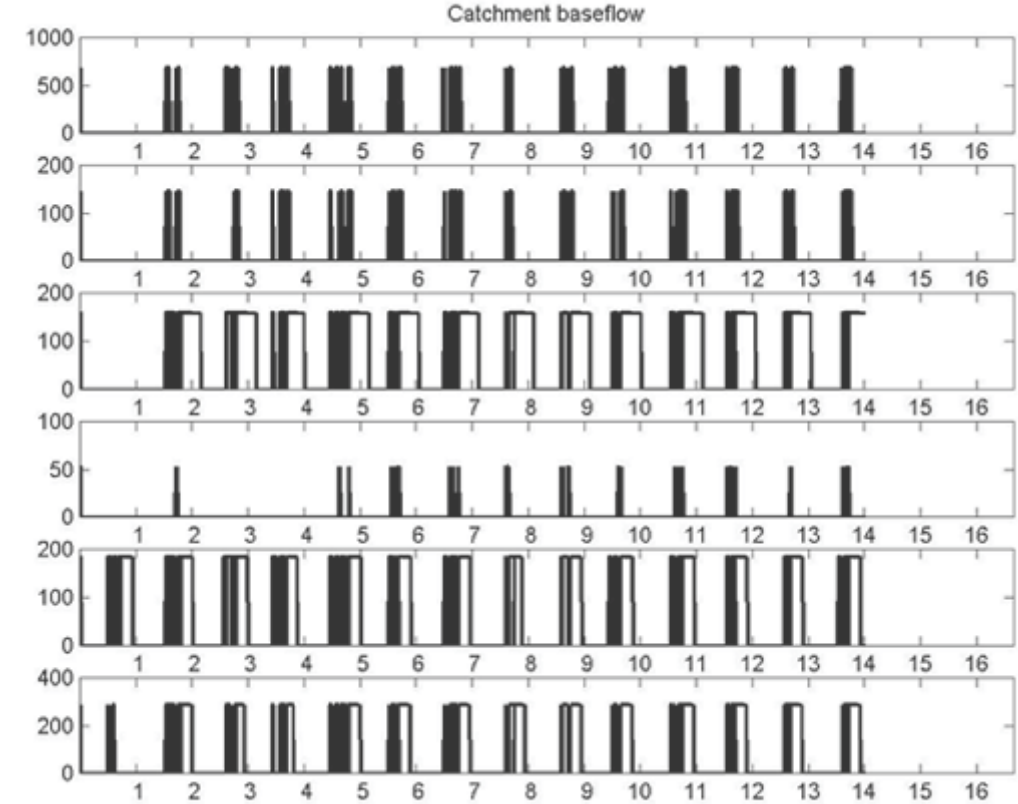


Figure 12: Aquifer storage

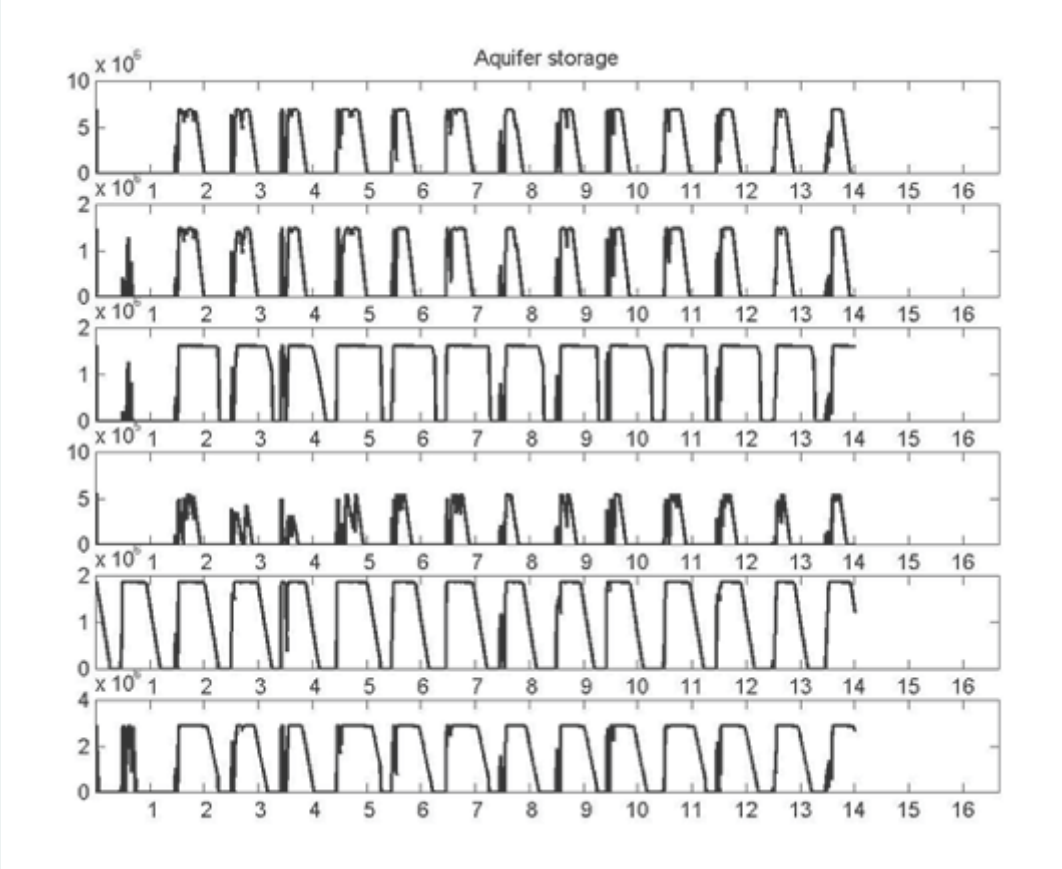
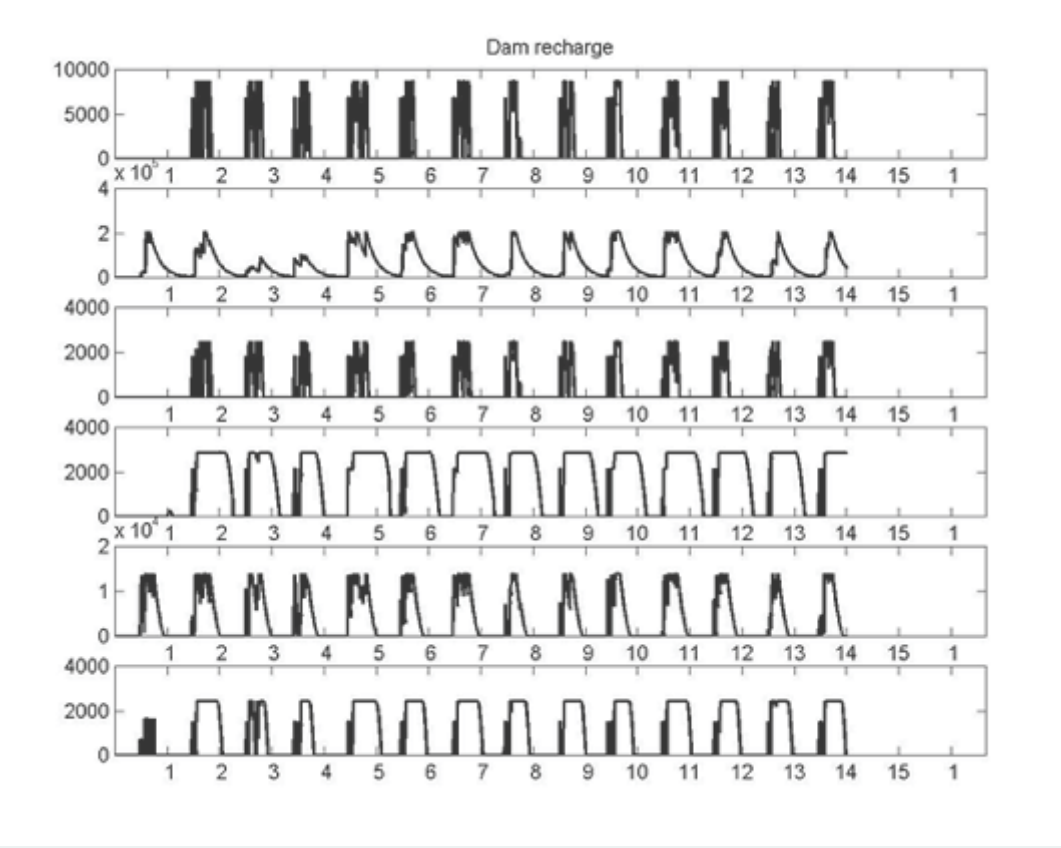


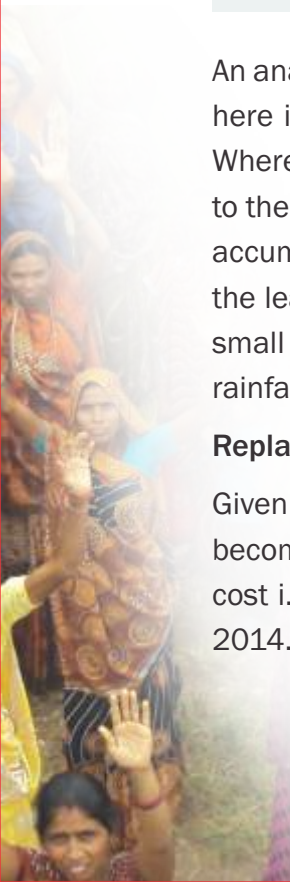
Figure 13: Total Dam recharge



An analysis of Figure 10 on storages in dams reveals a lot about the interactions happening here in Khan river basin. The storages of Dam set 1 is upstream to the large dam no 2. Whereas Dam sets no 3 and 5 in other catchments, the dam sets no 4 and 6 lie downstream to the large dam. Since the baseflows coming from the large dam and irrigation base flows accumulate downstream, we see that these dams are almost full for many years, except for the lean season, as compared to the other catchments. The close interaction of large and small dams is brought out here across 14 years of climatic variation with high and low rainfall, showing the power of this combination across years.

Replacement cost Analysis of Check Dams and Lift Irrigation systems

Given that such a large scale of water storage is being achieved across Dahod district, it becomes important to look at the value of these storage structures in terms of a replacement cost i.e. what would be the approximate cost of this storage if it were constructed now in 2014. We go about this in two ways.



First, we look at the total water storage created. We look at what is the rough unit cost of additional storage today and then calculate the replacement cost using this unit cost for the same total storage.

The second method is to look at the cost of each structure at the time of construction and then look at the depreciation as well as inflation adjusted value of each structure at present time to calculate the replacement cost of structures in Dahod district.

The first method gives is ₹ 13.32 lakhs/Mcft of unit cost and thereby ₹ 72 crore of replacement cost for the total storage of 544.5 Mcft in Dahod district.

The second method, using a 2% annual depreciation of structures and average 5% inflation gives us ₹ 32 crore as the replacement cost of structures constructed with Sadguru support in Dahod district.

This analysis gives us two estimates and a range – ₹ 32 crore to ₹ 72 crore – for the replacement cost of the storage structures. When we look at the annual agricultural GDP generated by these water storage structures, we need to look at it in the context of what is the base asset replacement value which supports this economy. Also, if we look at the structures requiring maintenance and eventual replacement over time, then one needs to plan and be ready for future investments, though in a staggered manner.

For Lift Irrigation schemes, we follow the first method as used above for check dams, i.e. we look at the total lift irrigation command area now and current norm costs of developing this command area. In this case, the total Lift Irrigation command area in Dahod district is 6579 Ha and cost per unit Ha of command area in 2014 is ₹ 1.0775 Lakh. This gives the total replacement cost in 2014 as ₹ 1.0775 lakh x 6579 i.e. equal to ₹ 70.8 crore.

This gives a total range estimate of Replacement cost for check dams and LI schemes in Dahod as minimum of ₹ 102.8 crore and maximum of ₹ 142.8 crore.

Agricultural Economy Generated
by Sadguru Interventions and in entire Dahod district

One way to look at linking water based interventions of Sadguru to cumulative impact on the economy is to look at the Agriculture GDP generated by such interventions and then compare it with the overall Agricultural GDP of Dahod district. Since neither of these is readily available, we have computed this using an elaborate methodology as described earlier.

Multiple sources of reliable information was procured from sources such as Dahod APMC, National Dairy Development Board, Agriculture department of Gujarat government and others including Sadguru's in-house surveys. Field checks and surveys were done to cross check unit numbers such as cost of cultivation. More information on this procedure is provided in the Appendix and spreadsheets of these calculations are available upon request.

We take the sections of cereals and pulses; non-food commercial crops, vegetables, horticulture, floriculture and dairy and then separately consider agro-forestry which has a massive contribution in terms of both direct and ecological benefits, but agro-forestry has been taken as a long term asset of the district, hence the occasional income from agro-forestry has not been considered in GDP calculation.

As far as possible, data has been procured for the Agricultural year 2011-12 and for some items for 2013-14, where information of 2011-12 was not available. Apart from this, we analyzed the impact due to agro-forestry and also look at Multiplier benefits to the economy later in this section.

In Table 2, we see the total Net Agriculture GDP of Dahod district is estimated to be ₹ 1568 crore and gross Agriculture GDP is ₹ 2036.79 crore. This needs to be looked at in the context of Gujarat state where the estimate of overall Gross Agriculture GDP is around ₹ 43,794 crore in 2009-10 (GoG 2011).

Table 2 shows that the contribution of Sadguru interventions to this economy is ₹ 116.35 crore (gross) and ₹ 79.47 (net). This comes to around a highly significant about 5.68% (gross) and 5.07% (net) of the overall Agriculture economy of the district. Given the fact that Sadguru

interventions are mostly with tribal farmers who are not traditionally farmers, this percentage is even more significant. These tribal farmers, who were earlier not at all part of the district economy, are now being able to play a significant role and almost entirely due to various interventions from Sadguru, based on its own programmes as well as in partnership with various government initiatives.

Inset 3

A valley of roses in Kamboi

The roses are grown in small pieces of flat lands in the hilly village of Kamboi. The village is 15 kms from Dahod and 25 kms from Chosala Sadguru campus. A village of 500 households – is populated by the social class of OBC, Bhills and Pateliyas. Two farmers started growing roses seven years ago; now there are 50 farmers growing roses, marigolds and chrysanthemums.

Mr Hemsingh Parmar of Kamboi has only 1½ acre of land. Out of this small piece of land he grows roses (gulabs), chrysanthemums (sevantis) and marigolds (haajaris) in one acre and rest of the land he grows wheat etc for his consumption. He has drip irrigation systems in his field. His annual income is more than ₹ 2 lakhs selling only roses since last 5 years. He purchased motorbike, made his house pucca and also constructed a dug well. There are other villages also like Kamboi namely Rozam. It is a good example of floriculture in Dahod!

A comparison of Dahod GDP number calculation with earlier study

The Dahod agricultural GDP calculated here comes to ₹ 1568 crore. Since no such calculation has been done before for a district agriculture GDP of Dahod, we do not easily have a number to compare with. Instead, we decided to use calculations from an earlier study which focused on Gujarat Agriculture Growth (Gulatai et al, 2009).

Within this earlier study the value generated out of Cereals and Pulses in 2005-06 with 1999-00 prices has been calculated as ₹ 163.37 crore. From this present study, the value generated for cereals and pulses come to **₹ 617 crore**. How do we compare both these numbers?

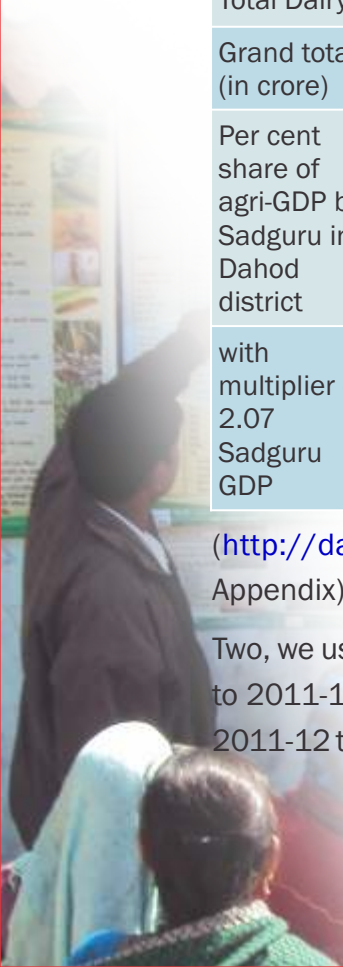
We process the figure from the earlier study in two ways – one, to adjust it with consumer inflation prices from 1999-00 till 2011-12. We do this by using annual inflation figures for each of the years of this 12-year period obtained from the World Bank website

Table 2: Agriculture GDP of Dahod and of Sadguru farmers for the year 2011-12

Reference year 2011-12								
Items	**Dahod**	**Sadguru**						
	Area (ha)	Gross GDP (₹ Crore)	Total cost (₹ Crore)	Net GDP (₹ Crore)	Area (ha)	Gross GDP (₹ Crore)	Total cost (₹ Crore)	Net GDP (₹ Crore)
Total of Cereal and Pulses	300400.00	617.73	238.73	379.00	10450.00	39.00	19.00	20.00
Non-food Commercial crops	2000.00	9.79	0.96	8.84	-	-	-	-
Total Vegetables	7810.00	711.63	66.39	645.24	895.00	22.00	7.00	15.00
Total Fruits and Orchards and Horticulture (Mango)	2850.00	148.73	7.29	141.44	1236.00	29.00	3.00	26.00
Total Floriculture	230.00	8.59	0.18	8.41	10.00	0.36	0.08	0.28
Total Dairy	-	550.12	165.04	385.08	-	25.99	7.80	18.19
Grand total (in crore)	313290.00	2047.00	479.00	1568.00	12591.00	116.35	36.88	79.47
Per cent share of agri-GDP by Sadguru in Dahod district						5.68		5.07
with multiplier of 2.07 Sadguru GDP						240.85		164.50

(http://data.worldbank.org/indicator/FP.CPI.TOTL.ZG - accessed 31 Dec 2014) see Appendix). This adjusted figure comes to as ₹ 341.5 crore.

Two, we use a 10% agriculture growth figure from above study to project this 2005-06 figure to 2011-12 by taking annual 10% growth for 6 years. This projects the value generated for 2011-12 to **₹ 605.02 crore**.



The difference between the calculation we have made in this study ie ₹ 617 crore and the estimate from the earlier study ie ₹ 605.02 crore can be considered to be minimal given that we are interested to look broadly at the overall range of numbers.

Agro forestry: A natural renewable resource

It is said that "forest provides multiple benefits to mankind that are essential for the survival and livelihood of people who are mainly dependent on forest". Forests occupy an important role in the contribution to the GDP, employment and livelihoods of poor people (Singh K and Mali, 2005). However 'agro-forestry' is more considered as 'future' asset for a region, or for a community or for an individual.

The intervention activities of Sadguru Foundation include agro-forestry making a huge asset and a perennial source of income for longer time period. This agro-forestry program is a mixed practice of plantation in open fallow land and on the boundaries of farm land of famers. This program has mixed cultivation of trees like, – eucalyptus, acacia, teak, bamboos and some more.

Inset 4

Vegetables are constant source of income

Dabhra village is on the side of Ahmedabad-Indore highway, in the Panam river bank. In this village about 80% household are growing vegetables. Ranchodbhai and family lives as joint family with their two sons – Bharatbhai and Bhagatsingh. Ranchodbhai has 15 acres of land. Before Sadguru's intervention they were doing vegetable but not so systematically – said Bharatbhai. They now do all kinds of seasonal vegetables.

Their wives Ramtiben and Ramilaben mainly taking daily care of fields and take vegetables packs by local pick up van or jeep to Dahod market which about 20-25 kms away from Dabhra village. Both Ramilaben and Ramtaben bring ₹ 500 each on an average every day now. They go about 25 days in a month to sell vegetablesto Dahod. Bharatbhai said that they have saved this year about ₹ 1 lakh by selling vegetables only. This saving is after all meeting all expenses in family – such as education cost of the whole year of 4 daughters of these two brothers. All 4 girls are going to college now. They have one dug well and one bore well, two motorbikes. They have plan of buying one pick up van of ₹ 4 lakh this year.

We received some estimated value from agro-forestry department of Sadguru as given in Appendix 2. It is said that the total value of Eucalyptus and Teak becomes (₹ 2521 + ₹ 11206) = ₹ 13727 crore.

Hence, this is the value of agro-forestry asset with Sadguru beneficiaries. However this is an estimated value of agro-forestry developed by the beneficiaries for the last four decades in Dahod district. This value we have not taken in estimating GDP value.

Inset 5

Bamboos are perennial source of income

The bamboo plants are ever green and perennial. Though depends of variety, it does not need much care in general. One shoot of a bamboo can give even up to 140 shoots – means bamboos. The very normal variety of bamboo can fetch ₹ 50/- in Dahod. There are many bamboo plots in Sadguru especially in Limkheda area. Many farmers put bamboo plants along boundary lines of their fields. It is a least cost plant. They earn a good amount of money out of very small investment.

Value of Bamboo plantations

Bamboo is a tribe of flowering perennial evegreen plants in the 'grass' family Poaceae, subfamily Bambusoideae, tribe Bambuseae. Giant bamboos are the largest members of the grass family. Especially for small and marginal farmers, bamboo is potentially a useful source of material for construction and with good quality, a source of income too.

It has been informed by Sadguru that there about 13 lakh bamboo plants in the year 2013. Each bamboo plant can have 140 shoots in a lifetime, therefore there will be total number bamboo of 13 lakh x 140 = 18,20,00,000 in the future; hence total worth of asset of bamboo is 18,20,00,000 (x) ₹ 50 = ₹ 910,00,00,000 = ₹ 910 crore – if ₹ 50 has been taken as its selling price. Thus ₹ 910 crore should be taken as total worth of bamboo asset.

Some other impacts of agro forestry such as Oxygen benefits are discussed in Appendix 3.

The total natural asset base estimated from Eucalyptus, Teak and Bamboo plantations comes to ₹ 14637 crore. Since there is no study on the actual benefit to the economy from this asset base, it is difficult to predict that. However, there is a potential in having a

sustainable 8% annual annuity of plantation-harvesting programme, which can create a wealth of ₹ 1171 crore. It is to be noted that this potential economic value is much greater than the agriculture economy contribution. This fact needs to be recognized and probed further.

Multiplier effect: *extended benefits of agriculture to other sectors*

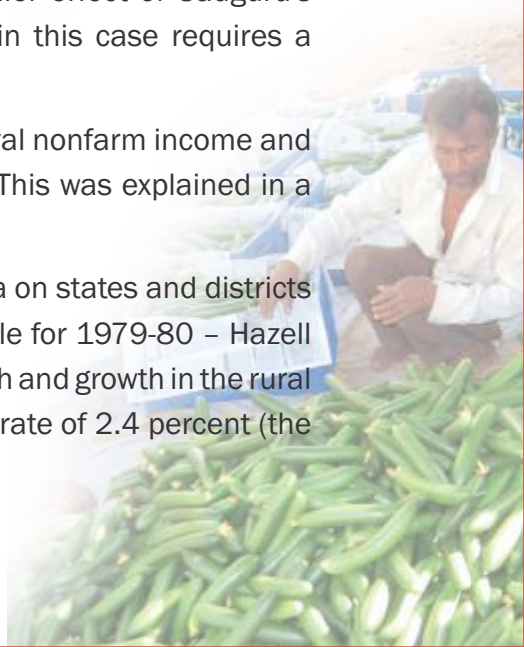
The economic activities are interlinked within a society and outside the society also, especially in this open global system. There is hardly any sector which is not dependent on another or not impacting on another. Agriculture sector requires steel industry for making implements, and so on. This requirement depends on how much advanced the agriculture sector of that region is. The needs will differ if the cultivation is typically based on irrigation or if it is based on rainfed cultivation. And people invest agriculture surplus money to other goods and services – may be in consumer goods or in long durable goods or in education. In the process of agricultural development other agro-industries and non-farm sector are developed. Thus, a large economy has been established even beyond agriculture which is a development phenomenon. Thus, non-farm industries grow from the farm industries and some 'multiplier' effects are found in the total economy of a geographical area.

Estimating "multiplier effect" of agriculture about a region needs a focussed study on that aspect alone. It will not be justifiable to put any arbitrary value of multiplier for an economy without studying properly the 'forward and backward' linkages between the two or more sectors. The multiplier effect in economics is a factor of 'proportionality' that measures how much an 'endogenous' variable changes in response to a change in some 'exogenous' variable.

It is true that any intervention in a society has its ripple, spillover or multiplier effect in the society whether it is drip or sprinkler irrigation like in North Gujarat (Indu, Borkar and Dave, 2008) or check dams in Dahod around. Technology changes the society – same for cell phone and automobile. It is obvious that there is a 'multiplier' effect of Sadguru's intervention in multiple areas of agriculture that has brought today's economic and sociological development in Dahod district. It is worth to estimate the multiplier effect of Sadguru's intervention, but that should be done in a scientific way, which in this case requires a separate study.

There is always a strong linkage between agriculture growth and rural nonfarm income and employment. They grow faster than their agricultural counterpart. This was explained in a Working Paper by Hazell and Haggblade, May 1990.

Using two models – an econometric analysis of cross-sectional data on states and districts and a semi-input-output model fitted to a national input-output table for 1979-80 – Hazell and Haggblade analyzed the relationship between agricultural growth and growth in the rural nonfarm economy. They even said "A sustained agricultural growth rate of 2.4 percent (the



past trend) will lead to 3.0 percent growth in nonfarm income in rural areas and towns and 2.8 percent growth in nonfarm employment. If agriculture grows 4 percent, these rates increase to 5.8 percent and 4.0 percent, respectively (Ibid, pp – ii)".

They also said that Agriculture and Growth of the Non-farm Economy – (Ibid, pp 15) ... resource endowments, location, ethnicity, historical happenstance, and government policy all play a role in the development of nonfarm activities and it varies over time and across regions.

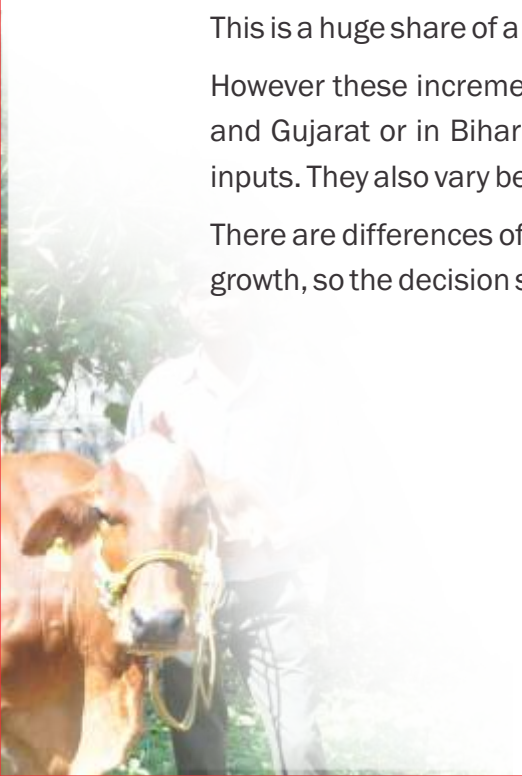
Agriculture can influence nonfarm activities at least three ways: production, consumption and labour market linkages. On the production side, a growing agriculture require inputs – fertilizer, seeds, herbicides, pumps, sprayers, equipments and repair services – produced or distributed by nonfarm enterprises. Increased agriculture outputs increase forward production linkages by providing raw materials required for milling, processing and distribution by nonfarm firms. Consumption linkages arise when growing farm income boost demand for basic consumer goods.

A 100-rupee increase in irrigated agrculture output generates 105 rupees of additional output in manufacturing, 114 rupees of additonal tertiary output and 45 rupees of of additional non-tradable agricultural output. This amounts to a total non-farm output multiplier of 2.19 and a total output of multiplier of 2.64; in contrast, rainfed agriculture, because of its less intense use of manufactured and tertiary inputs, generate nonfarm gross output multipliers that are about 5 to 10 percent small – ie, 2.05 and 2.55 when rainfed. Thus, if increase in income is 1.00 rupee from irrigated agriculture, non-farm income increases by 1.56 rupees, and in total it increases by 2.07 rupees (ibid).

Using the last result of Hazell and Haggblade 2.07 as multiplier in the share of Sadguru's share of Dahod agri-GDP which is 6.09%, we can say that Sadguru's intervention might have given a total impact in the ecnomy of [6.09 (x) 2.07] 12.60 per cent of total Dahod agri-GDP. This is a huge share of a single institution to make such impact!

However these increments are space specific – that is, the multiplier is different in Punjab and Gujarat or in Bihar and Tamil nadu, because of the use of manufactured and tertiary inputs. They also vary between small and medium farmers to big farmers in a economy.

There are differences of opinion about the magnitude of multiplier that should be applied for growth, so the decision should be understood as a subjective one.



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Appendix

Appendix 1: Notes on data used in GDP table for the year 2011-12

1. Data of Dahod district received from a website (see Appendix 4); It has the reference of Source: www.gswan.gov.in Chapter 4: Development of Agriculture Sector, Table 15: Present status of different crops in Dahod district (year 2011-12), page 48, C-DAP Dahod District. Name of crop, Area (ha), Production (MT), and Productivity for the year 2011-12.
2. Price of APMC, Dahod has been used for Gross Income calculation for Dahod district – all products like cereals, non-food crops, fruits, vegetables and flowers. Variety of crops has been omitted by averaging all varieties in to one crop. For example, there were 6 varieties of wheat then we mixed all variety's prices of all 12 months in 2011-12; calculate the average price for 1kg taking wheat as a whole.
3. For cost of cultivation of Dahod cereals, pulses, vegetables and fruit production – we used 2010-11 (as we could not get the data of cost of cultivation of 2011-12) — Ref: Gujarat Agriculture Statistics at a Glance – Year 2010-11- published by Directorate of Agriculture, Gujarat State, Gandhinagar. http://agri.gujarat.gov.in
4. Cost of cultivation of cotton is taken from 2010-11 as in point 3; reference above. For cotton price we used - http://www.moneycontrol.com/news/weather/the-cotton-productiongujarat-is-set-to-jump-to-118-lakh-bales_1042152.html - accessed on 28 Feb 2014 – which is ₹ 3600/- per Qtl as Minimum Support price in 2013. So per metric ton = ₹ 36000/-
5. For data of milk production quantity and price received from NDDB and used for value calculation. The cost of milk production at farm level is taken as 30% of the price received by the farmers. This information we got from Amul Dairy as a thumb rule – they said (personal corr). Later we clarified with other dairy cooperatives about this cost also.

NDDB has given following note for Dahod milk production and price the farmer get – we have noted here below in italics (we acknowledge the courtesy of NDDB).

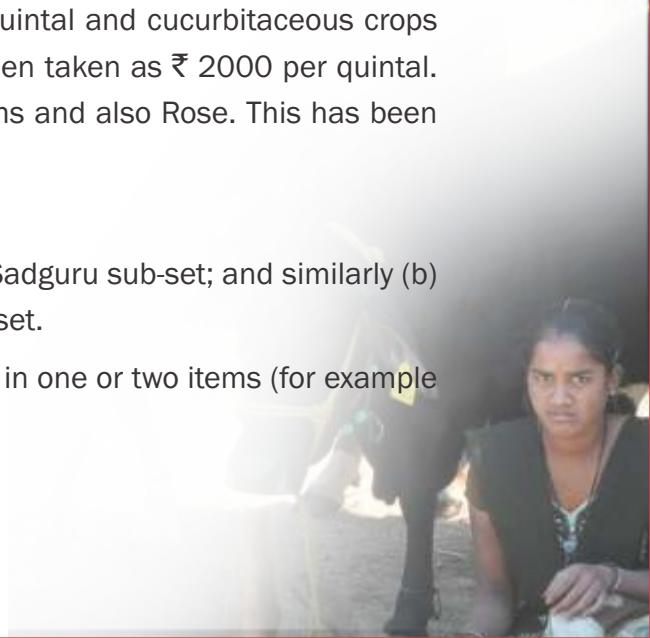
1. *It is escalated of milk production data of 2007 by a factor of 1.24 to get update of 2013, based on the in-milch animal population multiplied by their average yield rate*
2. *Milk prices in Gujarat are decided by the respective milk unions. It is not uniform across all the unions.*
3. *The price data that we have given is the benchmark price. The milk producers actually would receive higher price than this because realization of fat percent in Gujarat is much higher than 6% fat taken for price of benchmark.*
4. *Over and above the price that is paid to the milk producers they also get some amount in terms of price differential or bonus in a year. Generally, the range around is 10% of the total price received from sell of milk. The bonus is paid at the end of the year.*

6. For Lift Irrigation (Li) area and products – we used information given by respective departments of Sadguru regarding Wheat, Gram and Maize of the year 2011-12. They have given area, production, and unit cost of cultivation per acre for these 3 crops. As informed, the beneficiaries are engaged in producing these main 3 crops only, in Li area.
7. We have used the information of vegetable given by the horticulture department of Sadguru. We received data of 2011-12 and 2012-13 of total of all vegetables, all trellis, all floriculture, all horticulture – area, production, cost and income after deducting cost – they had sent the same.
8. Similarly, we received data of floriculture, horticulture and mango cultivation etc from Sadguru departments. (i) The cost of mango plantation is included for the 1st year only, later only nominal maintenance cost is calculated, that is ₹ 4,000/- or 5,000/- per year. (ii) The cost of all vegetables such as Tomato, Brinjal, Chilly Cauli-flower, Cabbage, Spinach, Fenugreek, Coriander and vegetables grow on Trellis – cucurbitaceous crops –were calculated on basis of average ₹ 1000 per Quintal and cucurbitaceous crops ₹ 800 per crops. The cost of growing flowers has been taken as ₹ 2000 per quintal. Floricultural crops are Marigold and Chrysanthemums and also Rose. This has been informed by respective departments of Sadguru.

Please note:

i. (a) Non-food commercial crop is not available in Sadguru sub-set; and similarly (b) agro-forestry is not available in Dahod district total set.

ii. We have calculated GDP for one year – 2011-12; in one or two items (for example



Mango) we have taken value of 2013-14 as given by the department of Sadguru.

iii. Sadguru has started its Dairy activities since 2006 and they have organized 86 dairy coops in Dahod districts till March 2014. We have put the income from dairy of the 2013 of total 86 dairy established since 2006 – data received from Sadguru.

Appendix 2: Eucalyptus, Teak and Bamboo wealth

1) With 50% survival rate, the existing number of plants are in 2013 = 28015000

2) According to Sadguru – the average selling price of Eucalyptus is ₹ 1000/- after deducting the cost of ₹ 70/- of 5 years of age or 5 years of maturity.

3) And, the average selling price of Teak is ₹ 40,000 after deducting the cost of ₹ 70/- of 15 years of age or 15 years of maturity.

4) The value of existing Eucalyptus trees is ₹ 2521,35,00,000 or, ₹ 2521.35 crore taking 90% of the total trees is eucalyptus (₹ 1000 x 25213500 = 2521,35,00,000) = ₹ 2521.35 crore

5) The value of existing Teak trees is ₹ 11206,00,00,000 or, ₹ 11206 crore taking 10% of the total trees is teak (₹ 40000 x 2801500 = 11206,00,00,000) = ₹ 11206 crore

6) It has been informed that there about 13 lakh bamboo plants in the year 2013. Each bamboo plant can have 140 shoots in a lifetime, therefore there will be total number bamboo of 13 lakh x 140 = 18,20,00,000 in the future; hence total worth of asset of bamboo is 18,20,00,000 (x) ₹ 50 = ₹ 910,00,00,000 = ₹ 910 crore – if ₹ 50 has been taken as its selling price. Thus ₹ 910 crore should be taken as total worth of bamboo asset.

So the total value of Agro-forestry together (Eucalyptus, Teak and Bamboo) is ₹ 2521+11206+910 = ₹ 14637 crore and 8% annual annuity = ₹ 14637x0.08 = ₹ 1171 crore

Appendix 3: Other benefits from Agro-forestry

Besides all these, forest has other impact on environment and health of human beings as trees absorb Carbon dioxide and give Oxygen in the nature – both are necessary for human beings of earth. There are some good estimation about absorption of CO2 and exhalation of O2 by one tree. About the forestry of Sadguru Foundation the following estimation has been sent to us by them.

Sadguru scientist has worked out the climate/environment impact of tree plantation referring some literature which was shared with us via e-mail dated 5 March 2014. Considering survival of grown up trees at 2,50,00,000, the working is as follows:

Effect of plantation on climate / environment

a. 2,50,00,000 plants absorb 5,41,750 ton carbon dioxide per year

b. 2,50,00,000 plants produce 29,48,252 ton oxygen per year

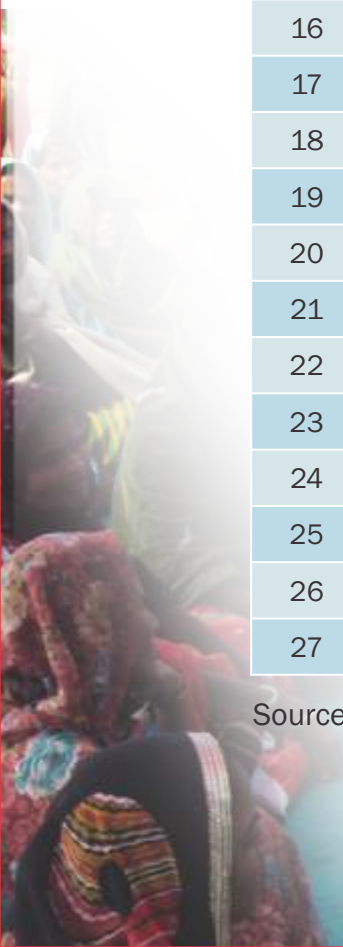
c. One mature tree can provide enough oxygen for two persons for a year, i.e. 5,00,00,000 persons can breathe

With these 'other impacts' of forestry, any large forestry has extended impact on environment and thereby on health on human beings, in the region. It is true for the Dahod agro-forestry also. However, the “impact on environment and health of human beings” of forestry is beyond the purview of this study.

Appendix 4:
Chapter 4: Development of Agriculture Sector: Page: 48: C-DAP Dahod district
Table 15: Present status of different crops in Dahod district (Year 2011-12)

Sr. No.	Name of crop	Area (ha)	Production (MT)	Productivity (kg/ha)
1	Paddy irr.	10700	15500	1452
2	Paddy unirr.	25100	16500	657
3	Kh. Maize	120000	203900	1700
4	Rabi Maize	2600	4875	1875
5	Soybean	34500	27500	798
6	Kh. Moong	500	200	453
7	Summer Moong	1600	800	534
8	Kh. Urad	8100	4800	588
9	Pigeon pea	13800	16900	1229
10	Wheat irr.	32800	65400	1990
11	Wheat unirr.	500	400	802
12	Gram	50200	41200	821
13	Kh. Groundnut	500	1000	1864
14	Sum. Groundnut	1000	1800	1777
15	Castor	400	800	2008
16	Cotton	100	100	283
17	Onion Rabi	900	14400	16000
18	Okra	700	6300	9000
19	Brinjal	1100	19250	17500
20	Guar	360	2520	70000
21	Cabbage	1200	18000	15000
22	Garlic	1000	8000	8000
23	Chilli	830	996 (green) 1287 (dry)	1200 (green) 1550 (dry)
24	Ginger	1500	16125	10750
25	Turmeric	220	2640	12000
26	Rose	85	340	4000
27	Marigold	145	870	6000

Source: www.gswan.gov.in



INREM Foundation

INREM Foundation is a research institution probing societal issues concerning water, public health, agriculture and the environment. The institution develops innovative inter-disciplinary solutions and brings them into the wider domain of practice by participating with communities and government. INREM works in the middle space between grass-root community based work, research on natural resource issues and policy formulation to bring about innovations to larger discussion.

The organization has contributed towards understanding water conservation and agriculture innovations in the field and their impact at large scales. The main contribution in recent times has been in the area of Water quality mitigation along with its linkages with different areas including that of public health. The organization is especially known for its pioneering contribution in the area of Fluoride water quality issues bringing about new ideas to the problem of mitigating the disease Fluorosis arising out of high Fluoride in water.

Sadguru Foundation

Established in 1974, Navinchandra Mafatlal Sadguru Water Development Foundation is a non-governmental organization which is non-political, non-profit making, secular organization registered under the Public Charitable Trust Act, the Societies Registration Act (1860) and the Foreign Contribution (Regulation) Act. It is recognized by the Department of Rural Development of the government of 3 states of Rajasthan, Gujarat and Madhya Pradesh. The organization is receiving funds from the state and central government, national and international funding agencies for its rural/tribal poverty alleviation NRM programs.

Its main objectives are to improve the living condition of rural and tribal people by developing environmentally sound land and water resources programmes; improve the environment; arrest the distress migration; improve the socio-economic status of rural people and strive for their overall development. This is prompted by facilitating the growth of local institutions that support and sustain the NRM Programmes.

The project area is classified as a drought prone semi-arid region of the country and is pre dominated by tribal and rural poor who are poorest of the poor struggling for their very existence. The project area is spread across 3 states in 16 districts of Rajasthan, Gujarat and Madhya Pradesh, covering approximately more than 3,25,000 households and about 19,75,000 people in more than 1400 villages under NRM activities.

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