



A Telling Tale

- Bhavarlal H. Jain



A Dreamer

On the hills and forests there were stones all over;
A dreamer collected them all together.

Shapeless and angular, stones of no beauty or grandeur;
He drew ridicule and derision from every corner.

But the dreamer was calm and his eyes shone;
For, his vision saw an idol in every stone.

Forming these idols was the mission of his strife;
Love was his strength; and faith the breath of his life.

His touch awakened even the inanimate;
Then emerged the idol of his vision articulate.

In the tale of its birth the idol does offer;
A living tribute to its creator – the dreamer.

– **Dr. Rajendra Malose**
Chandwad

Translated by Prof. G.P. Patil
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स्वप्न वेडा

पाषाण होते विखुरलेले डोंगरी रानीवनी।
स्वप्नवेडा एक त्याने आणले ते वेचुनी।।

आकार नव्हता, रूप नव्हते, दगड वेडे-वाकडे।
लोक हसले तुच्छतेने खूळ कुठले काढले।।

स्वप्नवेडा शांत होता, दृष्टी त्याची आगळी।
दगडामध्ये प्रत्येक त्याने मूर्ती होती पाहिली।।

साकार करणे मूर्ती त्याच्या जीवनाचा ध्यास होता।
प्रेम त्याची शक्ती अन् विश्वास त्याचा श्वास होता।।

स्पर्श त्याचा लाभता पार्थिवता संपून गेली।
संस्कारलेणी लेवुनी चैतन्यमूर्ती उमलली।।

आज जन्माची कहाणी तीच मूर्ती सांगते।
स्वप्नवेड्या माणसाची शब्दपूजा बांधते।।

– **डॉ. राजेंद्र मालोसे**
चांदवड



A TELLING TALE

A vision virtualised

- Bhavarlal. H. Jain

**Transformation of Rain-fed Wasteland through
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A TELLING TALE

A vision virtualised



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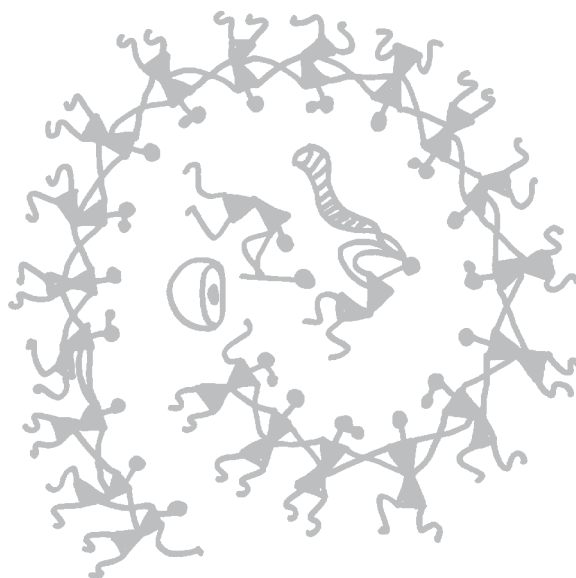
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“Conservation is managing our natural resources from the largest watershed to the smallest ecosystem.”

- Essex Region Conservation Authority



Dedicated to Gaurabai

To whom else can such a creation be dedicated if not to the creator of creators, that is, mother! It is Gaurabai, my mother, who inspired me to take to agriculture, not as a profession or avocation, but as a way of life. For the comfort and industry of all beings, not merely human beings.

- Bhavarlal Jain

Foreword



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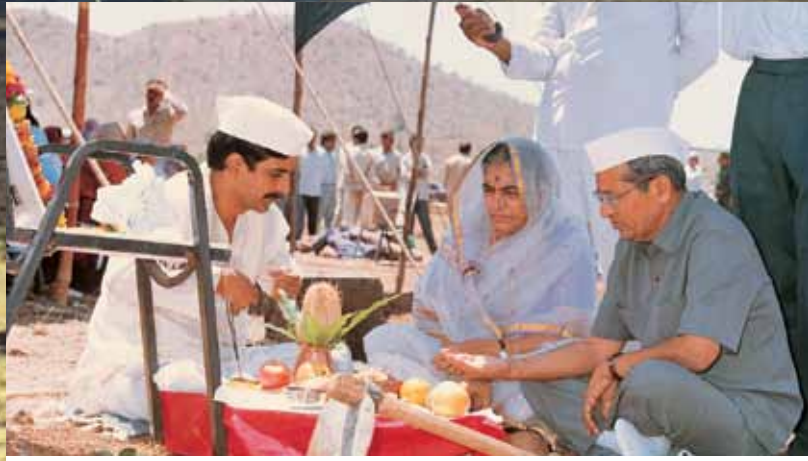
FOREWORD

With the ever-increasing stress on water resources, watershed development programmes assume greater significance, both for the Government and the farming community at large. Despite keen interest by all concerned, the progress is very slow mainly due to low investment in water sector, especially, irrigation projects. Some projects are successful where NGOs, through the involvement of local community, implement such projects. But, despite that, the concept of watershed management has not turned itself into a national movement.

The Jain Watershed Project, per se, is an atomistic model, where the co-operation of the neighbouring farmers is not required as a large area is under one ownership. However, every watershed, large or small, does create enduring value. The present document is an effort to make a focused analysis and evaluation of the project that Shri Bhavarlal Jain undertook as early as 1995. This may be the first private sector project covering more than 500 acres, being implemented for more than eight years. I had the opportunity to personally witness the development and its benefits. I am confident that the experiment will act as an enduring model for a real time rural resurgence. Shri Jain had earlier pioneered the use of drip irrigation in the country, which set the pace for conserving water, improving productivity and quality of produce. He has once again demonstrated his commitment to the cause of water. The model presented and being published through *A Telling Tale* by Mr. Jain can yield gratifying results. By following this model, large tracts of land lying idle can be gainfully transformed into profitable agro-forestry ventures and added benefits in terms of improved environment.

I am sure that the document will not only inspire commercialization of the watershed concept but also allow it to become a farmers' movement throughout the country. Even the urban industrial sector can take the advantage of this concept by adopting the water recycling method for industrial and agroforestry purposes. Jain watershed has added a novel dimension and may herald the beginning of a new movement.


(SOMPAL)



Bhau with wife Kantabai : Groundbreaking ceremony (1989)

Preface



There are certain facilities created within the farmlands covered, in what is generally described as Agri Park of Jain Hills (JH) and Food Park & Green Energy Park at Jain Valley (JV). These facilities, among others, pertain to Research & Development of basic farm resources, viz, land, water, energy and human. The Corporation conducts farm research and carries out development and imparts training for the benefit of its associates. It does the same for other stakeholders, including agricultural students, researchers, scientists, government officers, farmers both from India and abroad. The campus also serves as a demonstration farm for various experiments and trials of different crops and on crucial subjects like wasteland reclamation, watershed planning and development. The centre also promotes modern irrigation methods, organic farming, use of bio-planting mediums and materials as important tools for enhancing productivity and improving cost-benefit ratio. Energy conservation through use of renewable sources is also one of the focus areas.

It is indeed a demonstration of the commitment to transform rain-fed dry wasteland into horticulture, agro-forestry and irrigated agriculture. And that too, only with the help of integrated rainwater harvesting and watershed measures. The complete gamut of this research and development is conducted under the banner of “Jain Hi-Tech Agri Institute” (JHAI). It encompasses a full-fledged training institute, the Jain Gurukul, with state-of-the-art teaching, training and extension aids and accommodation facilities for farmers and opinion makers.

This live demonstration has attracted enormous attention and created pressure on me to document and share these experiences in the form of a book which can reach across the country and the world. Hence, this humble attempt.

These lands form part of Shirsoli hill area in the North-West of the Ajanta Mountain Ranges. The region is part of the Deccan Plateau rocky terrain formed by basaltic lava flows. It has an annual average rainfall of 650 mm. Temperatures range between 5 to 48 °C and has low humidity. Under these unfavourable geophysical conditions, experts had opined that groundwater availability, if any, would be scarce and thoroughly undependable. Not heeding their advice, the dreamer in me undertook the development of the entire area covering 263 ha (650 acres) of this wasteland as a challenge. I had another compelling reason to do so. I knew that agriculture is the mainstay of the region and that there can be nothing more precious than conservation of water because agriculture without water means very little. I continued the work unabated with commitment and faith in the ultimate success of rainwater harvesting and soil conservation techniques. And through this model I have exemplified that one can establish sustainable agriculture, generate high level of local employment and make a substantial addition to the GDP. I believe that the results of my experiments are for sharing and passing on to the people at large.



The water and soil conservation measures were planned sequentially starting from ridge and proceeding towards the valley. A step-by-step approach and experiments began. Field trenches, bench terraces and other appropriate structures were erected to harvest the rainwater right where it falls. The run-off, resulting from high intensity of rain, was stored at the foothills in storage and percolation tanks, which were sealed by technically sound cut-off trenches (COTs). This not only enhanced storage of rainwater, but also ensured recharging of the ground aquifers. The water thus stored was eventually reclaimed through a network of percolation open dug wells and borewells. The well water was then used only through close piping and modern irrigation techniques, such as drip irrigation, where the water-use efficiency is as high as 95%.

These measures ushered in a miracle. At the commencement of the venture in early 1989, we could hardly manage to obtain about 200 - 400 litres (0.2-0.4 cum) water in a given day from an old, abandoned, dilapidated dug well which later dried up. The various rainwater harvesting and soil conservation engineering structures created and maintained during the past 17 years (1993-2010) now ensure, even in drought years, a minimum draft of average 15 lakh litres per day (1500 cum/day). Indeed, during the past five years, the draft has averaged to 19 lakh litres/day (1900 cum/day). It has been observed that during a normal rainfall year, the draft averaged 25 lakh litres/day (2500 cum/day).

We have modified the general concept of watershed and divided it for the sake of clarity and the due emphasis which ought to be given to different aspects encompassed by this concept. We have added a few features which can be described as forward integration of conventional watershed concept.

The components presently covered by our integrated watershed approach are as follows:

- Land and Soil Conservation Measures
- Soil Improvement and Amendment Measures
- Rainwater Harvesting Structures
- Water Recovery Structures
- Artificial Recharging and Soil Moisture Improvement Measures
- Application of Higher Water-Use Efficiency Technologies such as MIS & SIS
- Establishment of Agro-Forestry
- Energy Conservation Through Biogas, Solar Thermal, Solar PV and Wind Energy
- Sustained Employment Generation and Self-Development of people
- Conscious Efforts to Promote Ecology and Environment at every step.

We are also working on an idea for making a packaged deal for the dry land farmer. This will help him to improve the productivity of his limited resources by a factor of at least 2-5 times.

*'You must have
the bird in your
heart before
you can find it
in the bush.'*

– John Burroughs



Vision, modern technology, on-site experiences, trials and scientific experiments as well as economic considerations have worked hand-in-hand at Jain Watershed. Our endeavour is to enlighten, guide and demonstrate to the farmers as well as other institutional land holders that one can reclaim and green wasteland with the help of rainwater harvesting combined with drip technology. Water budgeting, costing and water balance sheet have been worked out for our Jain Watershed to serve as a 'doable' model.

We, however, do not claim that this is the only or the most perfect model of watershed development or water and soil conservation. Nor do we wish to maintain that the whole development was pre-planned and/or systematically executed without any fault, shortcomings, setbacks, or is cost-effective in the short-run. It is, however, true that with faith in the concept of watershed, its consequence and hard work, we have realised a cherished dream, and the society at large stands to benefit, without an iota of doubt, out of such experiments.

The eventful achievement of about nine years of intense effort does present a feat acclaimed by many as unique and exemplary. This is a continuing saga of success, a living tribute to the highly motivated thousands of individuals who have ceaselessly toiled to create, what is now described by many as a 'Paradise on Earth'.

What has been created has become a pilgrimage centre that has inspired over 35,000 farmers and farm related visitors every year from every nook and corner of the world. The ensuing pages are a short history of this acclaimed experiment and is only a part of the work being done by JHAI.

*'One who solves the problem of water
is worth two Nobel Prizes,
one for Peace and another for Science'*

— John F. Kennedy



01. Layman's Water Expedition



Background

I come from a farming family and chose to go back to my ancestral farms at Wakod village during 1972-74. As a son-of-the-soil, I dug wells, laid non-pressure cement pipelines for farm irrigation, later replaced the cement pipes with PVC pipes, constructed a farmhouse and cattle sheds. I produced hybrid cotton seeds, high yielding chillies, and also ushered in ratoon cropping for hybrid jowar. With this kind of first-hand feel and experience, I became part and parcel of the rural ethos and, thus, rejuvenated and cemented my links with the farm, farmer and farming.

The exercise to convert traditional agriculture into modern farming closely acquainted me with the intricacies of farm operations, and the psychology and environment of village life. I quickly grasped the realities with my inherent farming instincts. The subsequent exposure to higher learning and the decade long experience of trading in farm inputs further honed my skills and understanding. However, no one, including myself, could have imagined at this stage that all this background would be absolutely relevant and, in fact, most critical for my long journey on the road to hi-tech agriculture in the future.

Need for Inexpensive Demo Centre

The year 1987-88 saw me set up a Public Corporation – the first of its kind in the private sector in the Khandesh region – for production, promotion and propagation of drip irrigation in the country. From my past background, I knew that for the farmer ‘seeing is believing’. I, therefore, wanted to set up a demonstration farm near our workplace, Jalgaon. This demo-farm would display the benefits of drip irrigation technology to the farmers at large. I could not afford to purchase land in the vicinity of Jalgaon city. I, therefore, purchased low priced, barren, hilly wasteland near village Shirsoli, south of Jalgaon, on the Jalgaon-Pachora road. I was astonished to find that there was no approach to the property! I, therefore, had to purchase a piece of land that was between the hill and the road. That provided me the necessary access to reach the hill which did not have even a bullock-cart track. However, mules were seen going up the hill and I did not hesitate to follow them. Some onlookers had a merry laugh.

The Shirsoli hill ranges have been traditionally shown in the Maharashtra Gazetteer to be situated at an altitude of approximately 200 to 300 m (650 to 950 feet) with average rainfall ranging from 650 to 750 mm (26-30 inches). The basaltic hard rock found there is formed from volcanic lava flows. Shallow light soil at the top is



I am sitting discussing the possibility of getting water from such a well with P.M. Chordia.



underlain by 600 to 900 mm (2 to 3 feet) thick layer of weathered basalt (murrum). Average assessment (आणेवारी) of this land from land revenue classification is less than that of degraded land. It is averagely assessed as Rs. 2.78 per hectare. Land along hill slopes is classified as ‘waste-land, uncultivable land, dry land or land unsuitable for crops’ in the land revenue records. I envisaged converting such a land into cultivable land and so began the chapter of its transformation into what is now recognised as the Jain Hills and Jain Valley or Jain Agri Park, Jain Food Park and Green Energy Park.

In the land at the foot of the hillock, I could spot a defunct well in a dilapidated condition filled with boulders, debris, silt, etc. It had arrangements to lift water by bullock power. Even though it was desilted not more than 200–400 litres of stored water could be available from it. “Let us use the well as a tank to store water” – I consoled myself and my colleagues. Farming without assured water was unthinkable – a tenet of which I was fully aware – and thus began the intense search for water.

For hiring drilling equipment, I made enquiries with the Groundwater Surveys and Development Agency (GSDA). The concerned officers sounded alarmed and cautioned me by stating, “We have already surveyed the Shirsoli and Mohadi area where there is no availability of groundwater”. R.B. Jain, an engineer, advised that some water could be stored by digging a farm pond and lining it with a plastic film. The work began forthwith. In the ensuing monsoon some water was stored in the pond, but eventually the film ruptured. As a remedial measure, on 26th April 1989, I drilled a bore downstream of the pond near the present VIP gate and was overjoyed to find success in striking groundwater at a depth of 100m (330ft). However, the joy was short-lived. The pump which worked for 2 to 2½ hours in a day to lift 15 to 20 thousand litres of water in the beginning became ineffective when the source dwindled. The pump could not be worked for more than an hour thereafter. This quantity was just enough for Drinking Water.

‘Could it be possible that instinct, which we have lost, is a better guide than logic? We have a lot to learn. But do we have the time?’

– Aga Khan

Search for Dependable Water Source

The search for a permanent and more dependable source of water became extremely urgent and imperative. There were two proposals under consideration. The first involved laying of a 5-km long pipeline from Nagzari village located on the bank of Girna river and pumping water from there to the farm site. The second proposal was to store water by constructing an earthen percolation dam of adequate size at a proper site on our own land. This would take a long time to fructify. No need to lose heart, I had close to my property a defunct ZP percolation tank. As a follow-up of the first proposal i.e. of laying PVC pipeline from a well, constructed on the bank of river Girna near Nagzari and pumping the river water to be stored in the old well, the work commenced in mid-1990. It marked the beginning of converting the rain-fed farm into an irrigated farm.



Agro-forestry trees like teak and neem were planted along the hill slopes. Work commenced for constructing approach roads and planting of coconut trees along both sides to form an avenue. Soon thereafter work for ‘Gauri’, which was to be our farmhouse, commenced. Plantation of a few horticultural plants such as mango, lemon and pomegranate with the help of drip irrigation was the next logical step. Along the hill slopes the contour trenches were excavated for preventing soil erosion and also for water conservation.

A storage tank of 3.25 lakh litres capacity was constructed on the hilltop to store water pumped from Nagzari (now named Jain River Face (JRF)). This elevated tank generated the required pressure for the drip irrigation system to operate for the land at the bottom of the hill without electric power. Even when these measures were being practised, a thought was paramount at the back of my mind: ‘What if the Girna river discharge dwindles and dries up, or the Government withdraws the permission?’ It was, hence, strongly felt that there was no alternative, but to construct a large percolation tank and adopt other rainwater harvesting measures to overcome the problem on a long-term basis.

I had earlier succeeded in constructing a simple bandhara across a small nalla bed. But it was not possible to construct a large percolation tank without taking technical advice. Hence, the first percolation tank – now known as Jain Sagar – with 12.5 crore litres storage capacity was completed in June 1993 as per design and guidance of the experts in the field with the hope that it would provide a reliable, captive and sustainable water storage and recharge mechanism. An open dug well, 17 m (55 feet) diameter was constructed in 1994 downstream of the embankment near the spillway. It is yielding on an average a minimum of 2 lakh litres and a maximum of 21 lakh litres per day. The well did not fail even during the drought year of 2000-2001.

By 1997-1998, four more wells had been dug in the downstream area which get recharged because of ‘Jain Sagar’. On an average, the yield of all these wells, during normal monsoon, together totals up to a minimum of 6 lakh and a maximum of 31 lakh (3100 cum) litres per day. I did not realise at that time that all these efforts are in essence part of, what is technically known as, rainwater harvesting, water conservation and groundwater recharging activities, generally described as watershed development. I merely acted according to the maxim : “Necessity is the mother of invention”. Every drop of water so made available was judiciously utilised through

*‘The nation
that destroys
its soil,
destroys
itself.’*



Percolation well, downstream of ‘Jain Sagar’.



drip irrigation. Purchase of surrounding wasteland continued as water availability through these measures kept increasing, enabling more areas to be brought under purposeful agriculture.

By now hundreds of farmers started visiting the site. They were amazed at the transformation of wasteland that had been brought about through watershed development and drip irrigation technology. The project had even attracted the attention of government extension officers and opinion makers. There was a growing demand for dissemination of information and training to these visitors. As it is, I had already begun the R&D activities which were attracting researchers and scientists from across the country. In order to provide accommodation to the visiting guests, ‘Jain Gurukul’ was completed in late 1995, as a residential training and information dissemination centre.

Wasteland Poses a Challenge

The development so far accomplished was mainly confined to the foot of the hill and along the slopes of the hill. Land at the top of the hill, however, remained dry and barren. It was so unpromising a proposition that even a casual look by the most enterprising farmer would have dissuaded him from attempting to bring such land under cultivation. Such a dry wasteland admeasuring 68 ha (168 acres) was purchased by me in 1996-97. It was devoid of the soil layer necessary to undertake farming. It was murrum, full of boulders and stones. Every colleague was beset with the big question as to how to develop such a land. However, I was quite calm and fully confident of success.



Terracing of Jain Hills : boulders exposed along drip lines

I concluded that first of all it would be necessary to get rid of boulders and pebbles if the wasteland was to be made cultivable. However, it was not easy to make the land free of boulders and stones. With bullock-carts and manual labour it would have taken a year and a half to accomplish the task. Hence all boulders and large stones were removed using bulldozers and front-end excavators. These boulders and stones were used to plug gullies and for contour bunding. The pebbles, to the extent that could be collected, were used for forming internal kutchra roads. These measures prevented soil erosion and facilitated cultivation of the land on the hilltop. Moreover, silt from the adjoining Mehrun lake was brought and spread to amend the soil. Thus the land which was once considered uncultivable was put to use. Two water distribution tanks of 3.25 lakh (325 cum) and 2.75 lakh (275 cum) litres were built for storage.



Land levelling was undertaken only where deemed necessary. Along slopes of the hill on all sides, bench terraces were formed to check soil erosion and facilitate plantation. Land along the slope had eroded exposing the boulders and stones. Terracing of such a land posed a problem. Tractors failed to plough, because of the steep slope and deeply imbedded exposed rocks and boulders lying along the slopes. The idea of deploying bulldozers to make terraces on the slopes of the hills was implemented. Later, a cultivator-like plough was specially designed and attached to a bulldozer. It was used to make these terraces cultivable. In some of the more difficult places the slopes were dressed and levelled manually.

As I went along, a few novel ideas emerged. To quote an example, a large gully was present at the road embankment near the present communication tower from where considerable erosion of land used to take place. During monsoon when I was standing on the Jain Valley road, I saw a waterfall from near the tower. I impulsively climbed up



Road-cum-drain bandhara near tower

the hill. I felt as if the soil flowing with the waterfall was crying, ‘Save me’! A waterway in the form of pipes is to be provided for the water to flow safely from below the road, as per the conventional civil engineering design. However, I constructed a bund/bank instead. I provided the pipes at a higher level of the existing road. This resulted

in a bandhara-cum-road and a small pond was formed in front of the eastern side of the bandhara. It was only the overflow from that pond that flowed through the pipes.

The gully was thereafter plugged by providing contour trenches and bench terraces. Trees like tamarind, custard-apple and guava were planted along the slopes to control soil erosion, stabilise soil and to harness water. Thereafter mango grafts were planted across the plateau on the hilltop. Looking at the mangoes thriving all over, farmers, even from Konkan, were dumbfounded and looked at the fruit in disbelief. It is noteworthy that all these horticulture trees, at the hilltop, on the slopes and at the foothill, are irrigated only through modern irrigation techniques. Nothing else could have done the job anyway.



Mango plants with onion intercrop in initial stage with drip irrigation (1999).

All these efforts and experiments were to demonstrate the techniques of rainwater harvesting and drip irrigation to the people at large. The message has indeed gone home. Visiting farmers enthusiastically try and emulate the model. I thought it was time to take a leap forward. I set in motion various field experiments and research projects on different aspects of soil, water, plant nutrition and growth relationship and management. These R&D efforts were in the backdrop of various rainwater harvesting structures which were created.



*‘Like a bridge
over troubled
waters,
I will lay me
down.’*

– Paul Simon

Commitment Got Deeper

As horizons broadened, I realised that it was not enough only to develop watershed and reclaim wasteland through modern technology like drip. I must take help from advanced tools like biotechnology and produce superior planting material. I, therefore, set up a Tissue culture laboratory for banana. I commercialised these, in the country for the first time – as the Grande Naine Banana variety. The tissue cultured plantlets improve the yield by 25 to 30% and reduce the maturity period from 18 months to 12 months. This helped farmers by providing them with yet another critical input. It also helped me complete my pledge to manufacture and market most of the critical hi-tech agro-inputs. Latest in the link are initiatives like manufacture of organic manure, tissue cultured pomegranate varieties, ultra high density plantation and solar powered drip irrigation system. This would also mean increase in food production in a socially and environmentally sustainable manner. Perhaps quite unawares, I had devised a way to solve fundamental issues such as population growth, land, water and electricity shortages through the use of these latest technologies.



I somehow and always tended to think holistically. In order to promote forward integration I created a world-class Onion & Vegetable Dehydration plant as well as a Fruit Processing facility. By purchasing the fruits and vegetables from the farmers I am realising my dream of creating a 'One Stop Agri Shop'. Thus we supply to the progressive farmer his basic needs of hi-tech planting materials, irrigation methods and a host of other modern technologies and know-how, and later buy back from him what he produces. We then add value to his produce by processing and marketing the same in domestic as well as international markets. We thus complete the agricultural value chain from under one roof. We believe this is the only integrated model of its kind in the country or, as far as we know, in the world.

What is more, we have now begun to create 'wealth from waste'. The residual waste from the fruit and onion plant is being converted into biogas (methane). This biogas is being used to generate power to run the plant. The slurry of the biogas plant is simultaneously used for production of high-value organic fertilizer. This, in turn, becomes an invaluable input for 'Nature Farming'. In short, the Company gives back to the soil what it takes from it. This way, we are going a step ahead of completing what is known as 'Agricultural Value Chain'.

The project in its entirety is called 'Jain Hi-tech Agri Institute' – i.e. Farm Resource Research & Development, Demonstration, Training and Extension Centre. In converting a hilly, barren, unproductive terrain into a green, well cultivated productive park, I feel that I have lived upto my fundamental belief : 'No land is wasteland. What is required is an infinite capacity to take pains and manage resources with care and craft'. I subscribe to Albert Einstein's thought when he says "A hundred times every day I remind myself that my inner and outer life depend on the labours of other men – living and dead. And that I must exert myself in order to give in the same measure that I have received and am still receiving."



02. Watershed Development : Concept & Consequence



What is a Watershed ?

A watershed is the entire land area on which rainwater falls and runs/drains off to a common point through streams.

The watershed comprises of catchment area (recharge zone), command area (transition zone) and delta area (discharge zone).

A watershed can be a small unit comprising of a small stream encompassed even by a few hectares or it can be a large area of thousands of square kilometres denoted by a large basin of a river such as Ganga.

In a plain land form it is far more difficult to delineate a watershed, whereas in a hilly terrain it will generally connote ridge to valley area as a unit.

In either case every watershed, whether small or large, is a natural hydrological entity. It responds more effectively to various engineering structures and/or biological and cultural treatments. These are designed to maximise productivity per unit of land as well as water for the purpose of maintaining natural ecological system and for the benefit of all forms of life.

In practice, watershed development means harnessing water in a catchment area of a particular stream or river by means of conservation, regeneration and judicious management of ecological, human and animal resources.

Watershed planning and development, as is conventionally understood, involves utilisation, conservation and overall management of the catchment precipitation, infiltration and percolation of monsoon rainwater.

We have, however, added the following dimensions to this conventional definition by way of forward integration: Creation of water reclamation structures, artificial recharging and soil quality enhancement measures, use of modern irrigation methods for achieving higher water-use efficiency of the harvested / percolated water, maximum use of non-conventional sources of energy and development of suitable green cover as well as natural habitat for the fauna.

Elements of Watershed Management

Watershed management is a holistic approach aimed at optimizing the use of land, water and vegetation in a given area. It helps alleviate drought, moderates floods, prevents soil erosion, improves water availability, and increases fodder and agricultural production on a sustained basis by achieving a balance between available natural resources and their use by living beings.

Soil and water are amongst the most important natural resources within the ecosystems. They form the basis of all life – plant, animal and human. Yet, the

*‘What we do
on land is
mirrored
in the water...’*

– Central
Lake Ontario
Conservation
Authority



exploitation of these precious resources without checks and balances has led to their rapid degradation. Interesting statistics in this regard is given in Table 2.1.

Table 2.1 State-wise extent of various kinds of Land Degradation in India
(As per NBSS&LUP-ICAR-2005) (Area in thousand hectares)

Name of the State	Water Erosion	Wind Erosion	Water Logging	Salinity/ Alkalinity	Soil Acidity	Complex Problem	De-graded Area	Geographical Area	Degraded Area (%)
Andhra Pradesh	11518	0	1896	517	905	156	14992	27505	54.5
Arunachal Pradesh	2372	0	176	0	1955	0	4503	8374	53.8
Assam	688	0	37	0	612	876	2213	7844	28.2
Bihar+ Jharkhand	3024	0	2001	229	1029	0	6283	17387	36.1
Goa	60	0	76	0	2	24	162	370	43.9
Gujarat	5207	443	523	294	0	1666	8133	19602	41.5
Haryana	315	536	146	256	0	214	1467	4421	33.2
Himachal Pradesh	2718	0	1303	0	157	0	4178	5567	75.0
J & K	5460	1360	200	0	0	0	7020	22224	31.6
Karnataka	5810	0	941	110	58	712	7631	19179	39.8
Kerala	76	0	2098	0	138	296	2608	3886	67.1
MP + CG	17883	0	359	46	6796	1126	26210	44345	59.1
Maharashtra	11179	0	0	1056	517	303	13055	30771	42.4
Manipur	133	0	111	0	481	227	952	2233	42.6
Mizoram	137	0	0	0	1050	694	1881	2108	89.2
Meghalaya	137	0	7	0	1030	34	1208	2243	53.9
Nagaland	390	0	0	0	127	478	995	1658	60.0
Orissa	5028	0	681	75	263	75	6122	15571	39.3
Punjab	372	282	338	288	0	0	1280	5036	25.4
Rajasthan	3137	6650	53	1418	0	110	11368	34224	33.2
Sikkim	158	0	0	0	76	0	234	710	33.0
Tamil Nadu	4926	0	96	96	78	138	5334	13006	41.0
Tripura	121	0	191	0	203	113	628	1049	59.9
UP+ Uttarakhand	11392	212	2350	1370	0	0	15324	29441	52.0
West Bengal	1197	0	710	170	556	119	2752	8875	31.0
Delhi	55	0	6	10	0	11	82	148	55.4
Union Territories	187	0	0	9	0	9	205	825	24.8
Grand Total	93680	9483	14299	5944	16033	7381	146820	328602	
Grand Total (Mha)	93.68	9.48	14.30	5.94	16.03	7.38	146.82	328.60	44.7

'If productivity per unit of soil and water is to improve, the focus has to shift from crop intensity to soil fertility, from large dams to watershed, from flood irrigation to drip irrigation and from food security to water security.'

– Bhavarlal Jain

Source : There are several estimates for the extent of degraded lands reported by various agencies in the country. These estimates vary largely due to variation in approaches and methodologies of estimation. In absence of comprehensive and periodic scientific surveys, the figures reported by National Bureau of Soil Survey & Land Use Planning, Nagpur based on studies and several estimates (2005) for various land degradation have been considered as logically concluded and are being used for various purposes.

Our suggestions: • National Watershed Development Programme in Rain Affected Area (NWDPPA), National Rural Employment Guarantee Act (NREGA), Integrated Rural Development Project (IRDP), Desert Development Programme (DDP) and Drought-Prone Area Programme (DPAP) etc. must all be amalgamated to form one Scheme of Wasteland Development & Rainwater Harvesting. • Similarly, Forest, Horticulture, Agriculture, Soil Conservation, Rural Development, Animal Husbandry Departments etc. must all be brought under one umbrella. • Each and all of these areas have to be differentially treated with appropriate need based measures to make them productive watershed is but on solution, though a major one.





Hill terracing at Jain Watershed

Watershed management is synonymous with soil conservation and rainwater harvesting with an emphasis on optimum benefits to maximise productivity of the land. Watershed management practices involve changes in land use, vegetative cover, increase in water use efficiency and other structural and non-structural actions to achieve specific objectives.

Here, the Jain Hills and Jain Valley area forms part of two major watersheds. In fact, in this area Government of Maharashtra had already provided two percolation tanks, one each near Jain Hills and Jain Valley. However, both of the percolation tanks were non-performing. We had to virtually rebuild both of these. Moreover, in our own area we planned and developed two more micro-watersheds. Together these are referred to as Jain Watershed. Map 2.1 shows the drainage lines within Jain Watershed.

Jain Watershed facilitated soil and water conservation of degraded land by taking up rainwater harvesting measures, constructing soil conservation structures and applying state-of-the-art micro irrigation system (MIS) technology. These measures helped in optimising agricultural output without undue exploitation of natural resources. Today, various farmers, researchers and eminent social workers are utilising these experiences. Some farmers have also successfully utilised and reproduced this experiment in part in their respective regions and thus validated this model.

Broadly, the objectives set for Jain Watershed development are :

- Maximising farm production
- Utilizing created irrigation potential fully
- Minimizing over-irrigation and ecological degradation
- Minimizing energy consumption
- Achieving high water conveyance and irrigation efficiency
- Converting rain-fed wasteland into sustainable agro-forestry, horticulture and, in part, open-field agriculture
- Generating employment and self-development opportunities on sustainable basis
- Promoting environmental regeneration of the flora and fauna.



What is Watershed Development?

Watershed development means rainwater harvesting and conservation, and rejuvenation of natural water resources. A balance between the available natural water and its use for human and livestock requirement has to be achieved. Accomplishing such an equilibrium ought to be the ultimate goal of this development.

Why Watershed?

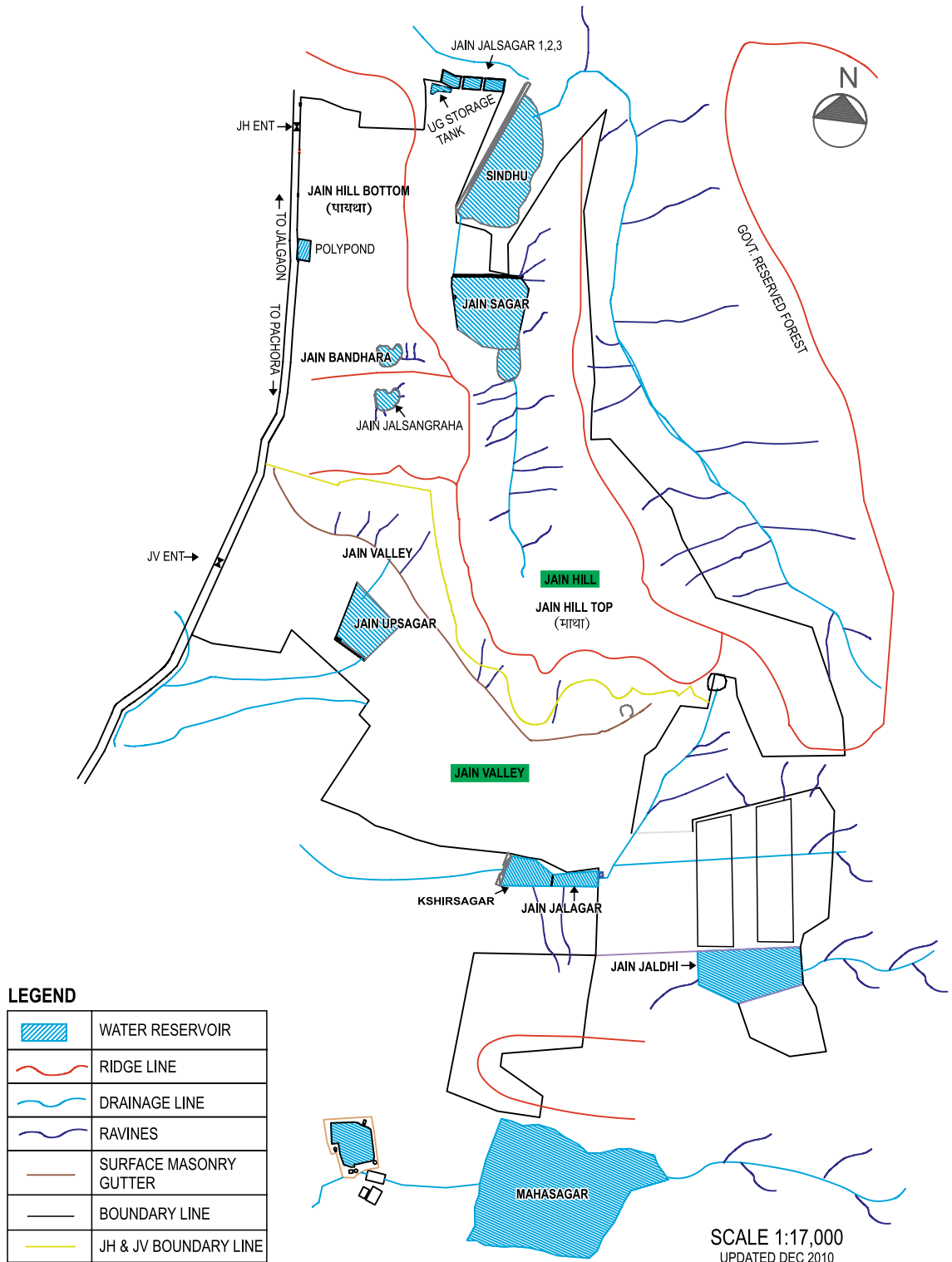
Early development of Jain Hills area started with literally no adequate water even for drinking. The crying need for water for irrigation compelled us to fashion a small polylined tank – a minor rainwater harvesting structure. Till then, nobody within the Corporation paid any attention to the concept of watershed and the technicalities involved. The whole scenario changed after construction of the first percolation tank named “Jain Sagar” at Jain Hills. The impact of Jain Sagar showed us the way and became the key to our efforts for fulfilling the water requirement of this area.



Jain Sagar Percolation Tank



Map 2.1 : Drainage lines within Jain Watershed



03. Jain Watershed : Locale & Features



Model Watershed Area (Jain Hills & Jain Valley)

Realizing the importance of the impact that practical demonstration has upon the farming community, I started farming experiments in Jain Hills (subsequently referred to as Agri Park) area since 1989. The model area is spread over more than 263 ha (650 acres) of land including Jain Hills and Jain Valley. The details of land purchased with year and development area are presented in Table 3.1.

Location

Situated between latitudes 20° 55' and 20° 58' North and longitudes 75° 30' and 75° 35' East, area of Jain Hills and Jain Valley falls in Survey of India topographical index number 46[P/9]. This area of Jain Watershed is located at a distance of about 7 km from Jalgaon on the Jalgaon – Pachora State Highway in the domain of Mohadi village (Refer Map 3.1).

Elevation of ground varies from 207m to 286m above mean sea level. It is recognised as part of Shirsol hills (Ref: Gazetteer of Government of Maharashtra, GoM – Jalgaon District). The hills in the watershed area are northerly spurs of the famous Ajanta hill ranges. It is an integral part of the Deccan Trap, undulating, degraded fallow land with occasional plateaus. The area forms part of the Girna Valley. River Girna being the main tributary of the river Tapi.

Location	Year of Procurement	Area (ha)
Jain Hills	1988	1.62
Jain Hills	1993	2.43
Jain Hills	1994	23.08
Jain Valley	1994	72.50
Jain Valley	1995	19.83
Jain Hills	1996	30.73
Jain Valley	1996	9.28
Jain Hills	1997	38.02
Jain Hills	1999	0.58
Jain Valley	2001	3.08
Jain Hills	2002	0.81
Jain Hills	2003	2.43
Jain Hills	2004	33.60
Jain Valley	2006	13.00
Jain Valley	2007	1.17
Jain Hills	2008	2.02
Jain Valley	2008	7.11
Jain Hills	2009	2.09
Total		263.38 (650 acres)

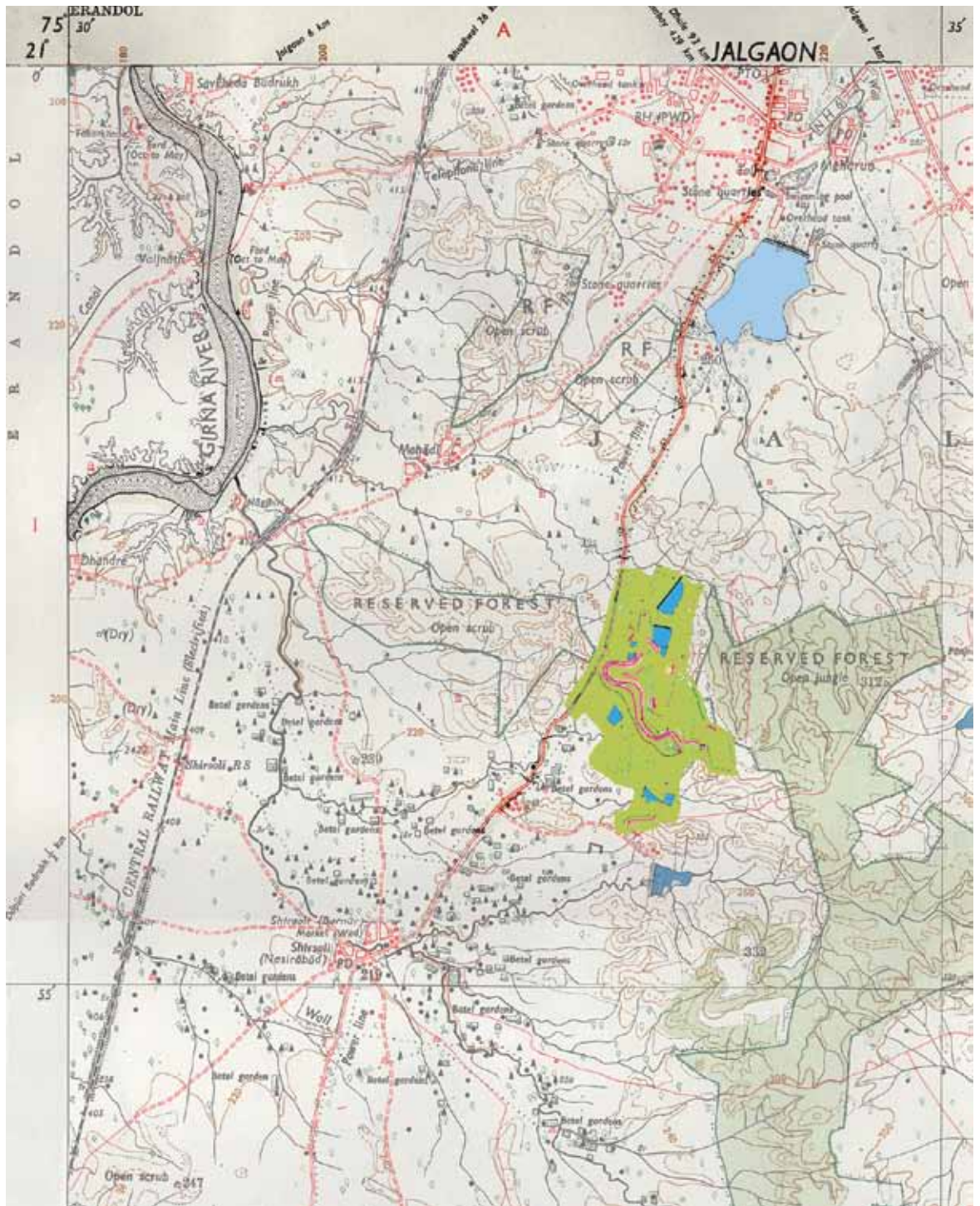
Rainfall & Climate

Climate of the watershed area is tropical. It falls in the zone 7 (Assured rainfall zone with rainfall 600-900mm) under Maharashtra State Agro Climatic Zones classification. (Refer Map 3.2)

However, in reality Jalgaon is in the rain-shadow region. The rainfall is often scanty and meagre, the annual average range being 650 mm–750 mm (26 inch – 30 inch). The rainy season normally starts in June and recedes by the last week of September. July and August are the wettest months of the year. Meteorological data from our automatic weather station installed in Jain Watershed is given at Table 3.2.



Map 3.1 : Location map of Jain Watershed (SOI index no.46[P/9])



 Jain Watershed

Map 3.2 : Agro-climatic Zones of Maharashtra

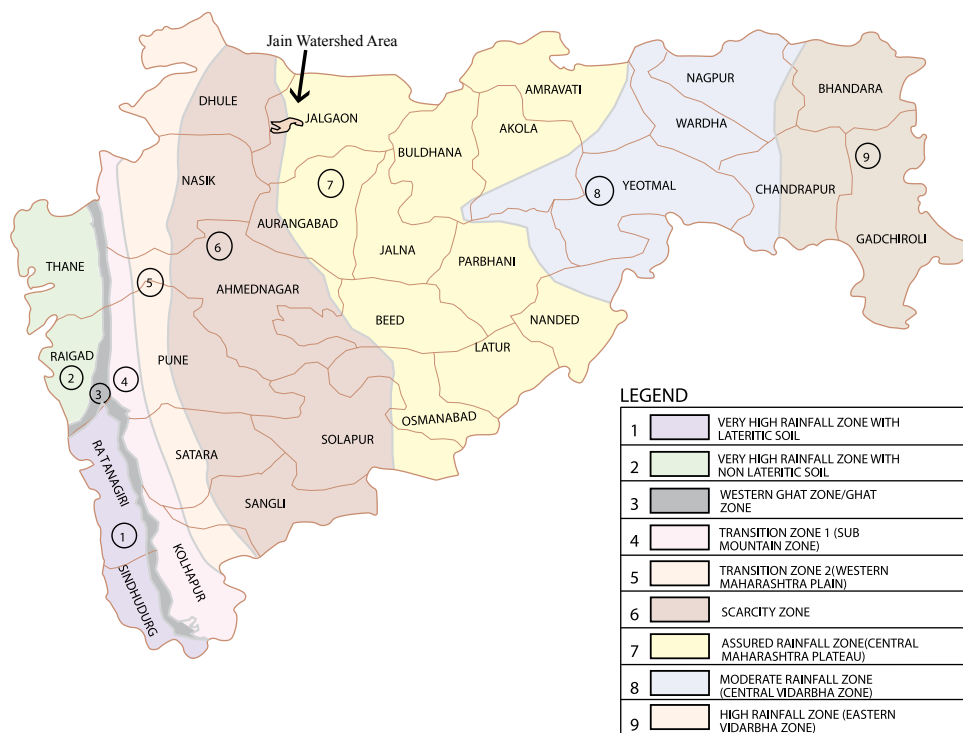


Table 3.2: Meteorological Data at Jain Watershed

Year	Description	Solar Rad. (Watts/m ²)	Temperature (°C)	Humidity (%)	Wind Speed (km/hr)	Annual Rainfall (mm)
2003	Max.	1488.2	45.9	100	37	1031.67
	Min.	5.9	11.7	12.1	1.3	
2004	Max.	1488.2	44	100	38.6	767.6
	Min.	5.9	13.7	10.9	1.6	
2005	Max.	1358	45.9	100	55.6	491.85
	Min.	8.8	11.7	1.6	1.6	
2006	Max.	1200	52.5	100	32.2	1354.6
	Min.	8.8	12.1	9.5	0.8	
2007	Max.	1488.2	48.2	100	51.5	691.9
	Min.	11.8	12.9	15.1	1.6	
2008	Max.	1470.2	46	98.7	33.8	510.2
	Min.	11.5	10.5	1.6	1.5	
2009	Max.	1382.4	49.2	98.7	51.5	899.1
	Min.	1.5	12.9	1.6	1.6	
2010	Max.	1135.3	48.2	100	35	770
	Min.	1	5.8	9.5	0	



Year	No. of days Temperature Above 40°C	No. of Hours Temperature Above 40°C	No. of days Temperature Above 45°C	No. of Hours Temperature Above 45°C	Annual Rainfall (mm)	No. of rainy days
2004	68	278.5	0	0	767.6	79
2005	65	270.5	1	2.0	491.8	64
2006	70	255.0	1	3.5	1354.6	63
2007	90	295.5	9	13.0	691.9	61
2008	85	306.5	7	9.0	510.2	54
2009	103	484.0	8	12.0	899.1	48
2010	92	487.5	23	26.5	770.0	71

There is a large difference between minimum and maximum values of temperature and humidity. This indicates the adversity of climate in Jalgaon.

Table 3.3 is an analysis report indicating the global warming effect on Jain Watershed. From 2007 onwards, incidences of temperature above 40°C and 45°C are increasing. The probable reason may be increase in urbanisation and industrialisation and reduction in green cover. It is high time everyone of us thinks about Watershed and Green Cover development.

Physiography

Physiographically the watershed lies in the northern aspect of the outermost Deccan Trap basaltic region. The hills are basically denuded and successively give rise to plateau top (PT), denudational slopes, moderately dissected plateau (MDP – A), slightly dissected plateau (SDP – B&C), gullied land (GL), and alluvium. The details of areas with the extent of their slopes are given in Table 3.4. Map 3.3 (page 27) shows contour lines and nature of slope in watershed development area.

Slope	Area (ha)	% of total area
Moderate Sloping (0 to 10%)	57	21.7
Moderate Steep (10 to 15%)	70	26.6
Steep (15 to 25 %)	84	31.9
Very Steep (25 to 33%)	43	16.3
Very Very Steep (>33%)	09	3.4

Hydrogeology

The area comprises of basaltic lava flows of the Cretaceo-Eocene epoch, when lava flows were emplaced in the form of Simple, Pahoehoe and Compound flows with individual flow thickness varying between 3m and 80m. There are possibly 5 flows in this area. There is a shallow soil cover of between 0.6m and 1.20m overlaying weathered and fractured basaltic murrum. The plateaus of the hill consist of medium black cotton soil mainly vertic inceptisols and vertisols.



Water Availability: Then and Now

The geological formation of the area was studied by Maharashtra Remote Sensing Applications Centre, MRSAC, Nagpur, in 1997 with the help of a satellite survey. According to this survey, the requirement of water for agriculture and horticulture in the watershed area is far more than the available storages and hence there is no way other than inter-basin transfer of water to cater to the agricultural needs of the area.



Photo of weather station

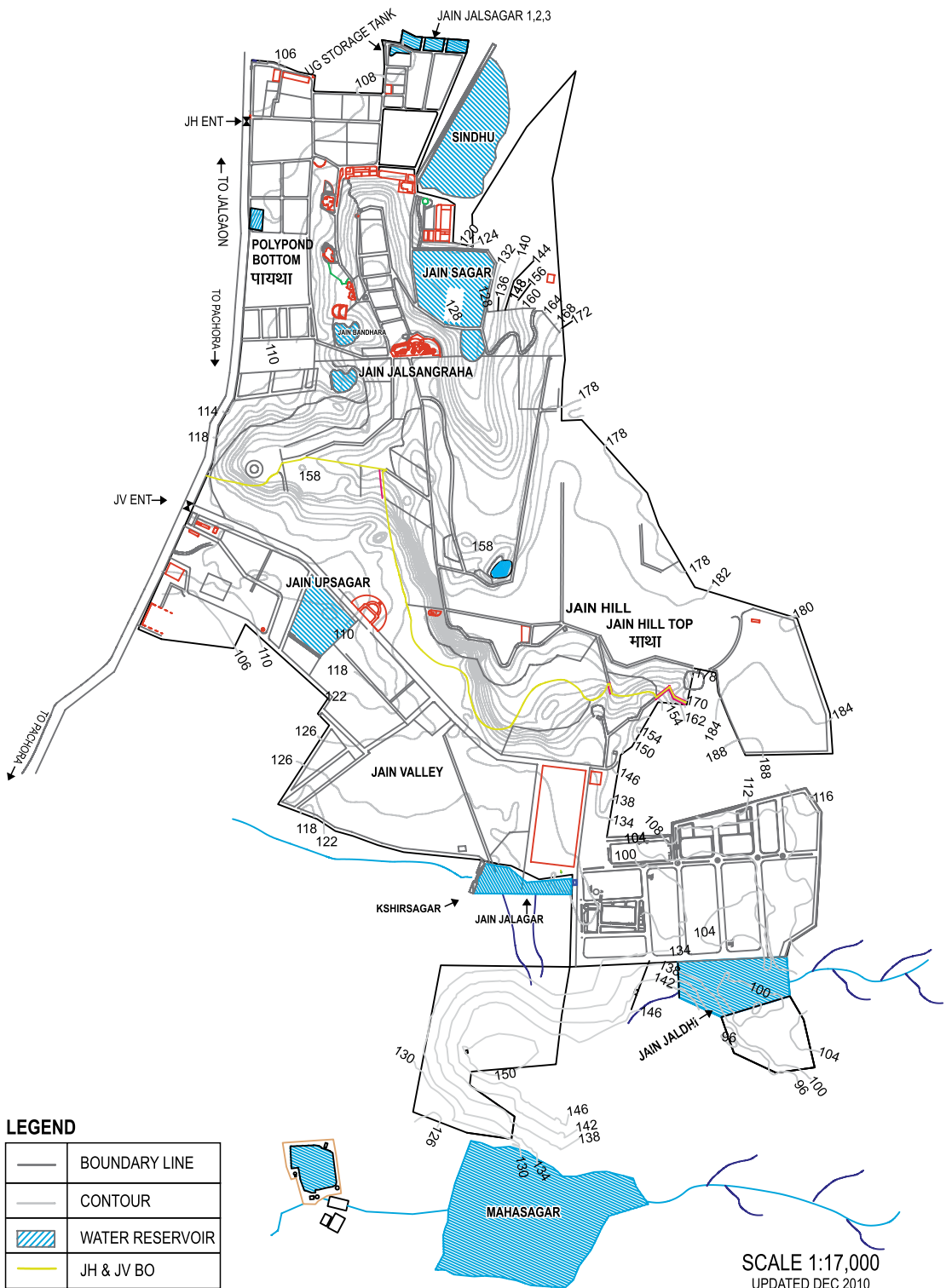
*'The water
of life is in
a single drop
of rain'*

*– Sophia Bedford
Pierce*

However, today, as a result of watershed development, the area has developed almost self-sufficiency in water required for agro-forestry assuming normal monsoon. The farming experiments, by transporting water entirely from outside, commenced here in 1988-1989. Today's requirement of water for irrigation in the area is 80 to 100 crore litres (8 to 10 lakh cum) per year. This quantity is created through watershed development efforts by harvesting every drop of rain.



Map 3.3 : Topographical contour map of Jain Watershed



04. Land & Soil Conservation Measures



Water, an element amongst others, is mainly responsible for land and soil erosion. Often the soil conservation works carried out for preventing soil erosion help in water conservation as well. Following are the main objectives of preventing soil erosion caused by high velocity run-off:

- Controlling, channelising and collecting surface run-off
- Reducing adverse impact of rain on soil
- Decreasing speed of flowing water to increase its infiltration
- Enhancing water infiltration and holding capacity
- Improving soil structure and fertility

Soil erosion not only has on-site, but also off-site impact by way of sedimentation of the waterways. The soil erosion depends upon, among others, the land slope and intensity of rainfall. The high velocity water takes away more soil with it, whereas the water flowing with low velocity causes deposition of silt carried by it. Water flowing with high velocity has less residence time resulting in lesser infiltration. On the other hand, the water flowing with lesser velocity has greater contact time permitting more infiltration resulting in augmentation of the ground water. In short, ‘slow down the flow of water and make it infiltrate’ is the principle of soil conservation.

Details of works carried out to achieve this objective are given chronologically in Table 4.1 below and shown in Map 4.1.

‘We shall never achieve harmony with the land; the important thing is not to achieve, but to strive.’

– Aldo Leopold

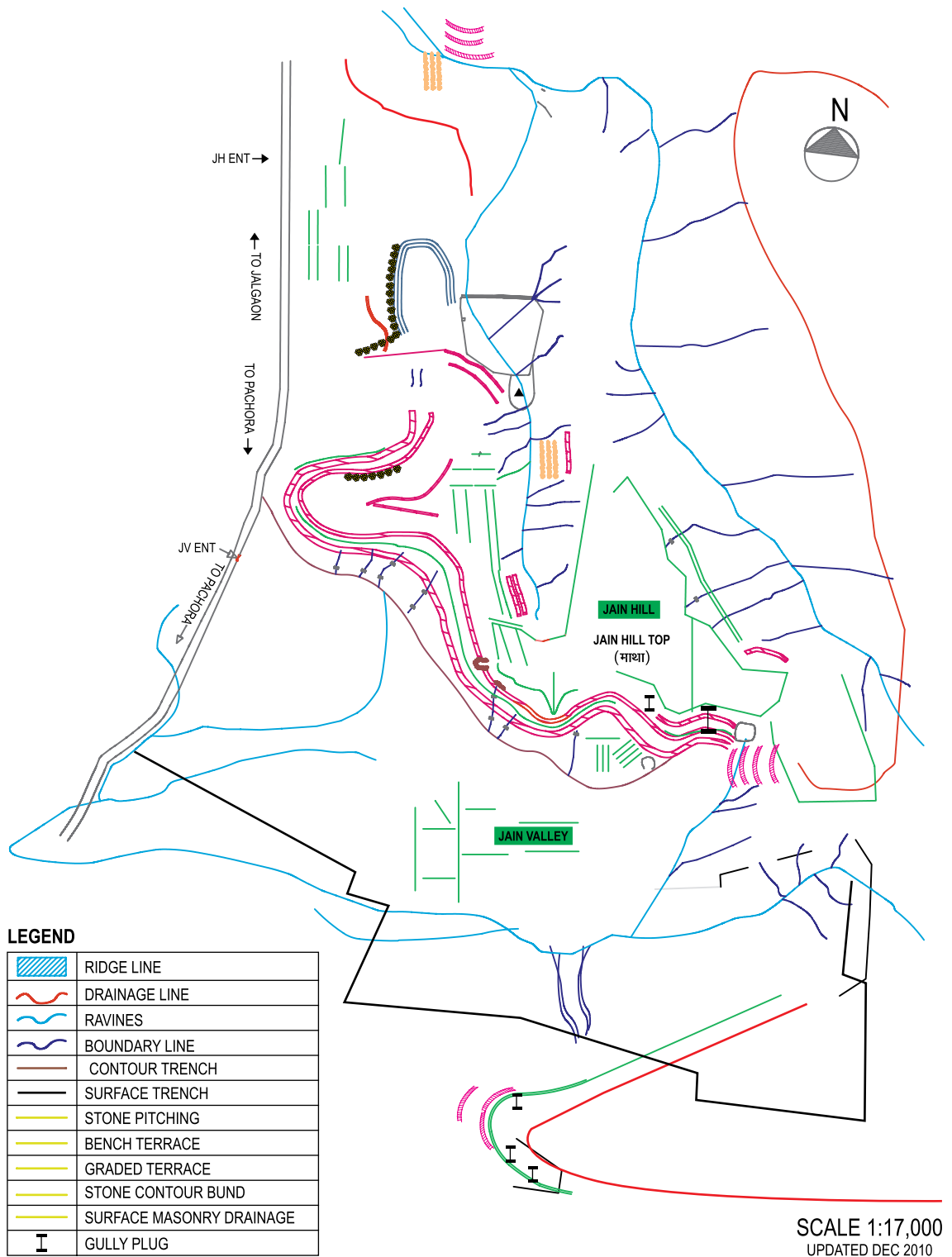
Measure unit/Year	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Sub-soil drainage (ha)	1.20	-	-	-	-	-	-	-	-	-	-	-	1.45	1.60	-	-	-	-	0.78	5.03
Contour trenches (ha)	-	2.00	1.20	-	-	-	-	-	-	-	-	0.75	1.28	0.85	-	0.30	-	-	0.20	6.58
Surface trenches (km)	-	-	-	-	-	3.65	-	-	2.99	1.50	0.25	-	1.46	1.18	0.97	-	0.85	1.23	0.47	14.55
Bench terracing (ha)	-	-	-	-	24.00	-	6.00	-	-	-	12.00	1.08	-	6.00	3.50	-	-	1.77	-	54.35
Graded terracing (ha)	-	-	-	-	-	1.20	2.00	-	-	-	-	0.35	0.43	0.76	-	0.15	0.20	-	0.18	5.27
Land levelling (ha)	-	0.80	-	03.50	4.80	-	-	-	-	08.80	-	-	1.93	3.09	1.96	-	0.85	1.45	1.05	28.23
Stone pitching, m ²	-	-	-	-	-	-	2370	1210	605	-	930	-	1170	1800	1200	400	1100	-	-	10785
Gully plugs (nos.)	-	-	-	-	8	-	2	-	2	-	-	3	2	-	2	2	-	-	-	21
Contour bunding (ha)	-	-	-	00.80	-	-	-	-	-	-	-	-	0.60	0.45	-	0.20	-	0.33	-	2.38

Soil Conservation

In our land where around 70% population is impacted by agriculture, depletion of cultivable land owing to soil erosion poses a major problem. We are losing agricultural land to erosion twice as fast as the new land we are gaining for farming. Soil conservation efforts therefore assumes greater significance. It is now an accepted fact that soil conservation leads to a number of benefits.



Map 4.1 : Land and soil conservation measures at Jain Watershed



In the model area of Jain Watershed, emphasis is on soil conservation works with a view to:

- Utilize the land according to its capability
- Develop adequate vegetative cover on the soil during rainy season
- Harvest as much rainwater as possible at the place of rain
- Channel excess water with safe velocity
- Optimise productivity per unit of area, time and water
- Increase cropping intensity and land equivalent ratio through intercropping and sequence cropping
- Utilize marginal lands through alternate land-use systems
- Reduce the high erosion vulnerability of the soil

Following soil conservation techniques have been used in Jain Watershed area.

Sub-Soil Drainage System

There is a percolation tank constructed by Zilla Parishad upstream of our land. As the cut-off-trench, COT, of this tank was not properly filled by impervious black soil, water seepage under the embankment of the tank damaged about 1.2 ha out of 1.64 ha of the initially acquired land due to waterlogging and salinity. Saturated soil condition and reduced air content thus adversely affected crop growth. Draining excess water, therefore, was of paramount importance.

To make drainage effective, speciality Rib-loc pipes with holes on upper half were laid at 0.9 - 1.2m below the surface, GL (Fig 4.1). By

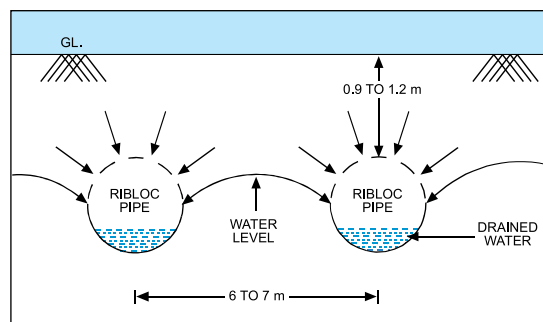


Fig. 4.1 : Sub-soil drainage network: layout geometry



'Rib-loc' pipes: Sub-soil drainage chamber at Jain Hills-Bottom.

making a network of these Rib-loc pipes, water could be effectively drained off the field. The underground drainage in the initial phase of development reclaimed the 1.2 ha (3 acres) water-logged land. The installed system is still operating.

Sub-soil drainage system offers the following benefits:

- Drainage system does not occupy usable land
- Drainage network does not hinder farming operations



- Excess water and unwanted salts are drained off, making soil suitable for cultivation
- Drainage causes good aeration enabling better growth of roots / crops
- Growth of weeds and accumulation of green waste is drastically reduced
- Excess rainwater gets drained off quickly reducing run-off which ultimately decreases soil erosion

Repairs of the upstream percolation tank, extraction of water collected through dug wells/bore wells and use of drip irrigation further reduced the occurrence of water-logging. The upstream percolation tank, Sindhu, was rebuilt in 2001. Many other measures were also initiated and completed to prevent recurrence of water-logging. Subsurface drainage is also done at the lawn area near Gurukul and other lawn areas in 2004-2005. In 2010, subsurface drainage is done for lawn near guest house. PE corrugated pipes wrapped with geofabric socks are used for this purpose.



Drainage work in progress near guest house; inset: corrugated pipe used for drainage

'It is important to save the earth because that is all what we have, we do not get another.'

Contour Trenches

Contour trench is useful for increasing soil moisture by impounding the run-off flowing over the slopes. In addition, it drastically reduces land erosion by entrapping the run-off from sloping lands. Any eroded soil gets trapped in the trenches, causing favourable condition for development of roots resulting in vigorous growth of trees. Contour trenches were dug on sloping side of Jain Hills land during 1993-94.



Trenches perpendicular to the slope



Surface trenches on Jain Hilltop

The trenches are excavated at right angles to the slope, at some specific distance where the land slopes are mild, to avoid / reduce problems in cultivation activities.



A Lesson Learnt

Field trenches are useful as soil conservation as well as run-off retention structures. However, if we throw the twigs and branches after pruning of the trees into these trenches, the trenches can become a breeding ground for stem borers. This did happen in Jain Hilltop area in the year 2001. One of the mango experts pointed out this fact and a timely corrective action saved the main plantation. A disaster was thus averted. A lesson was learnt that every aspect of watershed development has to be carefully reflected over and attended to.

On the upper slopes of Jain Hills, i.e. on the Jain Hilltop area, a single continuous trench is excavated around the periphery. Water flowing from all directions is collected in this trench. Contour Trench Geometry is shown in Fig. 4.2.

The depth of a contour trench is generally about 0.6m. However, in this area the depth is 0.9m for accumulating and composting dried leaves and grass. The compost manure, after decay, can be used periodically. The details of contour trench work are presented in Table 4.2.

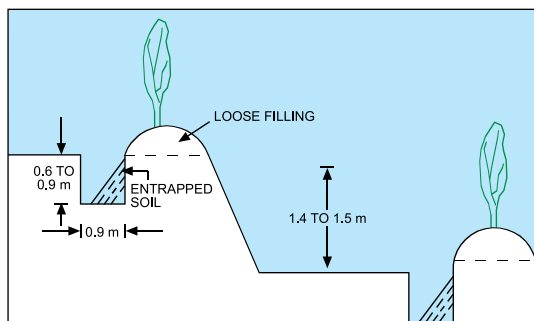


Fig. 4.2: Contour trench geometry

Table 4.2 : Contour trench work details (ref. Fig. 4.2)						
Location	Area (ha)	Hill slope (%)	Trench width (m)	Trench depth (m)	Trench spacing (m)	Type of plantation near trenches
Jain Hills	3.20	25-30	0.9	0.60-0.90	1.4 - 1.5	Agro-forestry, mainly teak
Jain Hills	2.23	25-30	1.0	0.45-0.60	1.25-1.5	Agro-forestry
Jain Valley	1.15	25-30	1.0	0.45-0.60	1.25-1.5	Mango, Agro-forestry

Bench Terracing

Wasteland development work started in 1995-96 on the plateau area of Jain Hilltop. By 2009 bench terracing on hill slopes was completed on 54 ha (134 acres) of land. Bench terracing geometry is illustrated in Fig. 4.3 and details of work are given in Table 4.3.

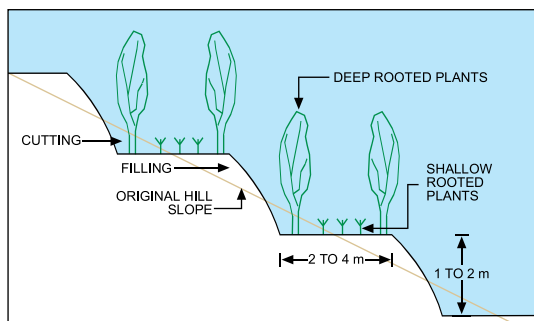


Fig. 4.3: Bench terracing geometry

Bench terracing is useful for both soil and water conservation. It helps in reducing the velocity of water flowing downhill, resulting in more infiltration of water and



increasing the moisture content of soil. At the same time it achieves, more or less, uniform distribution of soil moisture and retention of manure. The soil erosion and formation of ravines are also prevented. No new ravines have formed since this work was undertaken.

Table 4.3 : Details of bench terracing				
Location	Area (ha)	Hill Slope (%)	Terrace width (m)	Step height (m)
Jain Hills	48.4	20 to 30	2.5 – 3.7	1.2 – 1.8
Jain Valley	5.95	25 to 30	2.5 – 3.5	1.25–1.5

Trench on Foothill Side of Terrace



During 1999-2000, trenches were excavated on the inner side and embankments raised on outer sides. This enhanced water conservation effectiveness by reducing the run-off velocity.

These trenches were not continuous and were at a distance of 1.5m (5ft) on both sides. Original soil strata was left for plantation. These trenches, sealed from both sides and embanked on one side, provided sufficient storage for run-off and improved water uptake and moisture level for the trees planted.

Shallow rooted annual or biannual crops are cultivated on these terraces. Deep rooted trees like mango, aonla, guava, tamarind, lime, etc. are also planted on steep sloping lands to reduce soil erosion. Similarly sorghum, pearl millet are grown as intercrops in the light soil on the terraces during monsoon season. All these are under drip irrigation.



Aonla plantation on terraces under drip with sorghum as intercrop



Bench terracing work in progress with a bulldozer

Most bench terracing work in Jain Hills has been done with bulldozers. The age-long land erosion had resulted in diminishing the soil layer on slopes. Murrum and boulders in the soil made manual working difficult, time consuming and expensive



too. Terracing with bulldozers required less time, but resulted in some compromises with the technical requirements. The work completed before the rainy season prevented land erosion which could have continued for one more year.

Most of these terraces in Jain Hills area were sloping downwards. Their slope was subsequently changed to level terraces. Trees were then planted in a staggered way on the inner side and edges of the terrace. We have now realised that we ought to have made these terraces with an inward slope. We have initiated steps to change the slopes.

Graded Terracing

Graded terracing was also done on 5.09 ha (12.6 acres) of sloping land in the Jain Hills

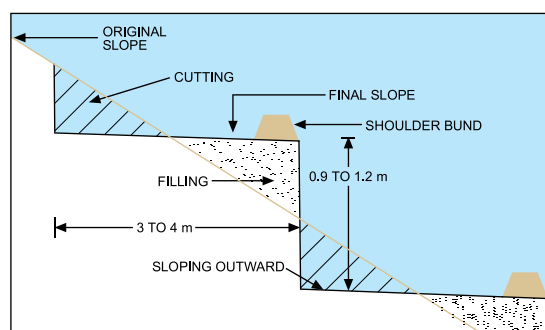


Fig. 4.4: Graded terracing geometry



Graded terracing with stone shoulder bunds

area. The graded terraces have a gentle lateral slope with rubble or earthen bunds at the end. Fig. 4.4 depicts the geometry of graded terracing.

Graded terracing proves useful in good drained soils for conservation of soil and water. The velocity of rainwater flow is reduced causing silt load to settle on the terraces. Similarly the flowing water is arrested at the bunds permitting more infiltration.

The graded terraces in Jain Hills are with downward slope and the bunds are mainly of stones.

Table 4.4 : Graded terracing geometry				
Location	Hill Slope (%)	Terrace width (m)	Slope of terrace (%)	Height Between two terraces (m)
Jain Hills	50 to 25 (Hilltop)	3 to 3.7	3 to 4	0.9 to 1.2

Due to the stone bunds, the original slope of terraces is reducing and they are becoming level. Details of graded terracing work in Jain Hills area are given in Table 4.4.

Land Levelling

Land levelling work in the area minimised the soil erosion and increased infiltration of water. It was done using bulldozers as manual work was difficult owing to very





Land levelling with a caterpillar bulldozer

thin soil cover (0.75 to 1m) and presence of murrum, pebbles and boulders. In the land on the west side of the percolation tank Jain Sagar and in Jain Hilltop area contours were marked for conducting land levelling. Soil on one side was excavated and dumped on the other to level the ground maintaining slope at about 1%.

Stone Pitching

To help stabilise the steep slopes and reduce soil erosion, stone pitching has been carried out on slopes of embankments, thus reducing ravines that were caused due to rainwater. The technical details of the stone pitching are as given below:

Slope of earthen embankment : 30-45 %

Thickness of pitching : 0.3 to 0.45m

Total area : 10785 sq.m



Stone pitching on steep slopes

Stone pitching has also been provided at some bench terracing structures to help stabilise their banks. The boulders obtained during land levelling were used for stone pitching thereby reducing the cost.

Gully Plugging

Gully plug as the name implies is a soil/water conservation structure across a small gully or stream. It prevents eroding and downcutting of gully heads, brings about



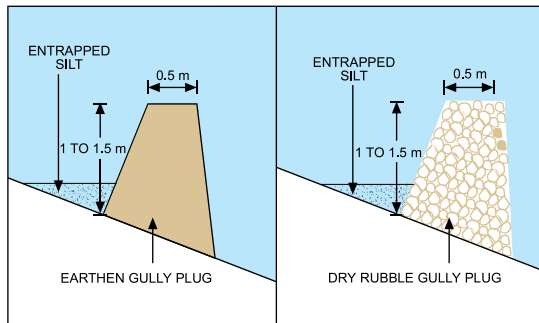


Fig. 4.5: Geometry of gully plugs

Table 4.5 : Gully plugging details	
Location	Gully plugs (no.)
Jain Hills	11
Jain Valley	10
Total	21

the deposition of silt load and creates micro-environment for the establishment of vegetative cover. Gully plugs act as grade stabilisation structures. It can be a dry rubble structure or a small earthen embankment.

Being upstream of the watershed, ravines are developed at a number of places in Jain Watershed due to land erosion. Most of the ravine formations are controlled with gully plugging. Fig. 4.5 depicts the geometry of a gully plug.

The construction details of gully plugs are given in Table 4.5. Rubble or earthen or combination constructions have been used. Soil erosion on slopes of plugs is prevented by raising khus grass at places.

Contour Bunding

Contour bunding is one of the most popular soil conservation measures. On the



Contour bund on hill slopes near protected forest



Dry rubble gully plug



Earthen gully plug



Location	Area (ha)	Land slope (%)	Vertical distance (m)	Height of bund (m)
Jain Hilltop	0.80	5	0.90	0.60
Jain Hills	0.80	5-7	0.75	0.60
Jain Valley	0.78	5-7	0.90	0.60

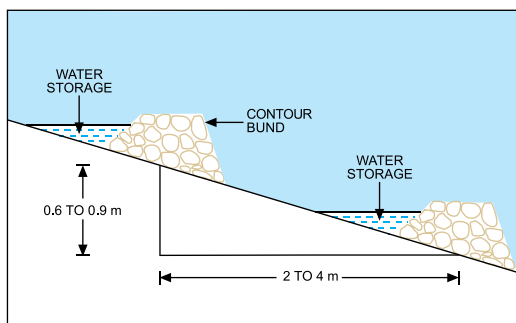


Fig. 4.6: Contour bunding geometry

right side of the protected forest area, situated in North-East of Jain Hills area, contour bunds are constructed.

All these bunds are made of stone and dry rubble. The details of contour bunding are given in Table 4.6. It is suitable for low rainfall area (< 600 mm) and for permeable soil. Contour bunding consists of constructing narrow-based embankment (bunds) to impound runoff. Fig. 4.6 shows the geometry of contour bunding. Velocity of rainwater flowing on slopes is arrested at these contour bunds. The silt load is deposited there itself resulting in reduction of soil erosion. The rainwater stored infiltrates in the ground raising the groundwater level.

Other Measures

In short, land and soil resource utilisation can be optimised by adopting some of the conventional soil conservation measures detailed above. There are however other measures such as controlling grazing, undertaking afforestation, improving ground vegetative cover and condition, planting of legumes as intercrop or in-crop rotation or by ensuring proper cropping intensity and pattern. Strip-cropping, suitable cultural and cultivational practices can also help. We have discussed this in greater detail in Chapter 05: ‘Soil Improvement and Amendment Measures.’

Expenditure on Land and Soil Conservation Measures

The details of the expenditure on land and soil conservation measures in Jain Watershed area for regulation and infiltration of rainwater are given in Table 4.7.

Structure	Year																			Total
	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Sub-soil drainage	5.00	-	-	-	-	-	-	-	-	-	-	-	2.39	2.75	-	-	-	-	1.33	11.47
Contour trenches	-	0.38	0.22	-	-	-	-	-	-	-	-	0.20	0.35	0.24	-	0.18	-	-	0.19	01.76
Surface trenches	-	-	-	-	-	0.15	-	-	0.12	0.06	0.09	-	0.41	0.35	0.4	-	0.28	0.54	0.16	02.56
Bench terracing	-	-	-	-	18.00	-	4.50	-	-	-	9.00	0.60	-	2.85	2.70	-	-	1.54	-	39.19
Graded terracing	-	-	-	-	-	0.96	1.60	-	-	-	-	0.38	0.45	0.80	-	0.27	0.35	-	0.32	05.13
Land levelling	-	0.02	-	0.10	0.14	-	-	-	-	0.27	-	-	0.12	0.35	0.15	-	0.11	0.27	0.21	1.74
Stone pitching	-	-	-	-	-	-	1.92	0.96	0.48	-	0.73	-	1.17	1.8	1.26	0.48	1.32	-	-	10.12
Gully plugs	-	-	-	-	1.60	-	0.40	-	0.40	-	-	0.90	0.58	-	0.64	0.70	-	-	-	05.22
Contour bunding	-	-	-	0.04	-	-	-	-	-	-	-	-	0.05	0.04	-	0.03	-	0.07	-	00.23
Total	5.00	0.4	0.22	0.14	19.74	1.11	8.42	0.96	1.00	0.33	9.82	2.08	5.52	9.18	5.15	1.66	2.06	2.42	2.21	77.42

05. Soil Improvement & Amendment Measures



Soil improvement is equally important in watershed development as is soil conservation. Soil texture is deteriorating day by day owing to excessive use of water and chemicals. This is a bad omen for agriculture. It is necessary to undertake planned efforts for improving the soil quality.

The quality of soil at Jain Hills was poor, to say the least. Therefore, soil improvement had also to be attended to along with soil and water conservation works. We began the experiments in 2000-2001. Use of drip and planned selection and rotation of crops have also indirectly benefited soil quality.

Following components were included in soil improvement programme:

- Organic manuring
- Green manuring
- Vermicompost application
- Crop rotation
- Addition of tank silt and lake dregs
- Deep ploughing for removal of stones/boulders
- Intercrop resulting in crop residue decomposition
- Use of leaves and twigs after pruning of trees.

Organic Manuring

Traditional Indian farming was based on application of organic manure. However, three consecutive drought years, 1965 through 1968, in major parts of India necessitated large scale imports of 3rd grade wheat under PL-480. The country was humbled. To prevent recurrence, GoI appointed an expert committee for suggesting means for higher agro productivity. The committee recommended provision of irrigation, hybrid seeds and chemical fertilisers. The liberal provision of these inputs made India not only self-sufficient in food, but also generated marginal surplus for exports. While self-sufficiency was achieved and food security was established, the continuous and excessive imbalanced use of chemical fertilisers and canal irrigation reduced soil fertility, and resulted in slow but sure decline in the rate of productivity over the past almost four decades. It is now accepted by all experts that excessive use of some chemical fertilisers and canal irrigation cannot remain a sustainable model for agro development. The major cause of decline in productivity was traced to increasing inadequacy of organic carbon in soil. Organic carbon can be replenished only by addition of organic matter to soil.

What is Organic Manure?

Organic manure has been defined as a biodegradable solid organic waste partially decomposed by a consortium of microbes under ambient temperature, aerobic/anaerobic atmosphere and around 50 – 55% humidity. The resulting manure is blackish brown matter, rich in humus and microbial fauna capable of imparting fertility to the soil. The chemical fertilisers are known to short-circuit the natural microbial processes and activity. Microbial inoculants such as Azotobacter, Rhizobium, phosphate solubilizer and sulphate metaboliser are variously known as

'It is important to save the earth because that is all what we have, we do not get another.'



Biofertilisers. They are also sometimes referred to as Nitrogen-Fixer, P-Solubiliser, etc. because of their functions.

Abundant and economical raw materials, such as biodegradable farm residues or wastes, food process industry waste and/or by products, municipal waste or household refuse available locally and easily, are subjected to (i) reduction in size for rapid decomposition, (ii) moisturisation to 45-55% humidity conducive for microbial growth, (iii) thorough mixing with decomposing microbial inoculum or cow dung slurry and (iv) composting in the pit or heap under normal environmental conditions, until initially high C/N ratio of composting matrix is brought down to 14-18, indicating that the phyto-toxic material is converted into phyto-promoter material (organic manure). Table 5.1 shows the desirable characteristics of organic manure.



1) Organic manure, 2) Earthworms, 3) Onion solid waste

Table 5.1 : Desirable characteristics of organic manure		
S. N.	Parameter	Specification/Ranges
1	Colour	Dark brownish black fluffy solid
2	Appearance	Amorphous powder/lumps/granular/pellets
3	Odour	Earthy without repellent smell
4	pH	6.5 - 7.5
5	Electrical Conductivity (Ec)	1.5 - 3.5 ms
6	Moisture	20 - 30 %
7	Organic Carbon	20 - 25 %
8	Nitrogen	1.3 - 2.0 %
9	Phosphate	0.3 - 0.5 %
10	Postassium	1.0 - 2.0 %
11	Total Viable Count (TVC)	1x 10 ⁵ - 10 ⁷ per g
12	Micro-nutrients	Adequate

We prepare organic manure by mixture of organic waste press mud cake (PMC), mahuwa, castor and neem cakes, vermicompost as well as various cultures and vermiwash, to achieve desirable characteristics as stated above. This facility has capacity to produce 10,000 M.T. of organic manure annually.

Benefits of the application of organic manure

- Alters the physical texture, chemical composition and microbial quality of soil
- Helps soil attain higher porosity, thereby promoting higher percentage of germination and providing enough air for the respiration of the root system, enhancing growth rate



- Enhances organic carbon percentage in soil, thereby promoting higher growth
- Builds up water holding capacity which imparts sustained moisture to soil and plants, reducing chances of heat stress
- Minimizes the frequency and quantum of irrigation, reduces the rate of soil salination, saves electricity and cost of manual labour
- Provides easily assimilable nutrients to plants upon transplantation and thereby assures higher rate of survival
- Raises qualitative and quantitative yield of crops via microbial activity
- Improves disease resistance because of microbes, growth hormones and regulators
- Enhances the efficacy of use of chemical fertilisers, by preventing wastage through leaching and surface evaporation
- Increases micro-flora by enhancing soil quality
- Gives end product that has longer shelf life and better taste
- Provides an eco-friendly and sustainable input better for human health

Green Manuring

Green manure not only supply plants with nutrients as fertilisers do, but also help in improving the soil texture and physical condition of the soil. Organic and green manures improve the rate of water infiltration and soil structure, and thereby arrest the soil erosion process. Compared to application of Farm Yard Manure (FYM), green manuring is more effective for improvement in the physical condition of the soil as decomposition occurs in situ. Green manuring may seem to cause loss of one season. However, this practice has to be adopted even for controlling weeds and addition of nutrients. In the long run this practice proves more beneficial.



Dhaincha cutting for green manuring

Green manuring with dhaincha (*Sesbania aculeata*) and/or sunnhemp (*Crotalaria juncea*) is done every year in mango plantation. It helps improve the soil texture and adds to the fertility of the soil.

Following are the advantages of using green manure crop:

- It grows thick and fast thus prevents weed growth
- Its root nodules contain nitrogen-fixing bacteria which fix atmospheric nitrogen (about 22 to 25kg of N/ha)
- It is cut when fully grown right from the roots and buried in the soil. On decomposition, the whole bio-mass helps increase organic content of the soil



- It increases the fertility of soil resulting in acceleration of other biological reactions (catalytic action).

Thus dhaincha green manuring plays a multipurpose role. Generally, it grows 0.6 to 0.15m high in 45 days. It is then uprooted just before flowering stage and buried in the soil. The ratoons when fully grown are uprooted by ploughing. In this process, green biomass quantity is doubled and the nodules having nitrogen fixing bacteria get fully developed giving more quantity of nitrogen.

Vermicompost Application

The waste (onion peels, stalk, mango stones and skins etc.) from Fruit Processing and Onion Dehydration plants in Jain Valley necessitated their planned disposal to prevent pollution. The earthworms in the wormery are fed with this waste. They digest it. The process is called vermicomposting. This vermicompost is rich in nutrients required by the plants. Thus, the waste which is harmful to the environment turns into useful organic manure.



Vermicomposting

A specific variety of red earthworm is selected for vermiculture. Their speciality is that they eat rapidly and excrete. The compost consists of this excreta. Proper upkeep of these worms is essential for their reproduction. Sheds are erected in Jain Valley to maintain proper shade and temperature. Filling material like dung is required for vermiculture.

Vermicompost offers the following benefits:

- It helps maintain ecological balance
- It contains nitrogen, phosphorus and potash (NPK). In addition it has nourishing micro elements, aminoacids and useful microbes
- It is devoid of side effects germane to inorganic fertilisers
- It improves pH and texture of the soil
- It creates its own bio-environment and helps make the plant self-sustaining in terms of most of its nutrient requirements

Crop Rotation

Soil texture and quality deteriorates with cultivation of the same crop over and over again. A planned crop rotation breaks the chain of life cycle of insects, pests, bacteria, etc. created by monocropping. Soya bean, green gram, green manure crops are cultivated after harvest of onion crop. Such crop rotation gives relief to the soil. The soil can also be subjected to solarisation so as to get rid of harmful organisms.



Other Measures

Addition of tank silt and lake dregs, deep ploughing and removal of stones and boulders and use of leaves and twigs after pruning should be done whenever and wherever possible and when found economical.

Effect of various soil improvement measures on soil health:

Since the watershed was conceived regular addition of organic manure and green manuring was undertaken which helped to improve soil productivity. This is evident from the table 5.2 (based on soil analysis from Plot No. 2 Jain Hilltop). pH has come down which used to be more than 7.5, simultaneously high levels of calcium and magnesium have also reduced. Depletion of nitrogen is very common in cultivated soil, but in the present case we could maintain the nitrogen level as nearly same for 5 years. Significant increase in organic carbon is also noticed which was less than 0.5% initially. It has now reached 1.65%.

S. N.	Parameters	1996	2005	2007	2009
1	pH	7.00	7.71	7.67	7.28
2	EC (ms)	0.252	0.12	0.17	0.145
3	Organic Carbon (%)	0.40	1.07	1.39	1.65
4	Available Nitrogen (Kg/ha)	120	182.0	181.80	183.9
5	P ₂ O ₅ (Kg/ha)	18.30	61.9	71.20	41.6
6	K ₂ O (Kg/ha)	450.0	806.0	537.60	295.0
7	Calcium (%)	Not Estimated	0.15	0.74	0.12
8	Sodium (%)		0.26	0.15	0.14
9	Mg (ppm)		215.0	970.00	1885
10	Mn (ppm)		51.3	53.75	14.12
11	Zn (ppm)		7.5	1.00	0.94
12	Cu (ppm)		2.4	5.85	4.48
13	Fe (ppm)		6.0	9.81	8.85

Organic Farming

During the period 1968 - 2000, we have followed the use of hybrid (high yielding) seeds, chemical fertilisers as nutrition for plants, irrigation to reduce heat stress and chemical pesticides to control any pests or diseases. However, use of chemical fertilisers and pesticides reduced useful microbial flora in the soil deteriorating its fertility as well as productivity. This observation made in different types of soils in varied agro-climatic conditions brought to the fore a reality, that to increase the fertility of the soil, it has to be nourished with organic carbon. A traditional method followed by our forefathers. This gave rise to the concept of organic farming, also known as natural farming or eco-friendly farming.





Onion within Aonla : Second year of organic cultivation

Organic farming was tried, to begin with, on 3.2 ha (8 acres) area in Jain Hills as a demonstration of integrated cropping pattern. Onion was grown as an intercrop in the aonla plantations. Vermicompost, neem cake, cow dung, press mud cake and green manure were used in place of inorganic fertilizers, and neem oil in place of insecticides. This was a live demonstration wherein it could be seen that fairly good yields were obtained without application of chemical fertilisers and insecticides. January 2002 onwards only organic manure is being applied in the entire farm area. Organic farming is the sure method for sustained improvement of and amendment to the soil.

Table 5.3: Improvement in Soil Quality after Organic Treatment				
S. N.	Parameter	Normal range	Before treatment	After treatment
1	pH	6.6 - 7.3	7.6	7.5
2	EC (ms)	0 - 1	0.11	0.21
3	Nitrogen (%)	0.28 - 0.42	0.16	0.20
4	p ₂ O ₅ (Kg/ha)	31 - 50	13.40	13.60
5	K ₂ O (Kg/ha)	181 - 240	159.60	193.20
6	Calcium (ppm)	20 - 60	65.60	70.54
7	Sodium (ppm)	25 - 75	350.00	519.00
8	Organic Carbon (%)	0.41 - 0.61	1.40	1.60
9	Bulk Density (g/cm ³)	1.0 - 1.7	1.30	1.10
10	Microbial Count (TVC/g) x 10 ⁶	0.1 - 1.0	3.26	4.70

• Sample from Plot No. 1, Jain Hilltop tested at Central Laboratory, Food Park.

Table 5.3 shows the changes in various parameters. The results are just after the first year of application of organic manure. It is too early to comment on these



results. Salutory effects of organic manuring can be seen only after a minimum two-three years. However, even these first year results are promising, as pH value is reduced from 7.6 to 7.5, and percentage of nitrogen, phosphorous and potassium content have also improved.

Organic carbon content and microbial count which are major indicators of soil health have increased. It indicates that humus content of the soil and organic (microbial) activity have increased which is desirable. Bulk density reduction suggests improved porosity/permeability. Percentage of sodium and calcium is almost constant. It indicates that we still need to improve on drainage of water from soil.

Soil Nutrient Mapping:

In 2009, we completed mapping the watershed area for physical and chemical properties including nutrient status. The whole area was divided into 64mx64m plots and homogenous samples were collected from each plot for analysis. Based on detailed laboratory analysis, maps for all nutrients were developed and the summary of analysis is given in Tables 5.4 and 5.5. Analysis revealed that the soil is neutral in soil reaction except for 17 per cent samples which have slightly high pH. Organic carbon content of soil has increased significantly in watershed and now 89 per cent samples were in optimum to high range. Among major nutrients, nitrogen is in deficient range for most of the samples analysed, while others are in optimum to high range. Sulphur and iron content was found low for most of the samples. Based on soil fertility, plot wise and location wise soil health card has been developed to monitor soil health and optimize manure and fertilizer application according to crop cultivated and expected yield. It gives a complete overview of soil health of a particular site and also has information about how much fertilizer is to be used in a particular area.

Map 5.1 to Map 5.12 show soil mapping done for various parameters.



Soil Health Card

No. : J021A	BU Code : D - 670354
Year : 2009-2010	
(1) Site : JAIN HILLTOP, WADA (JHT)	(2) Village : JAJGAON
(3) Area: 92.4 Acre	(4) Texture : CLAY
	(5) Total JCM Required : 896 MTs

Nutrients classification on the basis of average soil analysis of site:

Nutrients/ Parameter	Rating			Percent Soil Sample			Fertility Index	Rating
	Acidic*/ +Safe/ Low	Normal**/ Moderated++ Medium	Alkaline***/ Unsafe+++/ High	Acidic*/+ Safe/ Deficient	Normal**/ Moderate++/ Marginal	Alkaline**/ Unsafe+++ Sufficient		
pH		X		28.46	71.54	0.00	1.72	N
EC (dSm ⁻¹)	X			100.00	0.00	0.00	1.00	S
OC (%)			X	4.07	13.01	82.93	2.79	H
N	(kg ha ⁻¹)	X		99.20	0.81	0.00	1.01	L
P ₂ O ₅			X	0.00	4.88	95.12	2.95	H
K ₂ O			X	0.00	2.44	97.56	2.98	H
Ca			X	0.00	26.02	73.98	2.74	H
Mg	(mg ha ⁻¹)		X	0.00	0.00	100.00	3.00	H
S		X		95.93	4.07	0.00	1.04	L
Fe			X	67.5	12.20	20.33	1.53	L
Mn			X	11.38	30.89	57.72	2.46	H
Zn			X	8.13	30.08	61.79	2.54	H
Cu			X	0.00	0.00	100.00	3.00	H

Soil analysis results of site:

Nutrients		Results	Desirable	Nutrient Rating	
PH		6.69	6.5-7.5	N	OK
EC	(dS m ⁻¹)	0.2	< 1.0	S	OK
Organic Carbon	(%)	0.96	0.5 - 0.75	H	Sufficient
Nitrogen	(kg ha ⁻¹)	204	240 - 480	L	Deficient
Phosphorus		171	28 - 56	H	Sufficient
Potassium		776	140 - 280	H	Sufficient
Calcium	(mg kg ⁻¹)	4,668	500 - 4100	H	Sufficient
Magnesium		1,400	100 - 500	H	Sufficient
Sulphur		5.14	10 - 20	L	Deficient
Iron		5.12	5 - 10	M	Sufficient
Manganese		14.68	5 - 10	H	Sufficient
Zinc		1.23	0.5 - 1.0	H	Sufficient
Copper		5.38	0.2 - 0.4	H	Sufficient

Note : 1) */ ** / *** for pH and + / ++ / +++ for EC.

Fertilizer Calculation Table																									
Amount of nutrient required (kg)		Percent content of nutrient in fertilizer																							
		Amount of fertilizer required																							
10	12	13	14	15	16	17	18	19	20	21	22	24	25	26	28	30	32	35	36	38	45	50	60		
1	10	8.3	7.7	7.1	6.7	6.3	5.9	5.6	5.3	5.0	4.8	4.5	4.2	4.0	3.8	3.6	3.3	3.1	2.9	2.8	2.6	2.2	2.0	1.7	
2	20	16.7	15.4	14.3	13.3	12.5	11.8	11.1	10.5	10.0	9.5	9.1	8.3	8.0	7.7	7.1	6.7	6.3	5.7	5.6	5.3	4.4	4.0	3.3	
5	50	42	38	36	33	31	29	28	26	25	24	23	21	20	19	18	17	16	14	14	13	11	11	10	8
10	100	83	77	71	67	63	59	56	53	50	48	45	42	40	38	36	33	31	29	28	26	22	22	20	17
15	150	125	115	107	100	94	88	83	79	75	71	68	63	60	58	54	50	47	43	42	39	33	33	30	25
20	200	167	154	143	133	125	118	111	105	100	95	91	83	80	77	71	67	63	57	56	53	44	43	40	33
30	300	250	231	214	200	188	176	167	158	150	143	136	125	120	115	107	100	94	86	83	79	67	65	60	50
50	500	417	385	357	333	313	294	278	263	250	238	227	208	200	192	179	167	156	143	139	132	111	109	100	83
60	600	500	462	429	400	375	353	333	316	300	286	273	250	240	231	214	200	188	171	167	158	133	130	120	100
75	750	625	577	536	500	469	441	417	395	375	357	341	313	300	288	268	250	234	214	208	197	167	163	150	125
80	800	667	615	571	533	500	471	444	421	400	381	364	333	320	308	286	267	250	229	222	211	178	174	160	133
100	1000	833	769	714	667	675	588	556	526	500	476	455	417	400	385	357	333	313	286	278	263	222	217	200	167

Process for Calculation : The percent nutrient content in the chemical fertilizers are printed on fertilizer bag shown in the first horizontal line. However the amounts of nutrients required (kg) is shown in the first vertical column. Please read the percent nutrient content printed on the chemical fertilizer bag and choose the column of the same and see vertical below along with read the recommended amount of nutrient in kg from soil health card and select the same amount in vertical column and see horizontal. At the one point horizontal and vertical lines are crossed shows amount of chemical fertilizer required for one acre crop in kg.

Note : At the time of calculation of chemical fertilizer first calculate the potassium then phosphorus and then nitrogenous fertilizers.

Nutrients content of commonly recommended fertilizers:

S. N.	Name of Fertilizer	Percent Nutrient Content					Other	
		N	P ₂ O ₅	K ₂ O	S	%	Element	
1	Ammonium Sulphate	21	0	0	24	0	-	
2	Borax	0	0	0	0	10	B	
3	Boric Acid	0	0	0	0	18	B	
4	Complex Fertilizer	19	19	19	0	0	-	
5	Complex Fertilizer	14	35	14	0	0	-	
6	Copper Sulphate	0	0	0	13	24	Cu	
7	DAP	18	46	0	0	0	-	
8	Ferrous Sulphate	0	0	0	12	19	Fe	
9	Gypsum	0	0	0	13	17	Ca	

S. N.	Name of Fertilizer	Percent Nutrient Content					Other	
		N	P ₂ O ₅	K ₂ O	S	%	Element	
10	Magnesium Sulphate	0	0	0	13	16	Mg	
11	Manganese Sulphate	0	0	0	15	30	Min	
12	Potassium Chloride	0	0	60	0	48	Cl	
13	Potassium Nitrate	13	0	38	0	0	-	
14	Potassium Sulphate	0	0	50	18	0	-	
15	Single Super Phosphate	0	16	0	12	20	Ca	
16	Urea	46	0	0	0	0	-	
17	Zinc Sulphate	0	0	0	14	21	Zn	

Plot wise soil analysis results and required amount of nutrient to be applied as per soil test value.

Parameter	Plot No. 1 (Mango)			Plot No. 4 (Mango)			Plot No. 21 & 1/2 22 (MA)			Plot No. 1/2 22 & 23 (MA)			Plot No. 11 (Mango)			Plot No. 11 (Guava)		
	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF
PH	6.81	N	OK	6.66	N	OK	6.66	N	OK	6.67	N	OK	6.91	N	OK	6.91	N	OK
EC	0.22	S	OK	0.18	S	OK	0.17	S	OK	0.19	S	OK	0.32	S	OK	0.32	S	OK
Organic Carbon	1.03	H	10	0.81	H	10	1.07	H	10	0.99	H	10	0.77	H	10	0.77	H	8
Nitrogen	206	L	66	201	L	66	212	L	66	200	L	66	191	L	66	191	L	140
Phosphorus	157	H	23	150	H	23	208	H	23	191	H	23	145	H	23	145	H	50
Potassium	720	H	36	548	H	36	814	H	36	891	H	36	659	H	36	659	H	40
Calcium	4903	H	OK	4296	H	OK	4695	H	OK	5823	H	OK	4510	H	OK	4510	H	OK
Magnesium	1155	H	OK	1170	H	OK	1883	H	OK	1374	H	OK	1600	H	OK	1600	H	OK
Sulphur	6.38	L	7.7	4.96	L	9.0	6.43	L	7.7	5.41	L	8.6	2.74	L	11.0	2.74	L	11
Iron	2.71	L	4.3	6.34	M	1.0	5.69	M	1.6	1.86	L	5.0	2.16	L	4.8	2.16	L	4.8
Manganese	8.63	M	OK	10.86	H	OK	14.09	H	OK	11.24	H	OK	7.64	M	OK	7.64	M	OK
Zinc	1.09	H	OK	0.80	M	OK	2.12	H	OK	1.04	H	OK	0.66	M	OK	0.66	M	OK
Copper	6.46	H	OK	4.96	H	OK	6.36	H	OK	4.19	H	OK	2.34	H	OK	2.34	H	OK

Parameter	Plot No. 9 (Mango)			Plot No. 9 (Guava)			Plot No. 3 (C. Apple)			Plot No. 13A (Mango)			Plot No. 13 B (Mango)			Plot No. 11 (Guava)		
	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF	Results	Rating	RDF
PH	7.01	N	OK	7.01	N	OK	6.57	N	OK	6.71	N	OK	6.61	N	OK	6.78	N	OK
EC	0.26	S	OK	0.26	S	OK	0.23	S	OK	0.10	S	OK	0.71	S	OK	0.14	S	OK
Organic Carbon	0.90	H	10	0.90	H	8	1.20	H	8	0.66	M	10	1.12	H	10	1.05	H	10
Nitrogen	184	L	66	184	L	140	230	L	140	207	L	66	217	L	66	186	L	66
Phosphorus	176	H	23	176	H	50	86	H	50	112	H	23	87	H	23	109	H	23
Potassium	714	H	36	714	H	40	626	H	100	534	H	36	474	H	36	335	H	36
Calcium	4750	H	OK	4750	H	OK	4800	H	OK	2700	M	OK	2750	M	OK	2950	M	OK
Magnesium	1700	H	OK	1700	H	OK	1200	H	OK	1400	H	OK	1350	H	OK	1300	H	OK
Sulphur	2.67	L	11.0	2.67	L	11.0	4.9	L	9.0	4.17	L	9.7	5.30	L	8.7	7.01	L	7.2
Iron	1.57	L	5.3	1.57	L	5.3	2.1	L	4.9	9.12	M	OK	9.78	M	OK	8.59	M	OK
Manganese	4.94	L	2.3	4.94	L	2.3	10.3	H	OK	8.02	M	OK	13.68	H	OK	10.91	H	OK
Zinc	0.61	M	OK	0.61	M	OK	OK	M	OK	0.73	M	OK	0.81	M	OK	0.60	M	OK
Copper	3.37	H	OK	3.37	H	OK	OK	H	OK	3.90	H	OK	5.76	H	OK	4.34	H	OK

Note : 2) Rating : Acidic (AC), Normal (N), Alkaline (AK), Safe (S), Moderate (MO), Unsate (U), Low (L), Medium (M), and High (H); RDF: Recommended dose of fertilizer (kg ac⁻¹) / Manure (t ac⁻¹)
 3) JCM - Jain Compost Manure.

Fertilizer recommendation for the crop on the basis of soil analysis:

Season	Crops	Required amount of Nutrient/Manure to be applied as per soil test value				Dose of Fertilizer/Manure being applied presently				Dose of Fertilizer/Manure now required to remove deficiency			
		N	P ₂ O ₅	K ₂ O	JCM	N	P ₂ O ₅	K ₂ O	JCM	N	P ₂ O ₅	K ₂ O	JCM
		(kg ac ⁻¹)			(t ac ⁻¹)	(kg ac ⁻¹)			(t ac ⁻¹)	(kg ac ⁻¹)			(t ac ⁻¹)
Perennial Crops	Mango	66	23	36	10	56	28	56	10	10	-5	-20	0
	Guava	140	50	40	8	120	60	60	8	20	-10	-20	0
	Banana	267	64	288	18	247	74	308	18	20	-10	-20	0
	Pomegranate	140	50	100	8	120	60	120	8	20	-10	-20	0
	Custard Apple	140	50	100	8	120	60	120	8	20	-10	-20	0
	Aonla	66	23	13	10	56	28	28	10	10	-5	-15	0
	Sapota	66	23	36	10	56	28	56	10	10	-5	-20	0
	Coconut	104	23	64	10	84	28	84	10	20	-5	-20	0
	Citrus	110	28	57	8	90	34	67	8	20	-5	-10	0
Kharif Crops	Orange	110	28	57	8	90	34	67	8	20	-5	-10	0
	Bajra	15	0	10	4	20	10	10	4	-5	-10	0	0
	Sorghum	5	0	13	4	40	20	20	4	-35	-20	-7	0
	Moong	9	0	8	4	8	16	0	4	1	-16	8	0
	Black gram	12	8	0	4	8	16	0	4	4	-8	0	0
	Pigeon pea	11	0	25	4	10	20	0	4	1	-20	25	0
	Soya bean	39	0	27	4	20	30	0	4	19	-30	27	0
	Cotton	51	0	36	4	40	20	20	4	11	-20	16	0
	Onion	16	0	7	6	40	20	20	6	-24	-20	-13	0
Rabi Crops	Sugarcane (Adsali)	196	0	63	6	160	68	68	6	36	-68	-5	0
	Tomato	31	0	16	8	120	60	60	8	-89	-60	-44	0
	Wheat	68	0	0	4	48	24	16	4	20	-24	-16	0
	Barley	36	6	0	4	24	12	0	4	12	-6	0	0
	Maize	48	0	19	4	48	24	16	4	0	-24	3	0
	Sugarcane (Autumn)	196	0	63	6	140	68	68	6	56	-68	-5	0
Chickpea	13	0	4	4	8	16	0	4	5	-16	4	0	
Mustard	30	10	0	4	20	20	0	4	10	-10	0	0	

Other Recommendations:

(A)	Secondary and Micronutrients (kg ac ⁻¹)				
	Calculated amount of nutrients as per soil test value				
	S	Fe	Mn	Zn	Cu
	8.9	2.1	-	-	-
(B)	Gypsum Requirement (If pH is more than 8.0) :				
(C)	Lime Requirement (If pH is less than 6.0) :				
(D)	Foliar Spray of deficient micronutrients viz., Fe, Mn and Zn @ 0.5 % and B @ 0.3 % mixed with lime supernatant and 2 % Urea solution :				

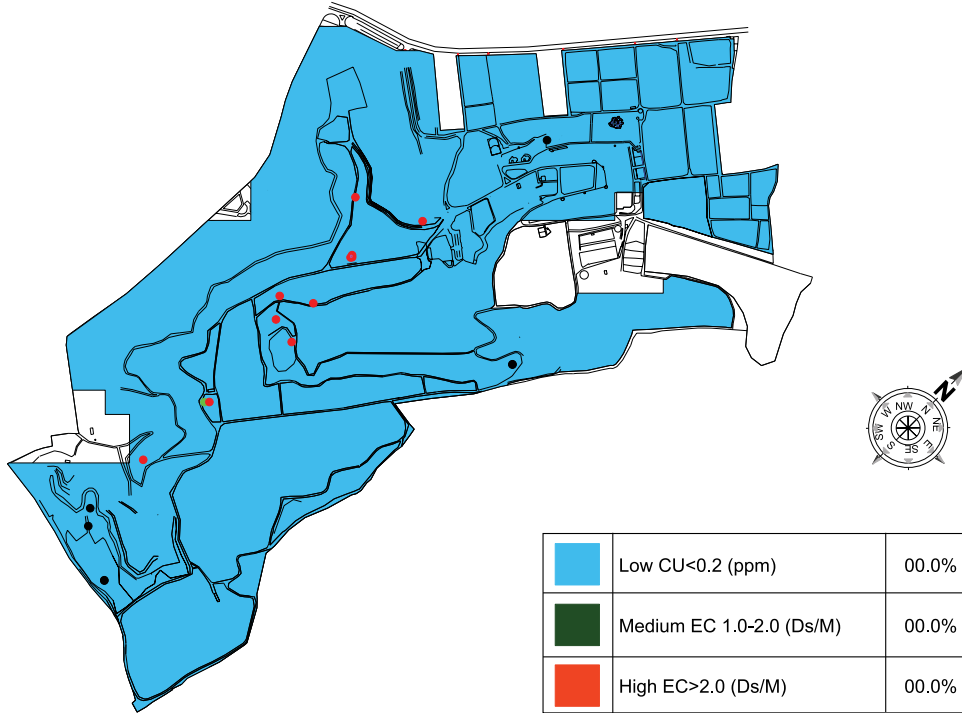
Table 5.4: Summary of Jain Watershed Soil Analysis, Dipping percentage of samples under different soil fertility category

Name of Area	No. of Samples analysed	Fertility category	Percent soil samples in different category												
			pH*	EC#	OC	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu
Jain wada	123	Deficient	28	100	4	99	0	0	0	0	96	7.7	11	8	0
		Optimum	72	0	13	1	5	2	26	0	4	0.7	31	30	0
		High	0	0	83	0	95	98	74	100	0	32.6	58	62	100
Abhyaran	23	Deficient	48	100	0	91	0	4	0	0	87	5.1	0	4	0
		Optimum	48	0	30	9	52	30	74	0	13	2.0	35	61	0
		High	4	0	70	0	48	65	26	100	0	26.4	65	35	100
25 Acres (Terrace)	12	Deficient	0	100	0	75	0	0	0	0	100	13.2	0	0	0
		Optimum	92	0	42	25	17	50	67	25	0	1.1	8	33	0
		High	8	0	58	0	83	50	33	75	0	12.1	92	67	100
25 Acres (Hilltop)	11	Deficient	100	100	0	18	0	0	0	0	82	10.0	0	0	0
		Optimum	0	0	18	82	36	18	64	18	18	11.3	0	36	0
		High	0	0	82	0	64	82	36	82	0	16.6	100	64	100
16 Acres (Jain Wada)	4	Deficient	100	100	0	100	0	0	0	0	100	13.5	0	0	0
		Optimum	0	0	0	0	0	0	75	0	0	11.0	0	25	0
		High	0	0	100	0	100	100	25	100	0	14.4	100	75	100
16 Acres (Terrace)	20	Deficient	50	100	0	100	0	0	0	0	100	13.3	0	0	0
		Optimum	50	0	35	0	0	0	100	0	0	6.8	0	55	0
		High	0	0	65	0	100	100	0	100	0	18.3	100	45	100
Terrace near old TC lab (West to Bhau ka Dhakka)	4	Deficient	0	100	0	100	0	0	0	0	100	9.8	0	0	0
		Optimum	100	0	25	0	25	0	0	0	0	0.9	100	100	0
		High	0	0	75	0	75	100	100	100	0	1.1	0	0	100
Area near proposed GRF & Guru-kul-2	11	Deficient	0	100	36	100	0	0	0	0	100	1.0	64	27	0
		Optimum	82	0	45	0	0	0	0	0	0	0.7	36	64	0
		High	18	0	18	0	100	100	100	100	0	6.1	0	9	100
OVERALL	369	Deficient	23	100	11	93	0	1	1	0	92	2.3	26	17	0
		Optimum	60	0	34	7	10	26	42	2	6	0.6	27	40	0
		High	17	0	55	0	90	73	58	98	2	32.6	47	43	100

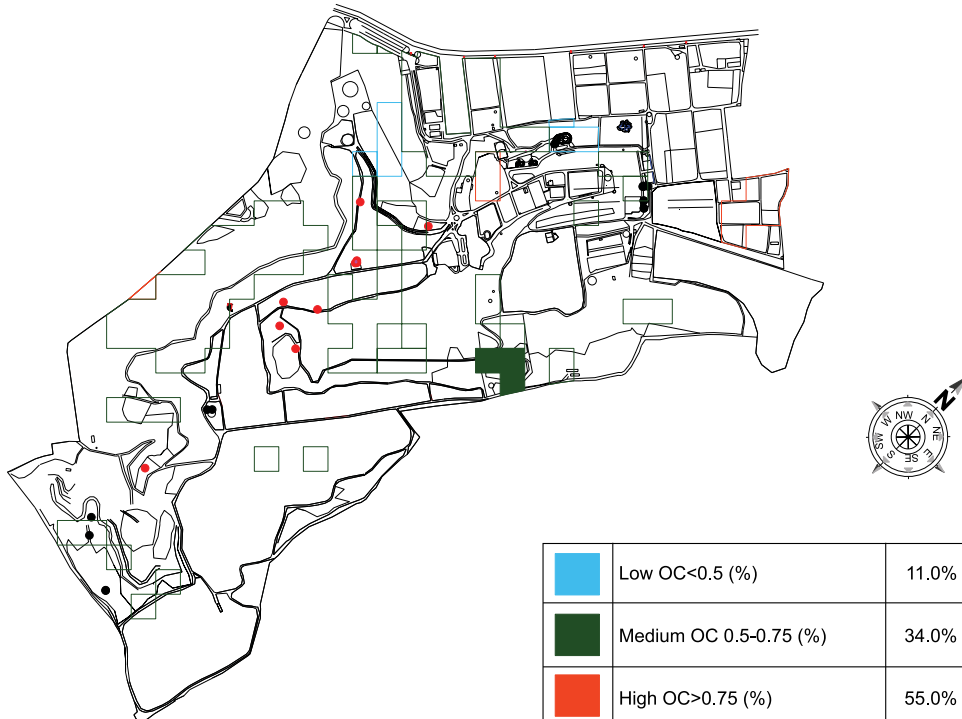
Note: pH*= Deficient: Acidic; Optimum: Neutral; High: Alkaline and EC#= Deficient: Safe; Optimum: Moderate; High: Unsafe

Table 5.5: Summary of Jain Watershed Soil Analysis, Dipicting range and mean of samples															
Name of Area	No. of Samples analysed	Range	Nutrient content												
			pH	EC	OC	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu
				dS/m	%	kg/ha			ppm						
Jain Hill Base	55	Min.	6.4	0.1	0.2	110	56	147	1600	800	1.6	0.6	2.1	0.4	1.7
		Max.	8.2	0.4	1.4	317	417	1012	9600	2929	44.7	13.3	16.5	4.8	14.1
		Mean	7.7	0.2	0.7	178	168	456	4980	1470	11.1	4.3	6.7	1.5	3.2
Terrace above ZP Dam	10	Min.	6.3	0.1	0.5	207	31	183	2300	700	2.7	8.4	19.0	0.6	2.8
		Max.	7.1	0.2	1.1	269	79	301	4400	1000	7.4	13.4	36.6	1.4	6.0
		Mean	6.8	0.2	0.8	238	54	225	3570	850	5.0	10.2	26.9	0.9	3.9
Terrace of GH No 2-5	6	Min.	7.5	0.2	0.5	138	144	191	5300	710	3.3	5.6	3.8	0.3	2.1
		Max.	7.7	0.3	0.9	207	175	504	6830	850	5.2	8.1	4.9	0.3	2.9
		Mean	7.6	0.3	0.7	168	163	318	6087	793	4.1	7.2	4.3	0.3	2.5
Terrace of Water Tank No. 1	6	Min.	6.5	0.1	0.5	179	45	175	4820	790	2.3	1.3	2.9	0.2	2.2
		Max.	7.0	0.3	1.0	214	160	270	5600	1200	3.5	11.4	6.2	0.4	4.1
		Mean	6.8	0.3	0.7	193	122	225	5313	987	2.6	7.9	4.7	0.4	2.9
NeemValley (JH)	3	Min.	7.0	0.2	0.6	97	61	157	4100	950	3.3	3.1	4.7	0.4	1.5
		Max.	7.5	0.3	0.8	193	161	308	5510	1300	3.5	11.1	6.9	0.4	3.2
		Mean	7.1	0.2	0.7	161	128	258	5040	1067	3.4	8.4	6.2	0.4	2.7
Terrace arround Helipad	23	Min.	6.5	0.1	0.4	97	61	157	200	1100	1.1	0.9	2.1	0.4	1.5
		Max.	7.9	0.6	1.0	221	167	780	6600	1900	19.1	16.2	22.6	1.7	3.9
		Mean	7.1	0.2	0.7	160	96	395	4388	1504	4.6	8.0	9.9	0.7	2.8
Terrace facing Jain Valley	58	Min.	6.3	0.1	0.2	110	42	132	2200	500	0.0	2.5	1.4	0.4	1.2
		Max.	7.6	0.4	1.2	248	149	607	6500	1700	6.4	15.4	19.7	1.7	5.5
		Mean	6.9	0.2	0.6	179	97	294	4040	992	2.7	7.7	6.6	0.7	2.8
Jain Wada	123	Min.	6.1	0.1	0.4	158	40	246	2400	600	0.4	0.7	2.1	0.4	1.0
		Max.	7.5	0.4	1.6	250	294	1365	7740	2800	18.5	32.6	56.4	6.2	14.3
		Mean	6.7	0.2	1.0	204	171	776	4668	1400	5.1	5.1	14.7	1.2	5.4
Abhyaran	23	Min.	6.2	0.1	0.6	179	29	136	2400	900	3.3	2.0	7.6	0.5	2.8
		Max.	7.8	0.4	1.1	244	232	626	4900	1600	13.8	26.4	21.9	1.6	7.0
		Mean	6.6	0.2	0.9	203	72	337	3314	1148	6.9	13.2	12.5	0.9	4.2
25 Acres (Terrace)	12	Min.	6.6	0.1	0.5	198	54	183	2500	270	2.3	1.1	8.6	0.7	3.1
		Max.	7.7	0.3	1.3	262	182	483	5700	1100	6.6	12.1	24.2	1.4	17.9
		Mean	6.9	0.2	0.8	226	91	301	3709	711	4.5	10.0	14.5	1.0	7.2
25 Acres (Hilltop)	11	Min.	6.2	0.1	0.7	235	46	204	2400	450	4.6	11.3	19.1	0.9	4.8
		Max.	6.3	0.2	1.1	255	112	402	4800	1000	10.4	16.6	36.6	1.4	18.4
		Mean	6.2	0.1	0.9	246	78	339	3782	747	6.4	13.5	26.8	1.0	10.1
16 Acres (Jain Wada)	4	Min.	6.1	0.2	0.8	224	125	499	3400	900	2.5	11.0	42.2	0.9	4.5
		Max.	6.4	0.3	1.2	237	169	804	4200	1500	3.5	14.4	48.6	1.1	7.9
		Mean	6.3	0.2	1.0	229	142	640	3925	1250	3.0	13.3	45.5	1.0	6.1
16 Acre (Terrace)	20	Min.	6.2	0.1	0.6	179	103	298	2400	800	0.3	6.8	12.0	0.6	2.6
		Max.	6.8	0.3	1.1	224	220	606	4000	1600	4.6	18.3	31.0	3.0	5.2
		Mean	6.5	0.1	0.8	209	138	465	3060	1060	2.5	9.8	16.5	1.1	3.8
Terrace near old TC lab (West to Bhau ka Dhakka)	4	Min.	6.7	0.2	0.7	200	55	414	5800	1100	4.6	0.9	5.5	0.6	2.5
		Max.	7.0	0.3	0.9	221	126	439	6000	1400	5.6	1.1	8.1	0.8	2.8
		Mean	6.8	0.3	0.8	210	89	428	5925	1300	5.1	1.0	6.9	0.7	2.7
Area near proposed GRF & Gurukul-2	11	Min.	7.1	0.2	0.3	171	73	383	4580	1200	1.0	0.7	1.5	0.4	2.8
		Max.	7.8	0.3	1.0	235	122	727	6210	1700	5.1	6.1	9.0	1.9	5.8
		Mean	7.3	0.3	0.6	207	99	546	5358	1355	2.6	2.3	4.3	0.7	3.8
OVERALL	369	Min.	6.1	0.1	0.2	97	29	132	200	270	0.0	0.6	1.4	0.2	1.0
		Max.	8.2	0.6	1.6	317	417	1365	9600	2929	44.7	32.6	56.4	6.2	18.4
		Mean	6.9	0.2	0.8	196	133	508	4402	1239	5.4	7.0	12.1	1.0	4.3

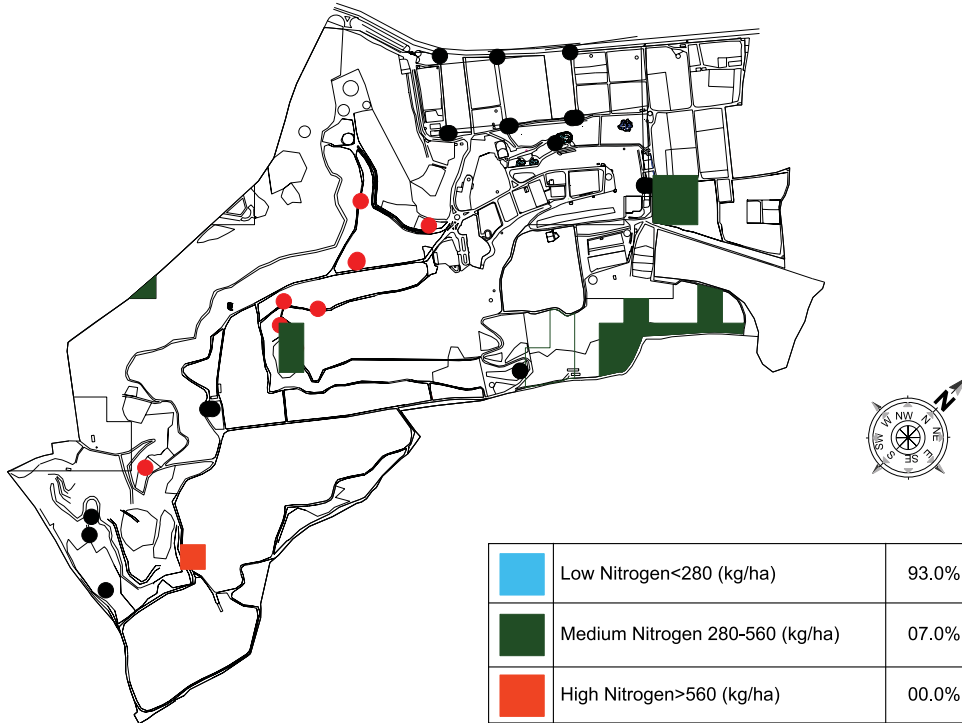
Map 5.1 Soil electrical conductivity



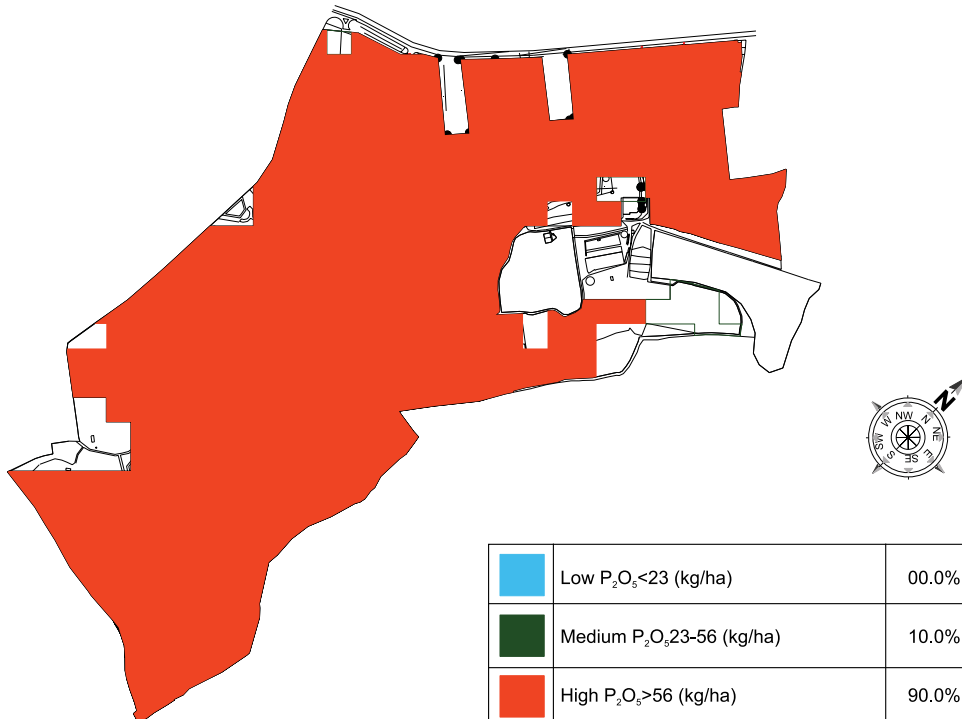
Map 5.2 Soil organic carbon status



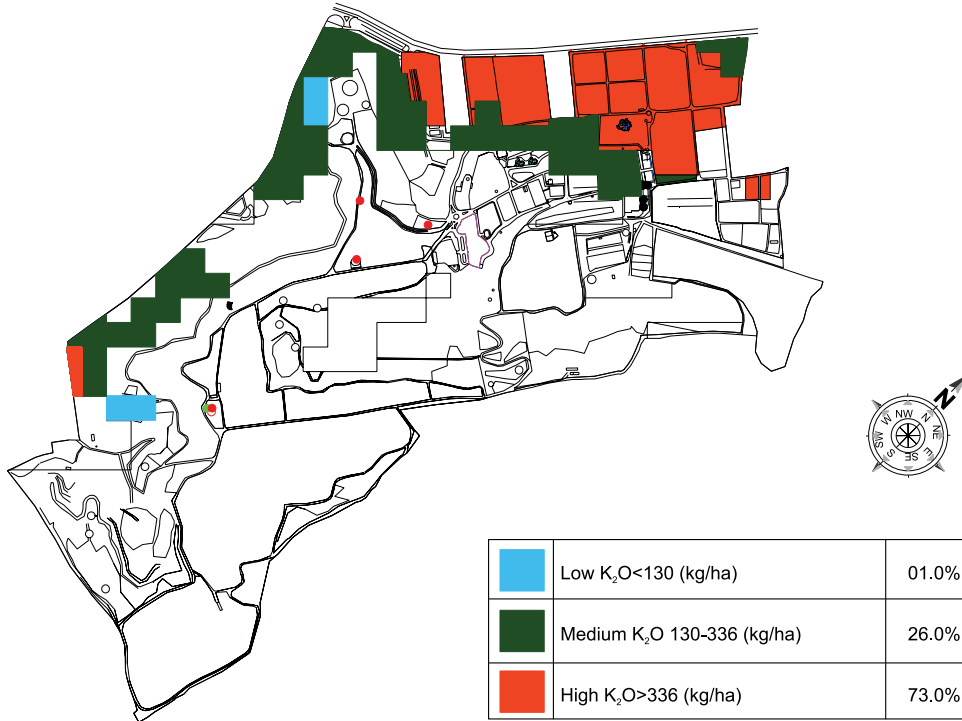
Map 5.3 Soil nitrogen status



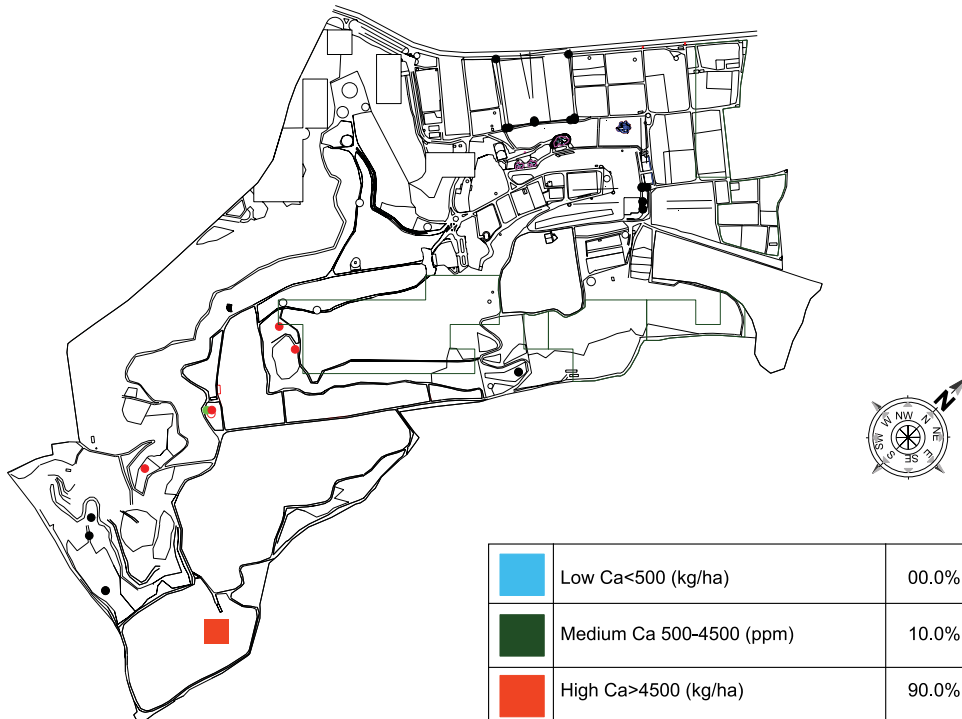
Map 5.4 Soil phosphorus



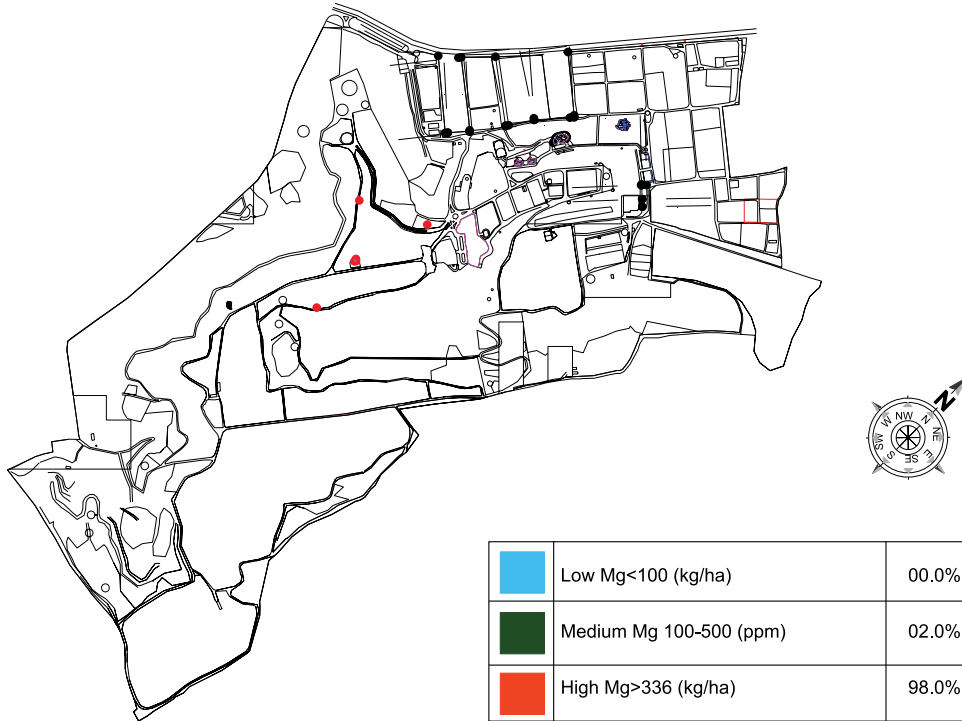
Map 5.5 Soil potassium



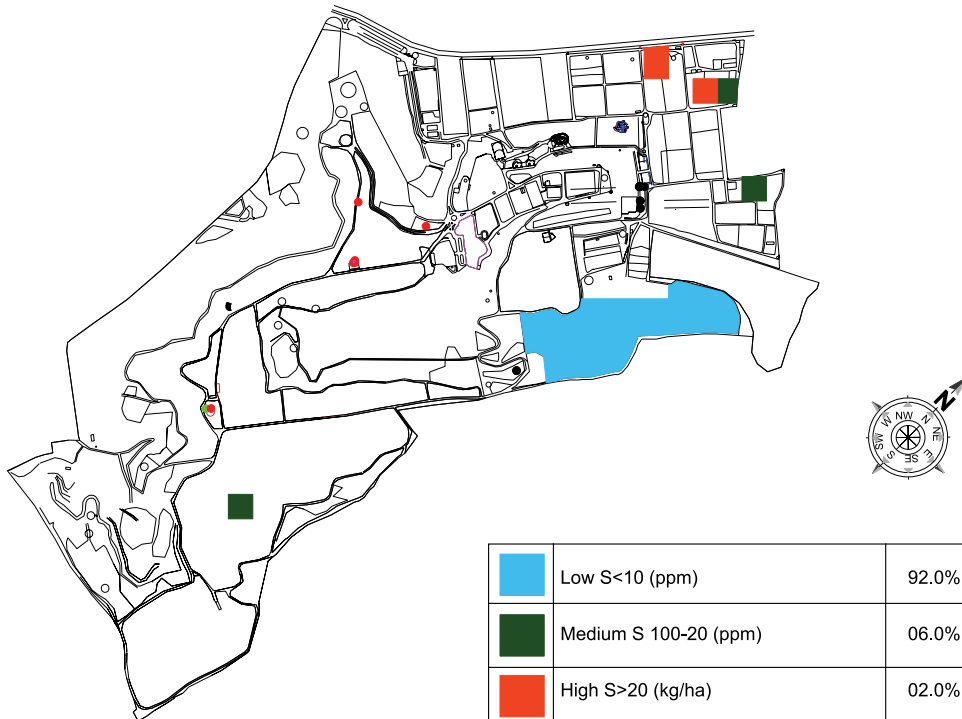
Map 5.6 Soil calcium



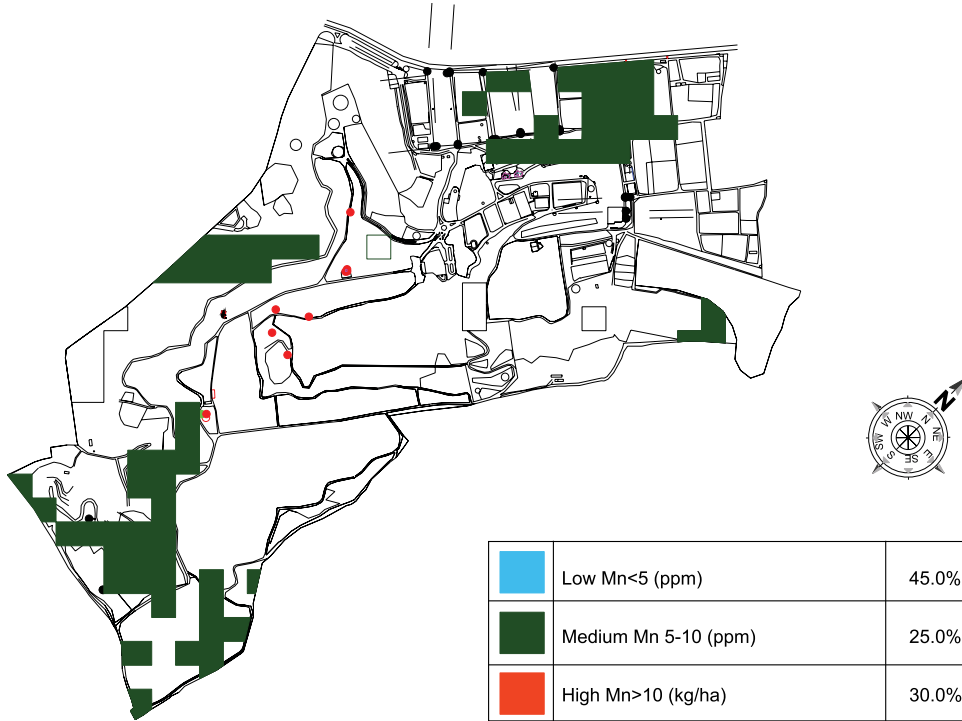
Map 5.7 Soil magnesium



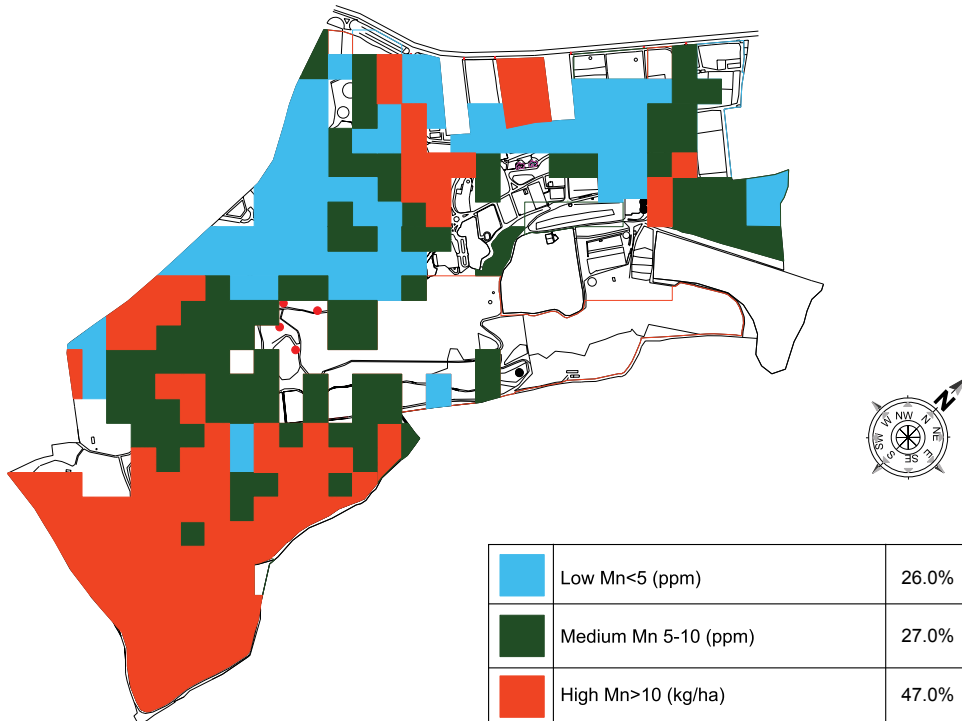
Map 5.8 Soil sulphur



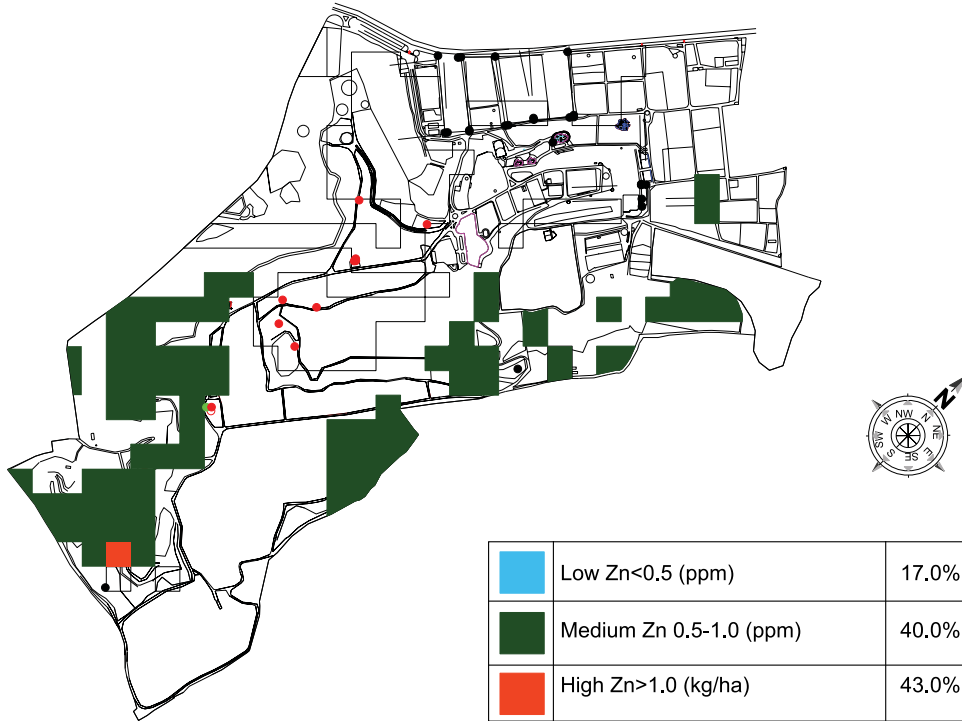
Map 5.9 Soil iron



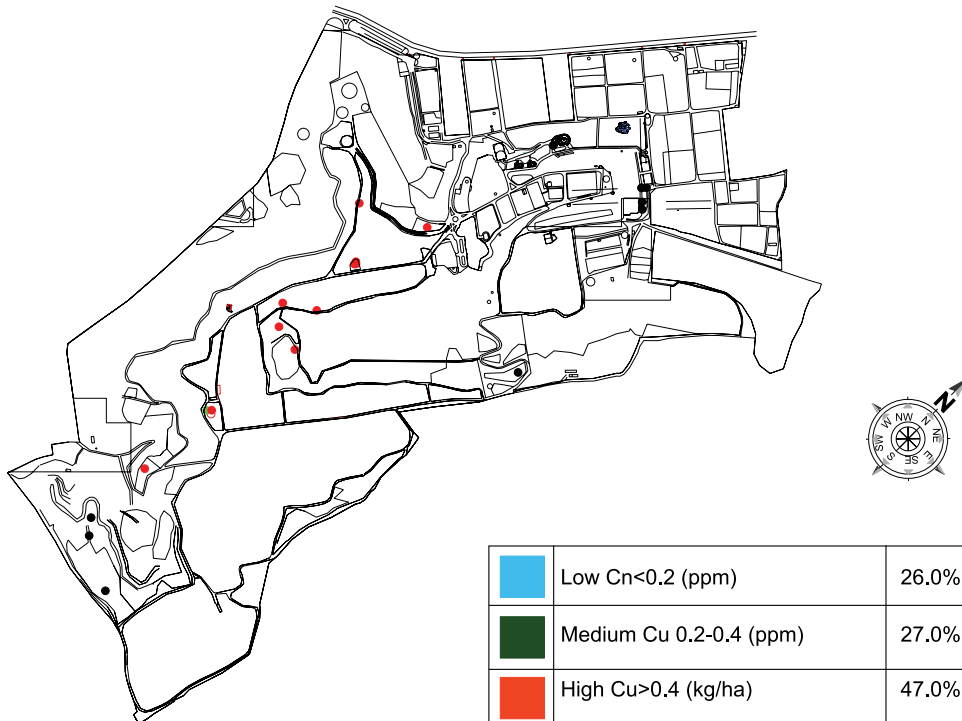
Map 5.10 Soil manganese



Map 5.11 Soil zinc



Map 5.12 Soil copper





‘The soil can also tell us much about our present-day environment. It is the home of millions of living things and a recycling factory for so much of the solar and geochemical energy that sustains life. In its form and properties it expresses the combined influences of local climate, shape of the land, and rocks and organisms that are broken down and incorporated in it.’

– Les Molloy



06. Rainwater Harvesting Structures



Rainwater harvesting is not a new concept to India. Irrigation khadins, village tanks, weirs (bandharas), and other local practices to trap the rainwater have been around from time immemorial.

About 90 million hectares of Indian land are totally dependent upon rainfall to grow any crop and provide livelihood to 70 per cent of the population. Rainwater harvesting can add at least 30 million hectares to the 'irrigated' area of the country by storing, in the soil pore spaces or surface ponds, 18 million hectare-metres of water from the rainfall. Then use it for supplemental irrigation at critical stages of plant growth – pre-sowing, tillage, flowering, etc.

Even in high rainfall regions, rainwater harvesting is relevant, as the rainy season lasts only 3 months or less. It is ironical that Cherapunjee, despite getting the world's highest rainfall, 12,500 mm, has no drinking water in the summer season.

Maximum use of water resources can be achieved if we are able to collect the run-off and let it be stored and percolated. The open reservoirs and percolation tanks help in natural recharge of underground aquifers. Gully plugging, bunding and terracing help improve soil moisture and increase rate of infiltration of rainwater into the soil. The details of water harvesting work done in Jain Watershed area are given yearwise in Table 6.1 and shown in Map 6.1.

*'Without a
conserver
society,
we could find
ourselves with
a resource-
based economy
and no
resources.'*
– Lawrence
Solomon

Measure	Year													Total
	1989	1993	1995	1998	1999	2001	2002	2004	2005	2007	2008	2009	2010	
Polylined tank	1	-	-	-	-	-	-	-	-	1	-	-	-	2
Percolation tanks	-	1	-	1	-	-	-	-	-	-	1	-	-	3
Earthen bund	-	-	1	-	1	1	1	1	2	-	-	-	2	7
Masonry retaining wall	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Rebuilt percolation tanks	-	-	-	-	-	2	-	-	-	-	-	-	-	2
Underground reservoir	-	-	-	-	-	-	-	-	-	-	1	-	-	1

Polylined Tank

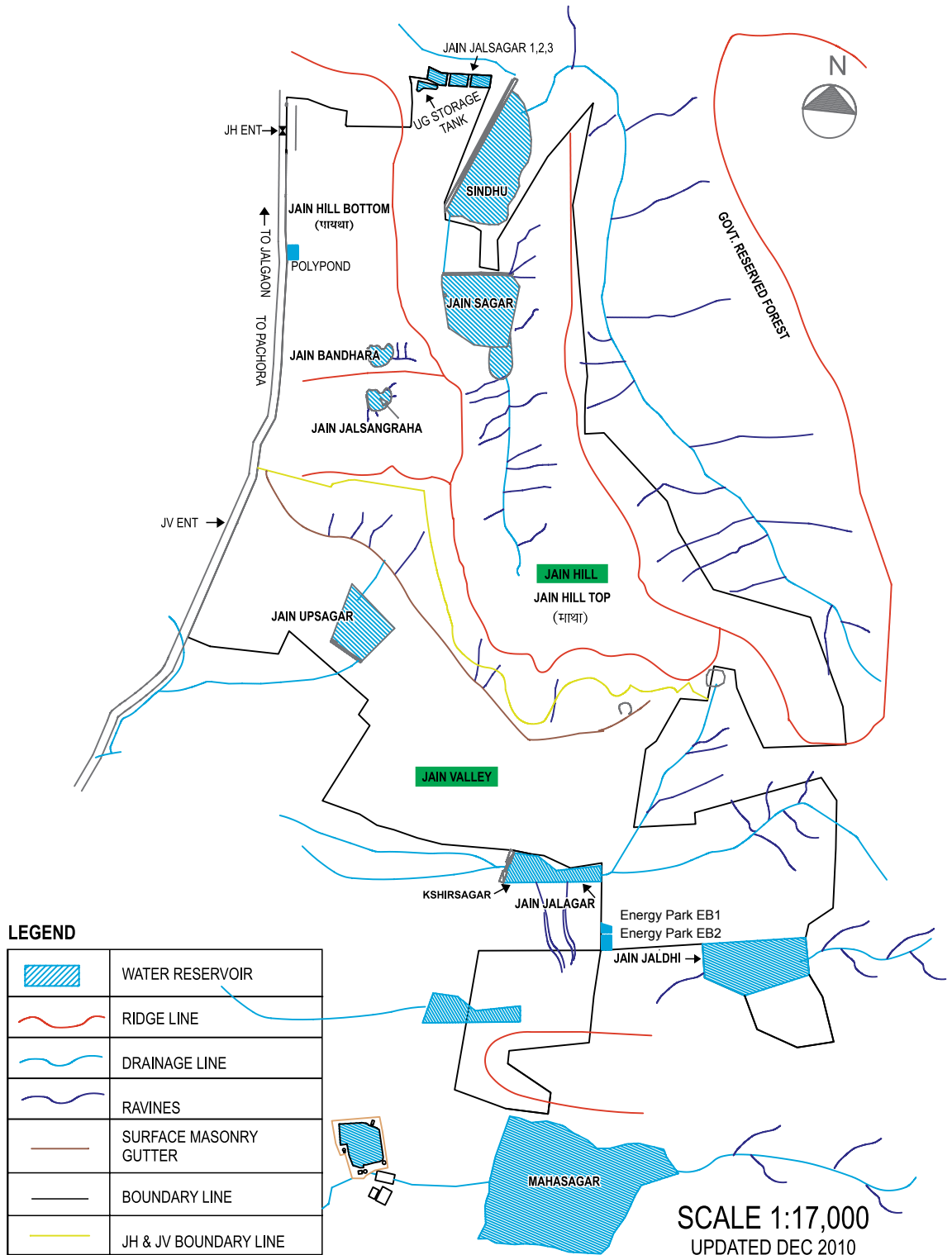
In the initial stages of development at Jain Hills, an earthen tank was made which was later lined with a plastic sheet. The stored water could not percolate due to the plastic lining. Bricks were laid on the plastic sheet. The stored water was used for irrigating the land. The technical details of this tank are given below:

Length: 30m; Width: 15m; Depth: 1.8m;

Storage Capacity: 560 cum (5,60,000 litres)



Map 6.1 : Rainwater harvesting structures



The plastic lining got torn/damaged at places after some time and water could not be stored in this pond. Therefore, the pond was abandoned, and subsequently filled and levelled up.

Second polylined tank was set up in the year 2007. Purpose of this tank was to demonstrate a model of 'Micro-catchment development'. In this model, thin polyethylene sheets are laid in the micro catchment area (in the field) between the rows of plants. Slope is maintained in such a way that water flows down and can be collected at a common point. A polylined tank is then constructed at such a collection point.

Where micro-catchment model can be beneficial -

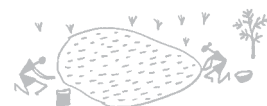
1. Highly saline soil: If the soil is highly saline, the raindrop also turns saline when and where it falls.
2. Scattered rainfall: The areas where rainfall is scattered and is in the range of 300 to 500mm per annum.
3. Highly permeable soil: Where soil is highly permeable (like in deserts of Rajasthan) and cannot hold water.

Water stored in the monsoon season can be utilised for three to four critical irrigations of rabi through micro irrigation system. These critical irrigations are very important and can effect yield increase by 25-30%.



Polylined Tank at Jain Hills (2007)

Model created at Jain Watershed was in operation for about two years and then dismantled because it developed leakages.



Percolation Tank

Two percolation tanks, one each in Jain Hills and Jain Valley, were constructed for water storage. The details of these tanks are given in Table 6.2.

Table 6.2 : Percolation tank details												
Name & Location	Year of Construction	Catchment Area (ha)	Capacity (cu m)	Submergence, (ha)	Length of Bund (m)	Bund max. Height (m)	Bund top width (m)	Side Slope	Waste weir length (m)	Max. water level (m)	Condition	Expenses (Rs. Lakh)
Jain Sagar, JH	1993	32	125000	3.20	197	6.12	6	2:1	14	5.0	Functional	27.00
Jain Upsagar, JV	1998	19	061000	1.60	106	5.25	6	2:1	1m (Pipe)	4.3	Functional	16.85
Jain Jalnidhi, JV	2008	27	055000	2.10	241	2.8	4.5	1.5:1	-	2.5	Functional	19.20
Total	-	-	241000	6.90	-	-	-	-	-	-	-	63.05

Percolation tank constitutes a necessary component for water conservation. Generally, the percolation tanks are constructed in the downstream area of a watershed. The stored water is not used directly by lift but is saved for percolation into the downstream wells from where it is lifted for use. Thus it helps in raising the groundwater level in the area by recharging the ground aquifer.

Cut-off-trenches (COTs), have been provided for both these percolation tanks. The impervious clay type black soil is filled up in the COTs to prevent seepage of stored water under the bund. Filling impervious clay in the core part of the bund also eliminates the possibility of a breach. Two types of earthen bunds have been used, viz. earthen bunds with and without impervious hearting material. The geometrical details of these two types of bunds are given in Fig. 6.2 and Fig. 6.3 respectively.

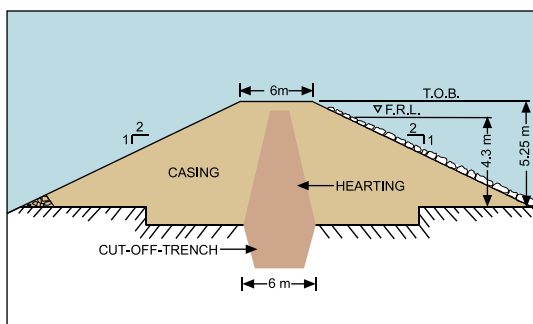


Fig 6.1 : Earthen Bund (with hearting) geometry

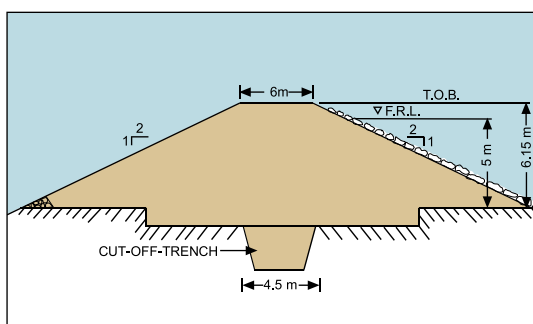


Fig. 6.2: Earthen Bund (without hearting) geometry



Sweet Taste of Success

There was one dug well and one bore well in Jain Hills till 1992. The well being dry was abandoned, whereas the maximum yield from the bore was 70,000 litres (70 cum) per day. This was not sufficient to irrigate 6.2 ha of fruit trees and 3.6 ha of agro-forestry. We were required to bring water from outside to meet the demand of the crops. In summer even this was not enough. There was one small earthen bund which was inadequate. Under these conditions, the construction work of 'Jain Sagar' percolation tank was taken up. COT of 6m depth was excavated and filled with black soil. It took 6-7 months of round-the-clock work to complete construction of this earthen bund. The rainwater got stored in this tank for the first time in 1993. The yield of the bore well increased from 70,000 litres (70 cum) per day to minimum of 2.50 lac litres (250 cum) per day. One well was excavated downstream of the tank. Five new bore wells were drilled. Irrigated area increased to 15 ha from 9.6 ha on account of availability of water. The benefits of watershed development could be realized after the construction of the percolation tank, Jain Sagar, and downstream wells. The success through this Percolation Tank provided inspiration for continuing further work on watershed development. In 2002, the capacity of 'Jain Sagar' was increased by around 1 crore litres by excavating the storage bed. Thus additional storage volume has been created.



Jain Sagar : Stepping stone for watershed development



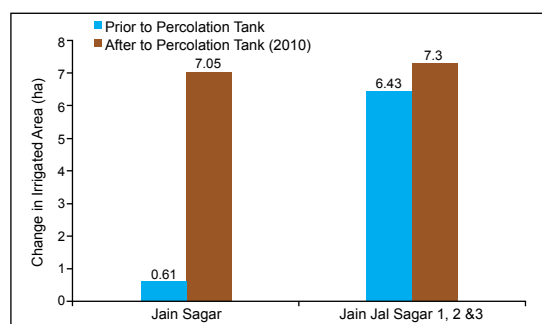
Impact of Percolation Tank

Success of any percolation tank can be measured by enhancement in rate of percolation, changes in yield of nearby wells, dug wells or bore wells, and degree of sustainability of available water. In Jain Watershed we have happily experienced this success in great measure. Table 6.3 gives data on the yields of dug wells and borewells nearby Jain Sagar and Jain Jal Sagar 1, 2 & 3 (three small water harvesting structures in a series) before and after their construction. The table also gives the areas under irrigation before and after the construction of these percolation tanks.

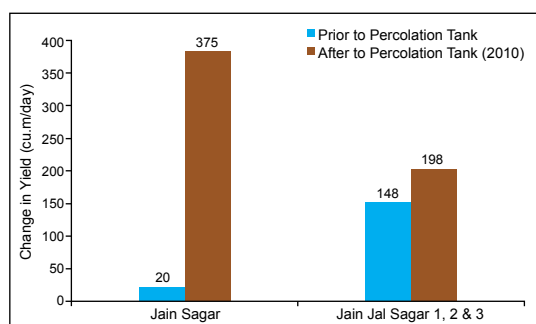
Table 6.3 Impact of percolation tank on water yield in well											
Name/ Location	Year of Construction	storage (cum)	Influential wells/ borewells		Status prior to construction of percolation tank				Status in 2010		
			Well/ Borewell No.	Distance (m) from Tank and direction	Year	Max. Yield (cum/ day)	Min. Yield (cum/ day)	Area irrigated (ha)	Max. Yield (cum/ day)	Min. Yield (cum/ day)	Area irrigated (ha)
Jain Sagar, Jain Hills	1993	125000	JHOW1	475W	Old	-	-	-	580	200	4.80
			JHBW1	600NW	1989	070	020	0.61	340	175	2.25
Sub Total						070	020	0.61	920	375	7.05
Jain Jal Sagar 1,2 & 3, Jain Hills	2004	27300	JHOW6	11S	2004	100	040	1.20	228	077	1.80
			JHOW7	20NE	2005	091	028	0.80	139	032	1.50
			JHOW8	40WS	2005	090	030	1.43	103	035	1.60
			JHOW12	80S	2005	080	050	3.00	119	054	2.40
Sub Total						361	148	6.43	589	198	7.30

The above comparison is done only for the dug wells and borewells existing prior to the construction of rainwater harvesting structures. In fact, the irrigated area is further increased due to new dug wells and borewells made after the construction of rainwater harvesting structures.

The data of increase in irrigated land and enhanced water yield of dugwells and borewells are also presented in Graph 6.1 and Graph 6.2 respectively. It can be seen from these graphs that there is a significant impact of water harvesting on the yield of wells due to which the area under irrigation also increased.



Graph 6.1: Changes in irrigated area



Graph 6.2: Changes in yield of wells



Disappointment through failure

In 1998, when the work of the percolation tank in Jain Valley was taken up, the site was expected to be suitable for a percolation tank on the basis of geological formations of a nearby well. The work of percolation tank was started. Water was struck during excavation of cut-off-trench (COT). A dug well was excavated just downstream of the weir, so that the water percolating from the tank could be lifted and the overflowing water would fall into the well. This dual benefit was expected. But exactly the reverse happened. The aquifer was fractured due to the well and the water stored in the tank found its way through the well by way of seepage. The tank went dry. Finally, construction of an additional COT was undertaken upstream of the weir. But still the water percolated through the junction of both COTs owing to the heterogeneity of soils in the two COTs. The quantum of seepage was, however, now reduced. It would have been useful if the well was constructed prior to COT or it should have been at some distance from COT. It would have rendered the storage in the tank to last longer and the capacity of the tank also would have increased. We are trying to correct the situation by extending the COT, plugging the leak, and hoping for the best. We have listed this as a failure because the seepage of this percolation tank through COT is far in excess of the expected rate. Because of this excess seepage, water does not get stored for a sufficiently long period for deeper penetration or recharging of the ground aquifer, which is the main objective of the percolation tanks. However, beyond the compound of our food park there are lush green farms belonging to other farmers who have obviously benefitted on account of the failure of Jain Upsagar.



'Jain Upsagar' : In search of innovation.



Earthen Bunds

Earthen bunds, seven in number, are constructed in the Jain Watershed area for soil and water conservation. The details are given in Table 6.4. The geometry of the earthen bund structure is illustrated in Fig. 6.3.

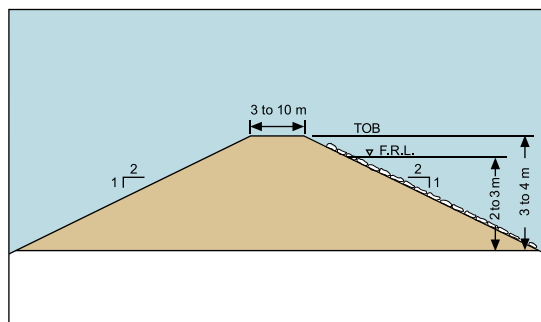


Fig. 6.4 : Earthen bund geometry



Jain Jal Sagar

Table 6.4 : Details of earthen bunds											
Name & Location	Year of construction	Catchment Area (ha)	Capacity (cum)	Sub-mergence (ha)	Length of bund (m)	Bund max. height (m)	Bund top width (m)	Side slope	Waste weir length (m)	Max. water level (m)	Status
Jain Jalashay, JV	1995	41	-	1.00	81.0	3.5	14.0	1:2	12.2	2.0	Abandoned
Jain Sangraha, JH	1999	12	-	0.30	26.5	3.2	3.0	1:2	04.5	2.0	Abandoned
Jain Jal Sagar, JV	2001	41	15,000	0.80	51.0	2.3	3.5	1:2	13.0	2.0	Functional
Jain Jalnidhi, JV	2002	10	-	0.25	31.0	3.7	3.7	1:2	2.4	2.5	Abandoned
Jain Jal Sagar -1 JH	2004	8	15,900	0.55	85.0	4.25	6.0	2:1	8.0	3.5	Functional
Jain Jal Sagar -2, JH	2005		10,000	0.42	65.0	2.95	6.0	1:1.5	6.2	2.5	Functional
JH, Jal Sagar -3, JH	2005		1,400	0.17	46.0	1.50	4.5	1:1.5	-	1.25	Functional
Energy Park EB1	2010	8	450	0.07	15.0	2.0	0.3	1:1.5	-	1.5	Functional
Energy Park EB1	2010		600	0.05	15.0	2.0	0.3	1:1.5	-	1.5	Functional
Total			43350	2.31							

The major difference between a percolation tank and earthen bunds is that the earthen bunds have no foolproof COT and hearting. Therefore, they cost less. The storage capacity of earthen bunds is less than the percolation tanks. If constructed upstream of a watershed, the earthen bunds serve the purpose of soil conservation as well as water conservation.



These structures when designed and constructed scientifically prove to be very effective both in terms of cost and function. They can also be designed for irrigation purposes. However in Jain Watershed the main objective in erecting these earthen structures is conservation of soil and water. This is with a view to reclaim the wasteland and to effect rainwater harvesting.

In 2008, the percolation tank ‘Jain Jalnidhi’ was constructed. The storage capacity of Jain Jalnidhi is 55,000 cum. It resulted in lowering of discharge through the stream which was the source for three earthen bunds in a series of water harvesting structures in Jain Valley area. Hence these water harvesting structures in Jain Valley area were refilled in 2008.



Bhau discussing technical aspects with Shri. Garge and Shri. Barve.

Rebuilding of Percolation Tanks

There are two old Government percolation tanks, one on North of Jain Hills and the other on South of Jain Valley. Water could not be stored in both these tanks owing to the faulty construction. The land downstream of the Jain Hills tank became water-logged and saline and the percolation tanks did not benefit the farmers around. It was, therefore, decided to undertake repairs of these tanks, so as to make them functional.

The COT of the percolation tank Sindhu upstream of Jain Hills was not properly compacted. Therefore, one additional COT was excavated upstream of the earlier one and filled with black soil. It was properly compacted. This has not only averted



Bhau smiling at site : Rebuilding of percolation tank, Sindhu.



Rebuilt Sindhu : Water, water and water...



Water overflowing from rebuilt ‘Kshirsagar’



the danger of soil becoming saline, but also raised the water level in the wells in the downstream area through sustainable recharging of the aquifers to the advantage of farmers. Similarly the percolation tank south of Jain Valley, Kshirsagar, which had been abandoned, was also rebuilt. The waste weir of this percolation tank was severely damaged. This waste weir was repaired to make this percolation tank functional. As a result of this all the farmers downstream of this tank got benefited.

The details of these percolation tanks are presented in Table 6.5.



Bhau guiding Shri. Dixit on repair work of percolation tank.

Table 6.5 : Rebuilt percolation tank's details											
Name & Location	Year of Construction	Catchment Area (ha)	Capacity (cum)	Submergence (ha)	Length of bund (m)	Bund max. height (m)	Bund top width (m)	Side Slope	Waste weir length (m)	Max. water level (m)	Expenses (Rs. Lakh)
Sindhu, JH	2001	75	165000	6.3	487	5.4	6.00	1:2	29.4	3.6	28.50
Kshirsagar, JV	2001	41	042500	1.3	138	3.3	7.33	1:2	10.2	2.4	3.50
Total	-	-	207500	7.6	-	-	-	-	-	-	32.00

Similar to these two percolation tanks, there are thousands of storage/percolation tanks constructed in India, but are not fulfilling their purpose due to their faulty/improper construction or improper maintenance. The time has come to undertake repairs and rebuilding of these tanks as we have done at Jain Watershed.

Underground storage reservoir

The area near Jain Jal Sagar and the renovated percolation tank Kshirsagar was facing problems of water logging. To overcome this problem an underground reservoir was constructed to tap the seepage and re-collect and use that water for irrigation. A 3.5m deep underground storage reservoir is constructed, it has the capacity to store 3250 cu.m of water. This way it served two purposes, one was resolving the water logging issue and the other of getting an additional storage.

'If there is but little water in the stream, it is the fault, not of the stream, but of the source.'

– St. Jerome



Masonry Retaining Wall

A masonry wall was constructed in 1999 in Neem Valley area of Jain Hills. An earthen bund would have been adequate here. However, since the retaining wall is an important component in watershed development works, in order to gain experience, this masonry structure was constructed. It has also become a demonstration of a failed model.



Masonry retaining wall in Neem Valley does not store even a single litre

Despite the fact that the foundation was taken as deep as was technically required, this retaining wall could never retain water as there was and is heavy seepage.

However, a borewell down stream has increased its yield and duration. Since the catchment area is too small we have not yet thought of any remedial measure. The details of this retaining wall are given in Table 6.6.

Table 6.6 : Masonry retaining wall details

Year of construction	Catchment Area (ha)	Capacity, (cu.m)	Submergence, (ha)	Bund max. length (m)	Bund top width (m)	Side Slope	Expenses (Rs. lakh)
1999	2.8	1200	0.12	28.9	3.87	0.5:1	1.2

Soil, Water & Crop Relationship

It may be noted that various soil and water conservation measures outlined above are interdependent, collective in nature and result in automatic improvement in each other's capacity, character and content. The measures taken for improvement in use of water, land and/or crop individually, also facilitate utilisation of the other resource(s) and finally the watershed becomes a resource-centered, environment-based focal point which promotes sustained and rapid integrated development.

In the same manner, it may be pointed out that the deterioration in one factor will have a devastating effect on the others. Thus, if heavy soil erosion takes place, and the land nutrients are lost, availability of water would be rendered much less effective. With the same logic, if water availability declines and rich soil/land mass is available, its productivity will get severely limited because it will be largely rain-dependent. Likewise, even if soil is rich, water availability is adequate but the crop planning is faulty, the returns from the land and water per unit may become economically poor.

Increase in cropping intensity is a natural outcome of watershed management. However, proper cropping pattern and rotation alone can result in higher utilisation of water and land. Scientific sowing and cultural practices, selection of crops/plants,



shifts in rotation of crops, strip-cropping, intercropping, planting of green manuring crops are essential for supplementing the withdrawal of nutrients by the plant and enrichment of the soil.

Thus the land, soil, water and crop relationship is a close-knit phenomenon. Effectiveness of one will affect the other(s). As such a holistic view about the management of each and all of them needs to be taken.

Evaporation Control Measures

Losses due to evaporation is a major concern for any water storage. According to water auditing in Maharashtra, the total evaporation losses were 14% of live storage for major projects, 23% for medium projects, and 24% for minor projects, with a state average of 16%.

At Jain Watershed most of the water harvesting structures are saucer shaped having larger surface area exposed for evaporation losses. Additionally, temperature goes as high as 48 degree celsius and humidity is low which encourage evaporation from water surface. At Jain Watershed the evaporation losses are as high as 27% of the live storage. An innovative step is taken to inhibit evaporation losses from water surface. One of our associates, Shri Shripad Joshi and his team from the Biotech Lab. has developed a chemical, which when spread over the water surface controls evaporation significantly. This chemical namely, 'Jain Aqua Saver' proved to save about 14000 litres of water per acre per day. Jain Aqua Saver is required to be spread daily over the water surface using a simple wooden float. Importantly, this chemical is an organic chemical having no harmful effect on agriculture, human and aquatic life.



Jain Aqua Saver mounted on the float



Evaporation control treatment at 'Jain Sagar'

Table 6.7 Results of trial conducted with 'Jain Aqua Saver'				
Month & year	Average evaporation of water without Jain Aqua Saver (lpd/acre)	Average evaporation of water with Jain Aqua Saver (lpd/acre)	Average Water Saved	
			litres/acre/day	% saving
Feb - 09	31242	22399	8843	28
March - 09	44209	34895	9314	21
April - 09	54853	41516	13337	24
May - 09	71272	53753	17519	25
June - 09	62957	43022	19935	32

Expenditure on Rainwater Harvesting Structures

The details of expenditure incurred for rain-water harvesting structures created for collection and storage of excess run-off for the purpose of natural recharge have been tabulated year wise in Table 6.8.

Table 6.8 : Expenditure on rainwater harvesting structures (Rs. Lakh)															
Name of structure	1989	1993	1995	1998	1999	2001	2002	2004	2005	2006	2007	2008	2009	2010	Total
Polylined tank	0.25	-	-	-	-	-	-	-	-	-	3.10	-	-	-	3.35
Percolation tank	-	27.00	-	16.85	-	-	-	-	-	-	-	19.20	-	-	63.05
Earthen bund	-	-	3.75	-	2.54	1.90	1.15	7.10	3.10	-	-	-	-	0.42	19.96
Masonry retaining wall	-	-	-	-	1.20	-	-	-	-	-	-	-	-	-	1.20
Rebuilt percolation tank	-	-	-	-	-	32.00	1.00	-	-	-	-	-	-	-	33.00
Underground storage reservoir	-	-	-	-	-	-	-	-	-	-	-	1.4	-	-	1.40
Total	0.25	27.00	3.75	16.85	3.74	33.90	2.15	7.10	3.10	-	3.10	20.60	-	0.42	121.96



07. Water Recovery Structures



Water which is harvested through rainwater harvesting structures has to be reclaimed for further use. Deep percolation recovery is possible through establishment of a network of downstream dug wells and/or borewells.

Details of Water Recovery Structures

It is only watershed development efforts that have converted this barren hilly wasteland into this sustainable irrigated farm. Details of dug wells done within the Jain Watershed area are given in Table 7.1. Details of operating borewells are given in Table 7.2.

Table 7.1 : Details of dug wells										
Dug well no.	Location/ Plot No.	Year	Size (m)	Area (sq.m)	Depth (m)	Yield (cum/day)		Storage (cum)	Arti. recharge	Expense (Rs. lakh)
						max.	min.			
Jain Hills										
JHOW1	11	Old	Ø 06	113	12.0	450	120	325	yes	0.8
JHOW2	17	1994	Ø 17	416	10.5	2100	200	1880	yes	3.1
JHOW3	09	2001	Ø 09	177	15.0	800	60	714	yes	1.6
JHOW4	02	1997	4.5 x 9	054	12.0	700	85	382	no	1.3
JHOW5	02	1999	5.5 x 10	184	15.0	600	75	520	yes	1.5
JHOW6	07	1998	4.5 x 18	252	09.0	1000	40	252	yes	2.3
JHOW7	07	2003	Ø 06	113	11.0	300	30	325	yes	1.6
JHOW8	05	2003	Ø 7.5	143	14.0	700	50	480	yes	2.1
JHOW9	12	2003	Ø 5.5	103	10	250	10	250	yes	1.9
JHOW10	13	old	Ø 0.3	087	18.0	30	10	170	yes	Nil
JHOW11	14	old	Ø 4.5	-	-	-	-	-	-	0.6
JHOW12	04	2003	Ø 7.5	143	017	800	65	325	yes	1.9
JHOW13	11	2003	Ø 7.5	045	12.0	200	15	325	yes	2.1
JHOW14	03	2004	Ø 7.5	140	12.5	350	40	275	yes	1.85
JHOW15	06	2004	Ø 8	165	13	500	90	320	yes	1.7
JHOW16	05	2004	Ø 6	115	12	450	50	250	yes	1.7
Jain Valley										
JVOW1	16	1997	6 x 15	252	11.5	1200	50	960	no	2.7
JVOW2	15	2001	Ø 09	176	12.0	1200	200	625	yes	1.4
JVOW3	02	1996	Ø13	20	09.0	600	150	970	yes	1.7
JVOW4	02	1994	Ø 5.5	104	11.5	450	120	215	yes	0.7
JVOW5	01	1998	4.5x9	158	11.5	425	10	370	yes	1.2
JVOW6	04	2004	Ø 8	170	14.0	600	125	750	yes	2.05
JVOW7	05	2004	Ø 6	115	12.5	400	120	300	yes	1.8
JVOW8	05	2004	Ø 16	300	12.5	1200	200	2250	yes	4.0
JVOW9	08	2005	Ø 9.5	178	15.0	550	160	1050	yes	2.6
Total				3723		15855	2075	14283		44.2



Table 7.2 : Details of operating borewells									
Borewell No.	Location Plot No.	Year	Size Ø (mm)	Area (sq.m)	Depth (m)	Yield (cum / day)		Arti. recharge	Expense (Rs. lakh)
						Max	Min		
Jain Hills									
JHBW1	01	1989	165	3.00	100	350	150	No	0.3
JHBW2	12	1994	165	8.00	220	205	080	Yes	0.6
JHBW3	14	1994	165	8.00	116	165	055	Yes	0.4
JHBW4	13	old	165	3.00	-	old hand pump		Yes	-
JHBW5	11	2003	190	3.00	122	080	015	No	0.4
JHBW6	17	2000	165	3.00	085	hand pump		No	0.2
Jain Valley									
JVBW2	16	1994	165	3.00	096	210	040	No	0.4
JVBW3	17	1994	165	8.00	145	150	095	Yes	0.4
JVBW4	02	1994	200	3.00	220	225	080	No	0.6
Total				42.00		1385	515		3.30

Presently, in Jain Watershed, there are 25 dug wells and 36 borewells. The locations of these structures are shown on page 73 in Map 7.1 : Harvested/Stored /Percolated water reclaiming structures. Two dug wells and 26 borewells out of these are non-water-bearing. The main reason for failure of borewells is the compact basalt trap with a depth of more than 100m - 170m (300 ft to 500 ft). This gives an idea how difficult it was to recharge and recover the groundwater in this area.

We have had more failures to our credit (or discredit?) with borewells than dug wells. In each case, however, we have completed the structures and we propose to make suitable arrangements for recharging these non-water-bearing wells in the hope that some day our watershed will come to our rescue and rejuvenate these. We are, however, keeping our fingers crossed. My associates are constantly reminded of an acknowledged fact that I am an incurable optimist.

I love speed. Hence anything that can give me quick results attracts me instantly. When the first few borewells were dug and they had a good water yield, I desperately looked for drilling rigs which could do the work at the speed I wanted. I had drawn up an ambitious plan of drilling 50 borewells. However, the drilling rigs are awfully busy during the summer and the drilling rig operators, who are found to be from another state, more often than not fail to keep their promises. Realising this difficulty, I opted to purchase one second-hand drilling rig. I completed



Bhau and P. A. Patil with boring rig

drilling of borewells with the help of our own drilling rig within this area in the same season. However, the operation proved to be quite tedious, and operators of the drilling rig had also to be trained. I finally got the drilling mechanism off-loaded and used the platform as a conventional truck.

Present Status of Non-water-Bearing Structures

A photograph of a failed dug well in Jain Hills is given here. Through long and costly experimentation we have realised that a dug well is a far better method for recovery of percolated water. At least in this area, the dug wells performed better though they were almost 3 to 4 times the cost of an average size borewell. Moreover, dug wells can be used for storage, and the pumping of water can be intermittent. With proper artificial recharging method it is possible to rejuvenate such failed dug wells. At Jain Hills such an experiment has succeeded.



Failed dug well



Failed borewell : Waiting to be recharged

The number of borewells which are non-bearing in Jain Watershed area is, by any standard, very high (26) as against the operating water-bearing borewells (10). In case of borewells, one needs minimum collection before one can start pumping. If the yield is too low, the borewell will go dry in a short while. Moreover, the life of a bore well (without arrangement for recharging) in this area is not very long. We are in the process of collecting the data to ascertain what is the average life of a borewell in this region. It is difficult to picturise a failed borewell. We have given here a symbolic photograph of a failed borewell. These failed borewells, however, have left enough scars on our minds and hearts. We are determined to remedy the situation.

Problems Faced and Solutions Found Regarding Dug Wells

It may be pertinent to note that excavation of dug wells is becoming difficult by the day. The digging of dug wells is quite a skilled job. There are teams which specialise in digging such open wells. However, these teams may not be available in the same village/location. They generally come from outside and camp at site for a certain period to do the job. They always find excuses to go back to their native places frequently. They normally take advance payment and many times simply do not return to work. In addition to being costly, this operation is, therefore, becoming quite bothersome and time consuming. We have located some Rajasthani teams

'When the well's dry, we know the worth of water.'

– Benjamin Franklin



which we have discovered to be far more efficient, cost effective and dependable when compared with local/nearby teams.

We, at Jain Hills, have lately adopted some measures which have made excavation of such dug wells a little easier and speedier. One such dug well, using the hybrid method of construction, is portrayed in the photograph. We employ a poclain excavator and dig up to a depth where hard strata is hit. It is observed that excavation with the excavator is possible up to a depth of around 3m (10 ft). Moreover, nowadays we do not opt for brick (BB) masonry or stone (UCR) masonry work, except for the bottom layer (hard strata upwards), of about 1m (3 ft). Thereafter, we cast in situ reinforced concrete rings of about 1m (3 ft) height. These rings have male-female features to form a firm joint. In this manner, we are able to finish the job speedily. Our dependence on the whims and fancies of skilled labour from the nearby area is reduced. Casting of rings can be undertaken by any civil construction contractor. In cost comparison, in situ the concrete rings are cheaper and a hybridisation approach of the first layer with stone masonry and the upper layers of in situ rings does not allow any compromise in quality of construction. However, the durability may be somewhat less than that of masonry construction.



Hybrid construction with UCR and RCC rings in a dug well



Expression of satisfaction

Expenditure on Water Reclaiming Structures

The expenditure incurred on constructing structures for recovering and reclaiming the stored/harvested/percolated rainwater through dug wells and borewells in Jain Watershed is tabulated in Table 7.3.



Table 7.3 Expenditure on Water Reclaiming Structures																				(Rs. in Lakhs)
Year	1989	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Dug wells	1.40	-	3.80	-	3.90	4.00	5.04	1.50	-	3.78	2.50	3.50	7.85	5.25	1.56	3.08	1.50	-	-	48.66
Non-operating dug wells	0.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.75	0.85	-	2.20
Bore wells	0.30	-	2.40	-	-	-	-	-	0.20	-	0.50	0.40	0.25	0.15	0.65	0.30	-	0.24	-	5.39
Non-operating bore wells	0.20	0.48	0.96	0.48	0.72	0.24	0.72	0.48	0.48	0.72	-	-	-	0.13	0.28	-	0.12	-	-	6.01
Total	2.50	0.48	7.16	0.48	4.62	4.24	5.76	1.98	0.68	4.50	3.00	3.90	8.10	5.53	2.49	3.38	2.37	1.09	-	62.26

Conclusion

Excavation of borewells or dug wells in a rainshadow Deccan Trap region is a gamble. It is, however, much less of a gamble if it is supported by and/or is preceded by development of a watershed. If development of watershed is technically correct/perfect, the chances of success of the downstream dug wells and borewells are brighter in the long run. One may have some failures, initially. However, that should not dissuade or discourage one from pursuing one's course. Development of a watershed will naturally result in enrichment of ground aquifer.





The waterhole : Primordial creator source.

08. Artificial Recharging & Soil Moisture Improvements



“Artificial Recharge” may be defined as the method of increasing, by artificial means, the amount of water that enters into an aquifer. Various methods are available to recharge the water table by increasing the rate of infiltration:

- Obstructing the flow of water.
- Spreading the water.
- Injecting water through wells and borewells (by gravity or by forced injection).

Advantages of Artificial Recharge

- Creates a groundwater ridge or mound around existing groundwater extraction structures
- Minimises the depth of water to pumping level
- Minimises the cone of depression, and cost and duration of pumping
- Increases discharge rates
- Improves quality of groundwater
- Prevents temporal decline of water table in the region
- Increases annual groundwater recharge
- Creates scope for additional groundwater extraction
- Maintains a safe groundwater balance
- Improves the overall available groundwater potential in the area
- Prevents salinity intrusion

From the geological studies and on the basis of experience, it is found that the water-holding capacity and hydraulic transmissivity of the

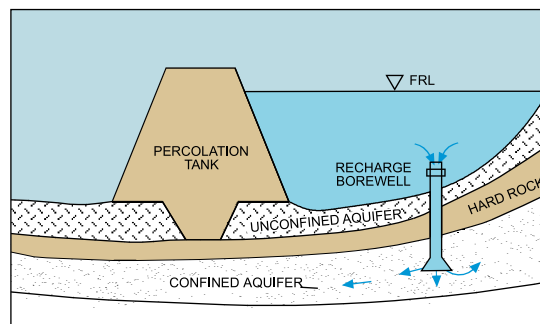


Fig. 8.1: Schematic diagram of artificial recharge of confined aquifer



Artificial recharging of a dug well

strata in Jain Watershed is poor. The infiltration is mainly from overlain soil and murrum layers. In order to recharge the aquifers and to increase the percolation from the tank, one borewell, about 120m (400 feet) deep in Jain Sagar was drilled. Physical verification of benefits of this artificial recharge is yet to be determined. Fig. 8.1 shows a schematic diagram of artificial recharge through borewell.



A pit, 3m deep, was excavated around Well No. JHOW3 during 2001-02 for artificial recharging. It was filled with boulders, rubble and coarse aggregate on the top. The rainwater flowing from nearby area of the well has been diverted into this pit. The silt and other debris are trapped in the filter thus created and clear water is infiltrated into the well. The recharge holes of the well do not get blocked due to filtration. The raised water level in the well also helps in recharging the ground water as indicated in Fig. 8.2.

After severe drought for three consecutive years, the importance of every drop of rainwater for storage and recharging was recognised. In

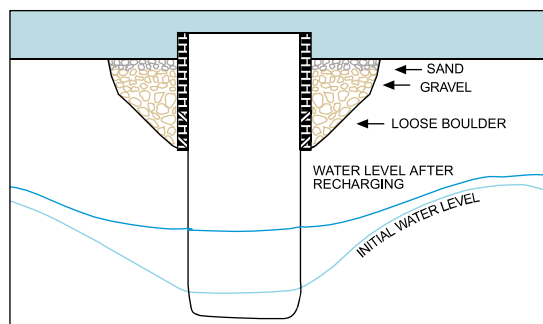


Fig. 8.2 : Schematic diagram of rainwater harvested in percolation well.



The future generation inquisitive about filter bed for recharging of dug well. Technical advisor Shri. V. R. Barve looks on.

the year 2002, major emphasis was given to creating artificial recharge structures or providing recharge facilities to old structures. Water flowing out of the Jain Watershed area is diverted to these structures and allowed to percolate down to augment the groundwater level.

Overpumping of Groundwater

As already mentioned, in less than a decade we dug as many as 25 open wells and drilled 36 borewells. In the same manner, everywhere else in the country phenomenal increase in the rate of growth of groundwater abstraction structures has taken place. It is estimated that the groundwater abstraction structures have increased from nearly 40 lakhs in 1951 to nearly 170 lakhs in 1997. This is mainly because power and diesel for pumping water from such abstraction structures have been vastly subsidised by the government. This has, however, helped stabilise agricultural production and facilitated drought management. Many areas, therefore, are witnessing overexploitation or overdraft of groundwater, i.e., groundwater development in



Borewell recharging



those areas has far exceeded the annual replenishable resource. This is leading to failure of wells, deepening of wells, increased pumping lifts and costs, and causing problems like salinity ingress in coastal areas and contamination of groundwater.

The problems have been further accentuated due to rapid urbanisation. In urban areas, run-off generated is generally lost. It is, therefore, essential to artificially recharge the groundwater because that will minimise evaporation losses, will not require storage space on surface and reverse the declining groundwater levels. In coastal areas, this will push the seawater-freshwater interface.

Recharging in Urban Areas

Traditional rainwater harvesting practices, which have been ignored with the introduction of piped water supply system, need to be revived. In urban areas, implementation of rooftop rainwater harvesting and artificial recharge needs to be made mandatory by incorporating suitable changes in the building bye-laws. In urban areas, recycled waste water can be used for horticulture, air-conditioning, etc. The waste water after primary treatment can also be utilised for recharging.



Dug well with open collection trench and artificial recharge arrangement

In urban areas, the surface methods would include infiltration trenches, porous pavements, street drainage and storm water systems, roof-top rainwater harvesting, waste-water treatment and its reuse, and other aquifer recharging treatment systems.

Natural and Artificial Recharging

The groundwater can be recharged naturally and/or artificially. The natural recharge is maximum from rainfall (51%). The next is from canal seepages and canal irrigated fields (23%). The artificial recharge of groundwater can occur if river/canal water is introduced in the given area or some measures based on water harvesting are undertaken for this purpose. However, in some places, it may not be necessary to resort to the artificial recharge measures.

In the areas where groundwater scarcity exists and where the overdraft exceeds the natural groundwater recharge level, artificial recharge becomes imperative. Similarly, the areas where groundwater storage is poor are favourable for artificial recharge. These areas, where artificial recharge methods have to be employed, fall into the following categories : (a) Rocky and plateau areas. (b) Dark grey blocks and deep water level areas. (c) Saline groundwater areas.



Methodologies for artificial recharge of groundwater vary depending on : (a) Hydrogeology (b) Physiography (c) Lithology (d) Aquifer behaviour (e) Available water resources and formations.

In alluvial areas, surface methods such as basin method, stream channel method, ditch and furrow method, flooding method, or irrigation method, pit method and induced recharge method are used for artificial recharge. Most of these will be practised in rural areas.



Exposed rock showing fractures and weathering effects

Status of Work in Jain Watershed

In this discussion, we are confining ourselves to a very limited aspect of groundwater recharge based on rainwater harvesting and water conservation techniques in rocky and semi-rocky areas with varying physiographic conditions.

As explained earlier, bunding (contour and graded), bench terracing, land development, afforestation and other on-farm developments are the obvious methods. Percolation tanks, gravel filled trenches, trapezoidal percolation/infiltration open trenches, underground bandharas, storage-cum-water spread check bund structures also have been commented upon earlier. More recently, bore-blast techniques, jacket well techniques, trench-cum-filter technique, fracture-seal cementation technique and hydro-fracturing technique are also being employed.

We, at Jain Hills, have so far mainly worked on rainwater borewell and dug well recharge technique, trench-cum-filter bore well technique and dug well jacket technique. We are soon going to experiment with hydrofracturing technique.

We have made it a standard practice to excavate 10m (30 ft) diameter pit up to the depth of hard strata whenever we wish to construct a dug well with 6.7m (20 ft) diameter. In this manner, we increase the effective diameter of the well without disturbing the well and fill the gap between the well structure and the pit with a base layer of boulders, next a layer of aggregate and finally a layer with sand gravel. We also propose to drill 100mm diameter holes around the well in a circular fashion. Two or three concentric circles of base holes are proposed to be formed. These bore holes will then be blasted to create interconnected fractures. Sand packing will be resorted for filling the fractures so created.



Year	Rs. lakh
1994	0.03
2000	0.04
2002	1.53
2003	0.18
2004	0.14
2005	0.28
2006	0.40
2007	0.60
2008	0.35
2009	0.65
2010	-
Total	4.20

The artificial recharging arrangements were aggressively undertaken only since 2002. Expenses on this account have aggregated to only Rs.4.2 lakh, as given in Table 8.1. However, hereafter for every abstraction structure, that is, a dug well and/or a borewell, we are going to make a provision for artificial recharge simultaneously with the construction of the structure. Furthermore, we are also contemplating use of newer techniques for fulfilling the objectives of artificial recharging in Jain Watershed.

We believe that provision of artificial recharging arrangements should form an integral part of construction of dug wells and/or borewells particularly in such areas as Jain Watershed. We do not see any other alternative to achieve sustainability except to maintain the water harvesting structures in good condition and also provide the artificial recharging facilities for structures created for the purposes of reclaiming/recovering harvested/percolated water through dug wells and borewells.

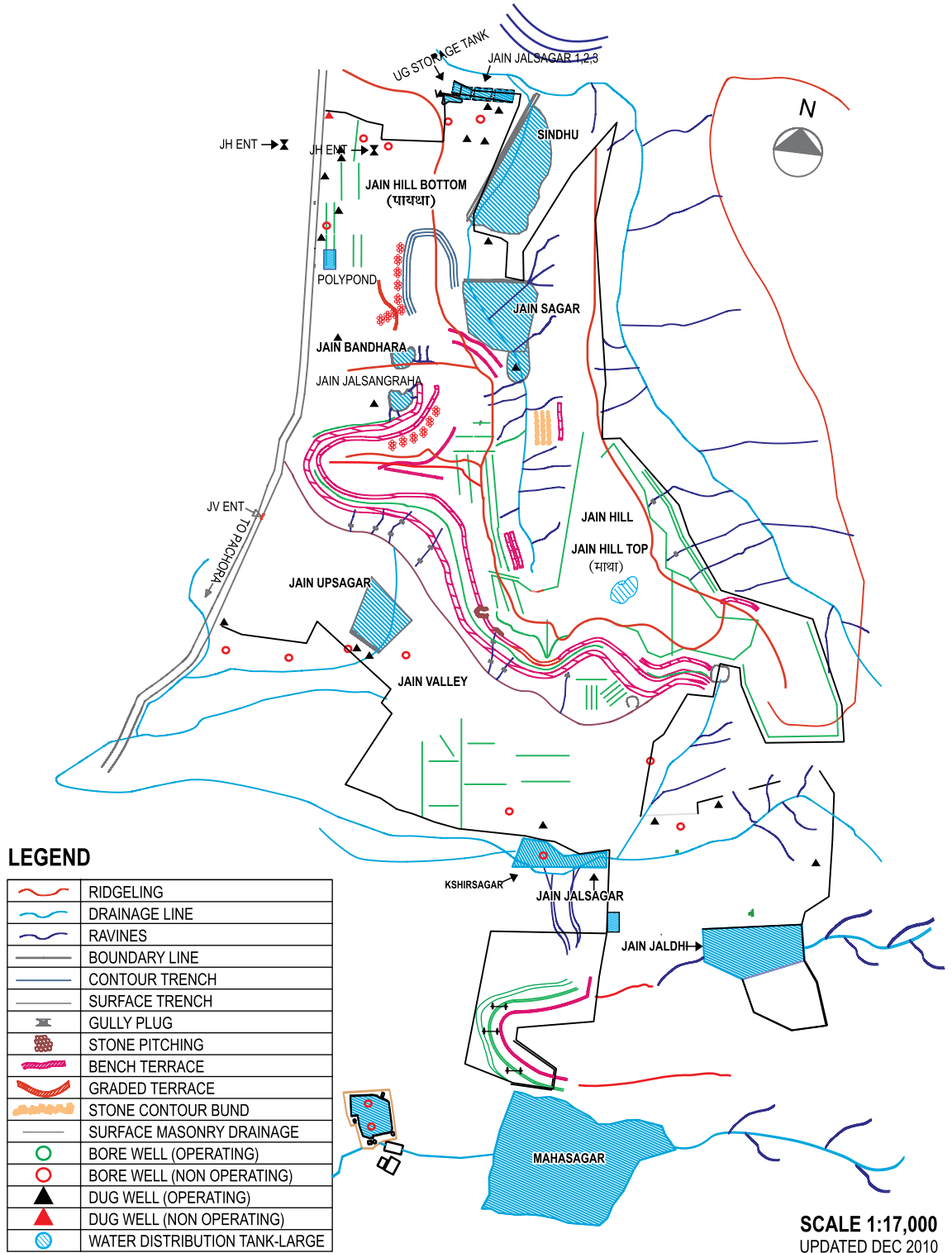
Map 8.1 gives an overall picture of the watershed development structures so far discussed in the previous chapters. It includes locations of land and soil conservation structures, rainwater harvesting structures and water recovery structures.

‘We must rethink water management. We no longer live in a world in which rivers can be endlessly dammed, aquifers relentlessly pumped, eco-systems ruthlessly impoverished. We have to focus on how to conserve water, how to create water and how to use the new found water.’

–Gleick



Map 8.1 : Consolidated watershed development



09. Higher Water-Use Efficiency through MIS



We have so far discussed water and soil conservation measures, structures along with steps required for improvements in the land and soil. It would be observed that the prime objective of any watershed development project, therefore, is generally restricted to conservation, storage of water and its increased availability covering life of the crop / plants. More importantly water availability for the planned purpose, irrigation or drinking, must be on a sustainable basis.

It is a very well accepted fact that uncontrolled use of water for irrigation of plant/crops through the conventional open furrow method has, over the years, given rise to multiple problems. It has resulted in, for example, deterioration of soil quality, depletion of groundwater to unacceptable levels, wastage of water causing excessive weed growth. Moreover, productivity per unit of water, land and resources, utilized for the farm operation, has reduced. And above all, it amounts to squandering away this scarce, precious, national resource.

The policy makers, farm researchers, scientists and academicians, engineers and every one connected with modern farming concepts and practices have all unequivocally opined and accepted that – irrespective of its availability or non-availability, excess or shortage – efforts must be made towards economic use of this resource. The water-use efficiency must be increased at all costs. This is not merely because there is shortage of water but also because its more effective use results in hitherto unacknowledged benefits like increased yields and improvement in quality of farm produce.



Higher crop density using MIS

The Micro Irrigation System (MIS)

Modern micro irrigation methods guarantee higher water-use efficiency as well as greater cost-benefit ratio to the user. The commonly accepted modern irrigation method from this standpoint is Micro Irrigation System, which is defined as a method of irrigation in which, ‘Water is applied to the root zone of the plants directly, at frequent intervals (daily) in controlled quantities as per requirements of the plants, through a low-pressure network of piping including Main, Sub-main and Lateral lines with Emitters or Drippers spaced along the lateral lines.’



Water applied is essentially passed through a filtration system to prevent suspended impurities, which may block the emitters. Water-soluble fertilisers and nutrients can also be applied along with micro irrigation through a fertiliser tank and/or venturi.



Filtration station

Major benefits of drip irrigation

- **Increased Yields:** The system facilitates water application at regular intervals thereby maintaining optimum moisture level at the root zone for a longer period thus preventing moisture stress or shock associated with other methods of irrigation. This promotes optimum plant growth resulting in higher yield and better quality produce.
- **Improved Quality and Early Maturity:** Crop quality improvement and early maturity are results of uniform growth and ripening. In addition, damage and loss because of water contact with fruit or foliage are eliminated.
- **Water Saving:** Water saving effected upto 23-68% in various crops as all percolation and evaporation losses are eliminated / minimised. (Table 9.1)

S. N.	Crop	Yield (Qtl/ha)			Water Requirement (mm/ha)		
		Conventional	Drip	Increase in yield (%)	Conventional	Drip	Water saving(%)
1	Banana	575	875	52	4447	2446	45
2	Grapes	325	364	23	2076	1080	48
3	Pomegranate	55	109	98	1440	785	46
4	Sugarcane	1124	1660	48	4750	1650	56
5	Tomato	320	480	50	1720	1050	39
6	Cotton	23.3	50	114	1889	888	53
7	Lady's Finger	152.61	177.24	16	1167	700	40
8	Brinjal	280	320	14	1595	750	53
9	Cabbage	105	200	90	2090	836	60
10	Papaya	18.4	23.48	28	4258	2044	68
11	Chilly	42.33	60.88	44	2368	900	62
12	Mango	50	81.5	63	2100	1410	32
13	Onion	20.1	46.3	130	740	600	23
14a	Paddy (R&D Experiment)	69.77	81.36	16.61	1409	2800	50
14b	Paddy (Farmer's Field Trial)	47	79	68	1648	740	55
15	Pigeon Pea	25	70	180	1750	1050	40

Report from the committee on Drip Irrigation Scheme, Dept. of Agriculture and Co-operation, Feb, 1991



- **Reduced Weed Growth:** Water is applied directly at the root zone, wetting only a fraction of the soil. Interspace between the row of plants is not allowed to go beyond the root zone. Hence weed population is minimal under drip irrigation.
- **Fertiliser & Nutrients Application and Saving:** Drip systems can have a device to enable application of soluble fertilisers and nutrients through the system, directly near the root zone of the plant. This saves up to 50% quantity of fertilisers. Besides labour costs of fertiliser application are eliminated.
- **Improved Disease Control:** Disease control is enhanced under micro irrigation system, because the soil moisture and chemical additive levels can be closely controlled. In addition, spread of any disease causing organisms by wetting the leaf and surface water movement is eliminated.
- **Ideally Suited for Difficult Terrain & Problem Soils & Water:** Drip irrigation can convert a vast area of wasteland into a productive farm. It does not call for land levelling which upsets productive top soil. Drip irrigation can be used on saline soil even with brackish water. As a matter of fact, for undulated hilly wasteland there is no substitute to MIS. The pressure compensating mechanism ensures equal discharge of water to the plant even if the plants are at different levels of the sloping land.
- **Energy Saving & Low Pumping cost:** Drip irrigation operates only to fulfil the water requirement of the crop. As a result, the pump is not operated for long hours resulting in energy saving and low pumping cost.
- **Saving in cultivation and operating costs:** In operations such as ploughing, tilling, weeding, etc.
- **Technology for Sustainable Environment:** Drip irrigation reduces pollution of soil and underground water due to leaching of applied nutrients in conventional flood irrigation and application of large amounts of fertilizer at a time. In contrast to conventional irrigation small quantities of fertilizers are frequently applied, which are just adequate for plants, and avoids leaching.
- **Technology for Social Justice:** Drip irrigation can also be used as a tool to bring about social justice through equitable distribution of water. Unlike canal water,



Fertigation station along with venturi assembly



Drip, the only solution for irrigating undulating terrain



drip technology can make water available to all segments of farmers whether they are located upstream or downstream, since it is a pressurised irrigation system and does not depend on gravity flow. We can take it to all locations as long as it is economically viable.

Automation in MIS

Automation of micro irrigation system means controlling operation of MIS with no or minimum manual intervention. Automation of MIS eliminates chances of human error in the operation. It helps save expenses on labour. More advanced and delicate crops can be grown within a controlled environment. More precise operation helps save pumping energy and fertilisers. Night irrigation is effectively possible with automation. Ultimately, it results in increase in yield and other benefits. Thus automation proves to be an important input for precision farming.



Automation in GH

In Jain Watershed most advanced techniques of MIS like automatic micro irrigation system are demonstrated at the Jain Greenhouse.

Water Distribution through MIS

It may be noted that MIS presupposes availability of stored water. Water may be stored either in an open reservoir or made available through a dug well or bore well or may be stored in specially constructed water distribution tanks. As a matter of fact, if water is to be supplied through MIS to plots located at different heights, it is beneficial to have water distribution tanks at strategic locations. Such specially constructed water distribution tanks facilitate irrigation of different plots within their respective command areas. They help improve irrigation efficiency. At Jain Watershed we have constructed water distribution tanks as detailed in Table 9.2.

Table 9.2 : Water Distribution tanks								
Tank No.	Location plot no.	Year of Construction	Size (m)	Depth (m)	Capacity (lakh litres)	Height from main road (m)	Total Area Serviced (ha)	Expenditure (Rs. lakh)
JHWST1	16	1991	φ 14.0	2.0	3.25	39.30	12.00	4.32
JHWST2	16	1993	φ 11.0	3.0	2.75	56.00	17.00	3.65
JHWST3	19	1993	φ 12.5	3.0	3.25	68.00	12.00	4.48
JHWST4	13	1996	φ 20.0	3.3	10.0	68.00	45.00	9.62
JHWST5	13	1993	11.25x2.75	1.5	0.45	04.25	05.00	0.70
JHWST6	01	1992	8.5x4.25	3.2	1.20	00.00	08.00	1.20
JHWST7	10	2003	1.5x2.0	1.5	0.06	00.00	00.45	0.20
JHWST8	5	2009	5.0x1.3	1.0	0.60	00.00	00.10	1.15
JHWST9	5	2009	5.0x1.15	0.7	0.45	00.00	00.10	0.95
Total					22.01		99.65	26.27



Construction and provision of water distribution tanks is almost a pre-requisite for proper, economical and efficient usage of water through MIS. Water distribution tanks have yet another outstanding feature. Since they are covered, there is no evaporation loss. Similarly, as they are constructed and made waterproof, there is no seepage or leakage of water. They easily allow storage and supply/distribution of measured quantities of water. In case of canal irrigation the water is supplied by turn at intervals which may extend up to two weeks. Under this system, therefore, water distribution tanks do not have any role to play.

Progressive Land Use and Intensity

The entire area in Jain Watershed is irrigated only with drip irrigation. Many experiments to determine the water requirement of different crops have been conducted to demonstrate the utility and efficacy of drip irrigation.

The combined impact of watershed development and use of MIS can be easily gauged from Table 9.3. The land use as well as intensity has increased, with time, in the Jain Watershed area. As water availability and its sustainability progressed in the watershed area, more and more areas were brought under crop and on the same area, more and more crops were taken. Intercropping of onions, while the mango and other orchard plants were young, ensured higher land use.

A close look at Map 9.1 brings home the point that with level difference ranging between 207 m to 286 m above mean sea level, and slopes ranging from 3% to 45%, it is only the micro irrigation system which could have irrigated this land. No other method of irrigation, whether furrow or sprinkler, would have been of use.

Table 9.4 gives water requirements of various crops within the Jain Watershed area. The water requirement is calculated on the basis of average evapotranspiration rate. Evapotranspiration rate is measured by using a fully automatic weather station installed in Jain Watershed area.

The Map 9.2 displays the wide variety of crops that can be irrigated with the help of MIS. About 65% of the total area is covered by horticulture plants (mango, guava, aonla and citrus fruits) while 27% of the area is covered by agroforestry crops (custard apple, teak, etc.) and the remaining 8% is covered by field crops (onion, seasonal crops, etc.) and nursery.

The crops like mango, orange, pomegranate, etc, which are not generally grown in Jalgaon region, are grown in Jain Watershed under drip irrigation. Alphonso is the speciality of Konkan but many varieties of mango including alphonso are grown in murrumy and inferior type of soils in Jain Hilltop area. The spacing between mango trees is reduced to 4.5 x 4.5m (15 x 15ft) from 9 x 9 m (30 x 30 ft) adopted traditionally. Experiments are also underway for ultra high density plantation of mango at a distance of 3 x 2m (10 x 6ft) for certain varieties. Similar experiments are underway for guava. Higher population will ensure higher yields. The visitors



from Konkan, prominent mango belt of Maharashtra, are surprised on seeing these green mango trees laden with fruits in this area.

Table 9.3 : Progressive increase in land use and plantation intensity (area in ha)																						
A. Crop	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Custard apple	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	1.60	20.0	20.0	6.83	2.17	11.36	11.36	10.75	10.75	10.75
Guava	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	5.27	5.27	5.27	5.27	5.27	5.06	5.07	5.06	4.64	4.55	4.55	2.23	2.23	2.23
Aonla	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	9.10	13.20	13.20	13.20	13.20	13.64	13.45	13.45	15.33	14.20	15.21	8.20	8.20	28.45
Sapota	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.12	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
Lime	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.45	1.06	1.06	1.06	1.06	1.01	0.40	0.40	0.40
Sweet Lemon	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-	-	-	-	-	-	-	-	-	-	-	0.61	0.61	0.61
Orange	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	-	-	-	-	-	-	-	-	-
Pomegranate	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-	-	-	-	-	-	-	-	1.82	1.82	2.63	4.15	4.00
Papaya	0.20	0.20	0.20	-	2.43	2.43	2.43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agro forestry	-	4.87	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	9.71	9.70	9.00	12.21	11.34	13.82	13.82	12.80	12.80	17.00
Mango	-	-	1.21	1.21	1.21	1.21	1.21	27.53	44.53	49.80	52.22	52.20	52.63	51.74	47.31	46.74	46.74	46.74	46.74	44.68	46.50	64.90
Banana	-	-	1.21	2.43	3.23	3.23	3.23	3.23	11.33	2.43	3.23	2.43	0.24	0.80	-	1.90	2.34	0.40	1.01	1.21	1.21	1.21
Grapes	-	-	0.20	-	0.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cotton	-	-	-	-	1.21	-	0.87	-	1.21	-	-	-	2.00	-	-	-	-	-	-	0.61	0.61	0.61
Onion	-	-	-	-	-	-	-	4.86	2.43	1.61	0.47	1.21	1.67	5.67	-	4.05	-	0.69	0.64	0.81	0.81	0.81
Sugarcane	-	-	-	-	-	-	-	2.43	2.43	-	-	-	0.20	-	-	-	-	-	-	-	-	-
Drum sticks	-	-	-	-	-	-	-	-	-	-	-	-	6.00	4.00	-	-	-	-	-	-	-	-
Nursery	-	-	-	-	-	-	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	0.61	0.61	1.21	1.21	1.21	1.21	1.21	1.21
Total (A)	2.94	7.81	9.20	10.02	15.26	3.25	5.73	46.04	83.45	79.07	81.14	81.06	94.83	112.79	97.10	93.12	96.04	97.15	98.58	87.36	90.70	133.39
B. Intercrop	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vegetables	0.20	-	-	0.40	0.40	0.40	0.40	0.80	0.80	1.60	4.04	4.04	1.21	0.80	-	-	-	-	-	0.20	-	-
Onion	-	-	-	-	-	-	-	26.32	34.41	32.54	6.47	2.02	12.15	8.90	-	-	-	-	-	-	1.62	-
Onion Set	-	-	-	-	-	-	-	-	8.90	8.90	8.90	8.90	8.90	-	-	-	-	-	2.53	-	-	-
Onion / Seed	-	-	-	-	-	-	-	-	1.21	-	0.80	-	4.45	2.00	-	1.01	-	-	0.81	-	4.05	-
Groundnut	-	-	-	-	-	-	-	-	2.02	-	-	-	-	-	-	-	-	-	-	-	-	-
Maize	-	-	-	-	-	-	-	-	1.21	1.21	1.21	1.21	1.21	0.40	-	-	-	-	-	-	0.40	-
Sorghum	-	-	-	-	-	-	-	-	1.21	4.04	4.04	1.21	1.21	3.23	-	-	-	0.68	-	-	-	-
Wheat	-	-	-	-	-	-	-	-	-	0.40	0.40	0.40	0.40	-	-	-	-	-	-	-	-	-
Chilli	-	-	-	-	-	-	-	-	-	0.40	-	-	-	-	-	-	-	-	-	-	-	-
Total (B)	0.20	-	-	0.40	0.40	0.40	0.40	27.12	49.76	49.09	25.86	17.78	29.53	15.33	-	1.01	-	0.68	3.34	0.20	6.07	0.00
Total (A+B)	3.14	7.81	9.20	10.42	15.66	13.75	16.13	73.16	133.21	128.16	107.00	98.84	124.36	128.12	97.10	94.13	96.06	97.83	101.92	87.56	96.77	133.39

Note: 1) Aonla is planted with the application of organic manure in 3.2 ha in 1998; 2) 122 varieties of Mango are planted in 3.2 ha out of 52.22 ha under Mango; 3) Mango planting is experimented with 2.5m x 2.5m (8'x8') spacing in 2001 and 3m x 2m (10'x6') spacing in 2009; 4) During 1993-96 Banana plantation was done with different spacings in 1.6 ha area to reduce the expenditure for drip; 5) A record production of 70,000 Mango grafts was achieved in 1999.

* The road side plantation like Coconut, Tissue-culture Teak, Ashok, Neem, Gliricidia, etc. are not included above.

Map 9.1 : Use of reclaimed water through micro irrigation system

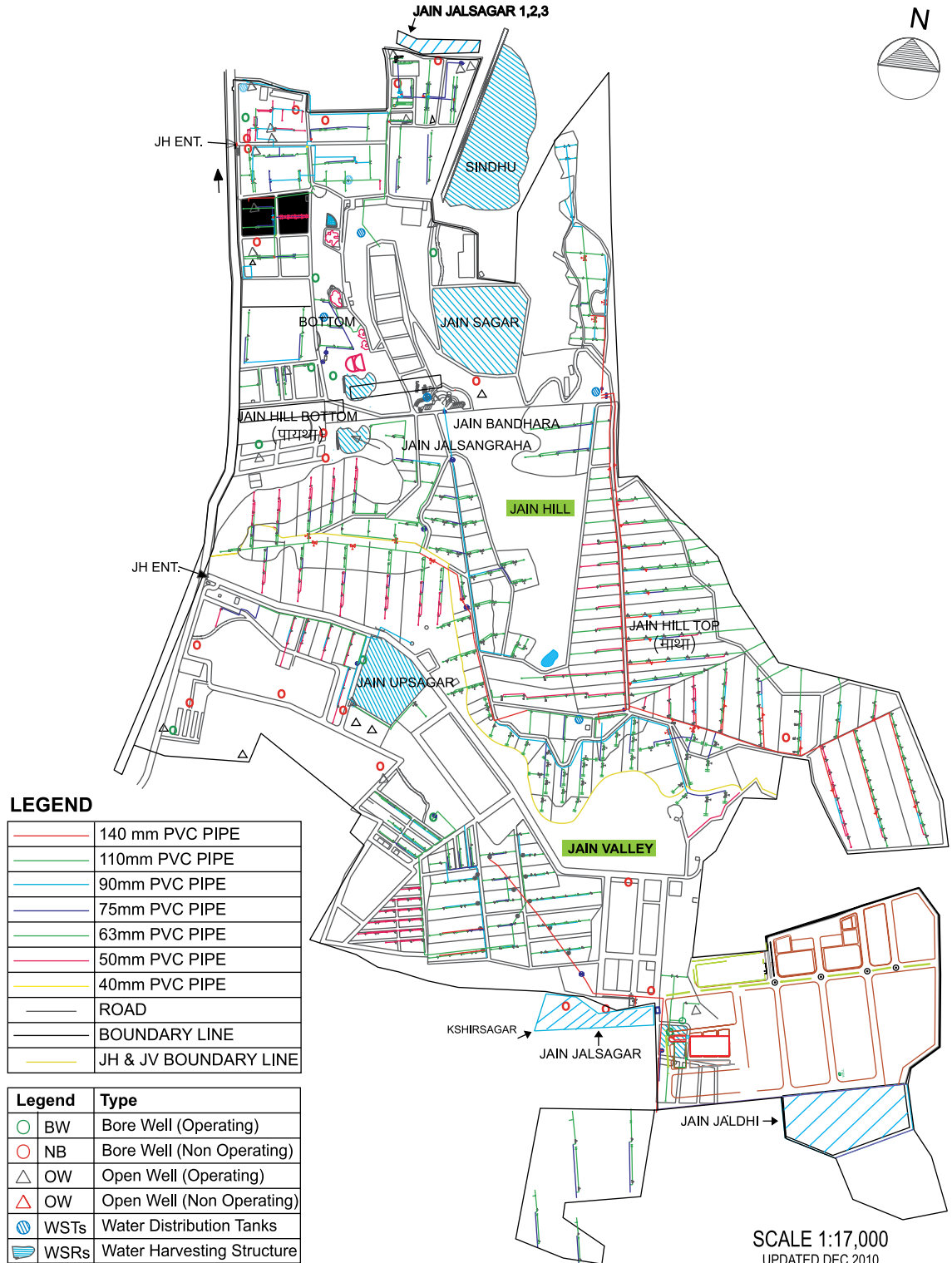


Table 9.4 A: Water requirement of various crops within Jain Watershed area (lpd/plant except vegetables & onion lpd/acre).

Month	Avg. ETp	Mango										Pomegranate			
		674 no./acre				193 no./acre						333 no./acre			
		Age, year				Age, year						Age, year			
		1	2	3	≥4	1	2	3	4	5	≥6	1	2	3	≥4
Jan.	4.5	0.5	2.1	4.7	8.4	0.5	1.2	4.9	13.6	26.7	34.8	3.5	9.3	14.0	19.3
Feb.	5.3	0.9	3.7	8.3	14.8	1.0	2.1	8.6	23.9	46.8	61.1	5.1	13.6	20.4	28.0
March	7.5	1.1	4.3	9.6	17.1	1.1	2.5	9.9	27.6	54.1	70.7	6.1	16.3	24.5	33.7
April	10.3	1.6	6.2	13.8	24.6	1.6	3.6	14.3	39.8	78.0	101.9	3.5	9.4	14.1	19.3
May	9.8	2.0	7.8	17.6	31.2	2.0	4.5	18.2	50.5	98.9	129.2	4.5	11.9	17.9	24.6
June	4.9	1.1	4.4	9.8	17.5	1.1	2.5	10.2	28.2	55.4	72.3	3.4	9.0	13.5	18.5
July	3.0	0.5	1.9	4.3	7.6	0.5	1.1	4.4	12.3	24.2	31.6	2.8	7.4	11.1	15.3
Aug.	5.2	1.0	3.9	8.7	15.4	1.0	2.2	9.0	24.9	48.8	63.7	3.5	9.3	13.9	19.1
Sept.	3.5	0.2	0.8	1.9	3.4	0.2	0.5	2.0	5.5	10.7	14.0	2.9	7.7	11.6	15.9
Oct.	3.7	0.3	1.1	2.4	4.2	0.3	0.6	2.5	6.9	13.4	17.6	4.1	10.9	16.4	22.5
Nov.	3.1	0.4	1.6	3.6	6.3	0.4	0.9	3.7	10.3	20.1	26.3	3.2	8.6	12.9	17.8
Dec.	2.5	0.4	1.4	3.2	5.7	0.4	0.8	3.3	9.2	18.0	23.5	2.8	7.5	11.2	15.4
Per year per plant 000 l		0.3	1.2	2.7	4.8	0.3	0.7	2.8	7.7	15.1	19.7	1.4	3.7	5.5	7.6
Per year acre 00000 l		2.0	8.0	18.0	32.0	0.6	1.3	5.3	14.8	29.1	38.0	4.6	12.2	18.4	25.3

Note: water requirement is crop-.location-, soil-type-and season-specific

Table 9.4 B: Water requirement of various crops within Jain Watershed area (lpd/plant except vegetables & onion lpd/acre).

Month	Avg. ETp	Sweet Orange & Acid Lime								Custard Apple				Neem	
		193 no./acre								300 no./acre				193 no./acre	
		Age, year								Age, year				Age, year	
		1	2	3	4	5	6	7	≥8	1	2	3	≥4	3	≥4
Jan.	4.5	1.1	2.1	4.7	8.4	3.2	9.0	25.8	33.7	3.2	8.5	12.8	19.2	40.0	50.0
Feb.	5.3	1.6	3.1	6.9	12.3	19.2	27.6	37.6	49.0	3.9	10.4	15.6	23.4	45.0	50.0
March	7.5	1.9	3.7	8.3	14.8	23.0	33.2	45.2	59.0	2.1	5.5	8.3	12.4	52.0	60.0
April	10.3	2.6	5.2	11.6	20.6	32.1	46.2	62.9	82.2	2.2	5.9	8.9	13.4	60.0	60.0
May	9.8	3.3	6.6	14.7	26.1	40.8	58.7	80.0	104.4	2.8	7.6	11.3	17.0	60.0	60.0
June	4.9	2.5	5.0	11.1	19.6	30.7	44.2	60.2	78.6	5.6	14.9	22.3	33.4	32.0	45.0
July	3.0	1.2	2.4	5.3	9.5	14.8	21.3	29.0	37.8	3.6	9.6	14.4	21.6	32.0	37.0
Aug.	5.2	2.0	4.0	8.8	15.6	24.4	35.1	47.8	62.4	3.8	10.1	15.1	22.6	32.0	37.0
Sept.	3.5	0.9	1.8	3.9	7.0	10.9	15.6	21.3	27.8	2.8	7.5	11.3	17.0	32.0	45.0
Oct.	3.7	1.2	2.5	5.5	9.8	15.4	22.2	30.2	39.4	4.0	10.7	16.0	24.1	40.0	45.0
Nov.	3.1	1.0	2.0	4.4	7.8	12.1	17.5	23.8	31.1	3.2	8.4	12.6	19.0	40.0	45.0
Dec.	2.5	0.9	1.7	3.8	6.7	10.5	5.2	20.7	27.0	2.7	7.3	11.0	16.5	32.0	50.0
Per year per plant 000 l		0.6	1.2	2.7	4.8	7.5	0.8	14.7	19.2	1.2	3.2	4.9	7.3	15.1	17.8
Per year acre 00000 l		1.2	2.3	5.2	9.3	14.5	20.9	28.4	37.1	3.6	9.7	14.6	21.9	29.2	34.3

Note: water requirement is crop-.location-, soil-type-and season-specific



Table 9.4 C: Water requirement of various crops within Jain Watershed area (lpd/plant except vegetables & onion lpd/acre).

Month	Avg. ETp	Sapota								Aonla					
		70 no./acre								193 no./acre					
		Age, year								Age, year					
		1	2	3	4	5	6	7	≥8	1	2	3	4	5	≥6
Jan.	4.5	0.5	1.2	4.6	12.8	28.8	41	62	86	0.5	1.1	4.4	12.3	24.1	31.5
Feb.	5.3	0.7	1.7	6.7	18.6	41.9	60	90	126	0.6	1.3	5.4	15.0	29.4	38.4
March	7.5	0.9	2.0	8.1	22.4	50.4	73	108	151	0.3	0.7	2.9	8.0	15.6	20.4
April	10.3	1.2	2.8	11.2	31.2	70.2	101	151	211	0.3	0.8	3.1	8.6	16.8	21.9
May	9.8	1.6	3.6	14.3	39.6	89.1	128	192	268	0.4	1.0	3.9	10.9	21.3	27.9
June	4.9	1.2	2.7	10.7	29.8	67.1	97	144	202	0.9	1.9	7.7	21.4	41.9	54.7
July	3.0	0.6	1.3	5.2	14.4	32.3	46	69	97	0.6	1.2	5.0	13.8	27.0	35.3
Aug.	5.2	0.9	2.1	8.5	23.7	53.3	77	115	160	0.6	1.3	5.2	14.4	28.3	37.0
Sept.	3.5	0.4	0.9	3.8	10.5	23.7	34	51	71	0.4	0.9	3.6	10.1	19.9	26.0
Oct.	3.7	0.6	1.3	5.4	14.9	33.6	48	72	101	0.6	1.3	5.2	14.4	28.1	36.8
Nov.	3.1	0.5	1.1	4.2	11.8	26.5	38	57	80	0.5	1.0	4.1	11.3	22.2	29.0
Dec.	2.5	0.4	0.9	3.7	10.2	23.0	33	50	69	0.4	0.9	3.5	9.8	19.3	25.2
Per year per plant 000 l		0.3	0.7	2.6	7.3	16.4	23.6	35.3	49.3	0.2	0.4	1.6	4.6	8.9	11.7
Per year acre 00000 l		0.2	0.5	1.8	5.1	11.5	16.6	24.7	34.5	0.4	0.8	3.2	8.8	17.3	22.5

Note: water requirement is crop-, location-, soil-type-and season-specific

Table 9.4 D: Water requirement of various crops within Jain Watershed area (lpd/plant except vegetables & onion lpd/acre).

Month	Avg. ETp	Guava								Banana			Teak, Bamboo clumps	Vegetables & Onion (000)	
		2,000 no./acre		193 no./acre						1450 no./acre			450 no./acre		
		Age, year		Age, year						Age, year			Age, year		
		1	≥2	1	2	3	4	5	≥6	Initial stage	Full Grown	Ra-toon	≥3		
Jan.	4.5	0.5	3.3	1.3	5.1	14.1	20.2	27.5	36.0	4.4	10.2	11.2	20.0	12.9	
Feb.	5.3	0.6	3.8	1.5	6.0	16.2	23.4	31.8	41.5	5.2	11.9	13.1	22.0	15.0	
March	7.5	0.6	1.9	1.4	5.7	8.0	11.5	15.6	20.4	7.3	16.9	18.5	24.0	21.2	
April	10.3	0.7	2.0	1.5	6.2	8.6	12.3	16.8	21.9	10.1	23.1	25.4	24.0	29.2	
May	9.8	0.9	2.6	2.0	7.8	10.9	15.7	21.3	27.9	9.6	22.1	24.3	24.0	27.8	
June	4.9	1.1	6.7	2.6	10.3	28.7	41.3	56.2	73.4	4.8	11.0	12.1	16.0	13.9	
July	3.0	0.6	3.7	1.4	5.7	15.8	22.7	30.9	40.4	2.9	6.7	7.4	16.0	8.5	
Aug.	5.2	0.8	4.0	1.8	7.1	17.2	24.7	33.7	44.0	5.1	11.8	12.9	16.0	14.8	
Sept.	3.5	0.5	2.7	1.0	4.2	11.6	16.7	22.7	29.7	3.5	7.9	8.7	16.0	10.0	
Oct.	3.7	0.6	3.8	1.5	5.9	16.4	23.6	32.2	42.0	3.7	8.4	9.3	20.0	10.6	
Nov.	3.1	0.5	3.0	1.2	4.7	12.9	18.6	25.4	33.1	3.0	6.9	7.6	20.0	8.7	
Dec.	2.5	0.4	2.6	1.0	4.0	11.2	16.2	22.0	28.8	2.4	5.5	6.1	16	6.9	
Per year per plant 000 l		0.2	1.2	0.6	2.2	5.2	7.5	10.2	13.4	1.9	4.3	4.8	7.1	Khari*	17.3
Per year acre 00000 l		4.8	24.5	1.1	4.3	10.1	14.5	19.7	25.8	27.3	62.8	69.1	32.0	Rabi*	19.4

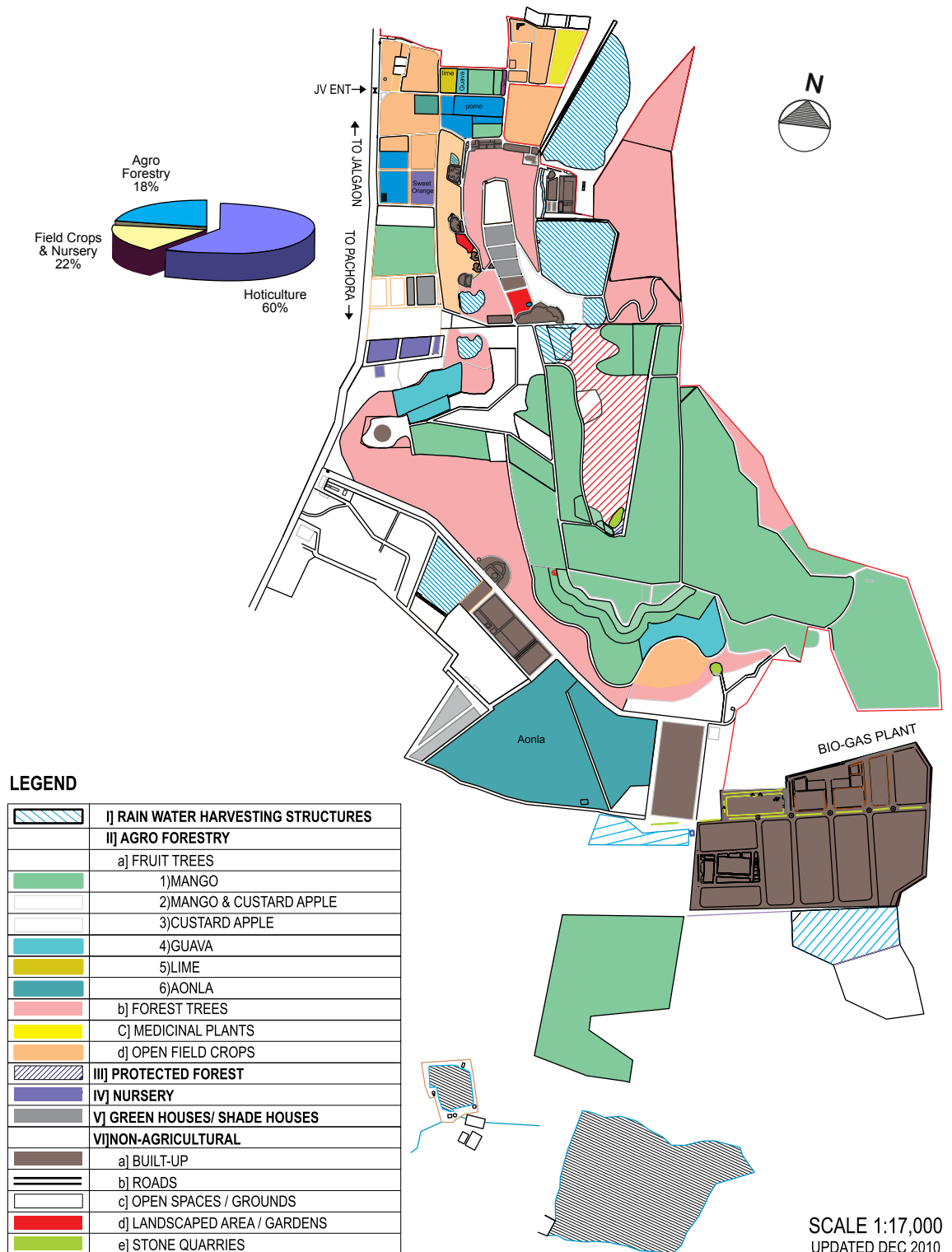
Note: water requirement is crop-, location-, soil-type-and season-specific

*lakh litre per crop

‘Efficient water use through micro-irrigation system and recycling effluent after treatment are destined to play a key role in sustainable development of water. It can save off further investments in major dam and related infrastructure. New investments, therefore, must be undertaken in the context of optimising current water use.’

– Bhavarlal Jain.

Map 9.2 : Map showing land use and land cover 2002



Banana is one of the main cash crops of Jalgaon region. Farmers generally believe that the banana crop requires more water, and hence drip cannot be used for it. However, it has been proved by now that 40 to 50 % water could be saved using drip irrigation. Trials have also been carried out with water soluble fertilisers injected through drip. That use of tissue culture plants and drip irrigation along with watershed development can prove profitable has been demonstrated successfully for the past decade.

The onion crop is grown on a large scale in the Nashik area. But people were not aware of use of drip for this crop. Therefore, onion was grown as an intercrop with the use of drip in the Jain Hills area to demonstrate the benefits of use of MIS for onion.

Trials are also taken for 'Rainport Mini Sprinkler Irrigation System'. This system is a clever modification of the conventional sprinkler irrigation system. This system is useful for crops like potato, onion, leafy vegetables etc. Due to its flexibility in operation and higher distribution uniformity this system has gained wide popularity across the country.

Conventionally, the paddy crop is known as a water guzzler. It needs stagnant water. It takes 5000 litres of water to produce one kilogram of rice. Trials are going on to establish practices to grow paddy on drip irrigation. Initial trials conducted at our R& D farm at Udumalpet and at Saguna Baug, Neral, Maharashtra, are highly encouraging. Cultivating rice under drip irrigation will prove to be a boon for the water sector. According to IRRI, International Rice Research Institute, even a 10 per cent reduction in water used to irrigate rice would free up 150,00 million cubic metres of water or 25 per



Mango plantation in fifth year using drip irrigation



Grande Naine Tissue Cultured Banana under drip



Rice Trial Plant



cent of total fresh water that is used globally for non-agricultural purpose. Saving in electricity and increase in yield are the additional advantages.

Irregular supply of electricity or no electricity is the major hurdle that the agriculture sector is facing today. I visualise that in the coming years the severity of this problem would increase manifold. To overcome this problem, trials are underway to operate the micro irrigation system on solar power. Efforts are being taken to make this concept more cost effective.

Cost of Micro Irrigation System Installation

At Jain Watershed, the effective area under micro irrigation system, in the year 2010 was about 97 ha. Table 9.5 details the expenses on micro irrigation systems. Average cost per hectare works out to about Rs. 1.46 lakh. This includes construction of water distribution tanks, the cost involved in procuring, installing micro irrigation system including filtration and fertigation stations, and cost of replacing old material from time to time. It may be noted that no government subsidies are availed.

	1989	1990	1991	1992	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Micro irrigation systems	1.29	1.99	0.6	0.52	2.54	0.19	34.37	36.99	1.87	1.42	7.05	2	1.7	0.93	3.5	2.67	1.9	1.38	2.18	3.10	7.8	115.99
Water distribution tanks	-	-	4.32	1.20	8.83	-	9.62	-	-	-	-	-	-	0.20	-	-	-	-	-	2.10	-	26.27
Total	1.29	1.99	4.92	1.72	11.37	0.19	43.99	36.99	1.87	1.42	7.05	2	1.7	1.13	3.5	2.67	1.9	1.38	2.18	5.20	7.8	142.26



10. Balancing the Water Budget of Jain Watershed



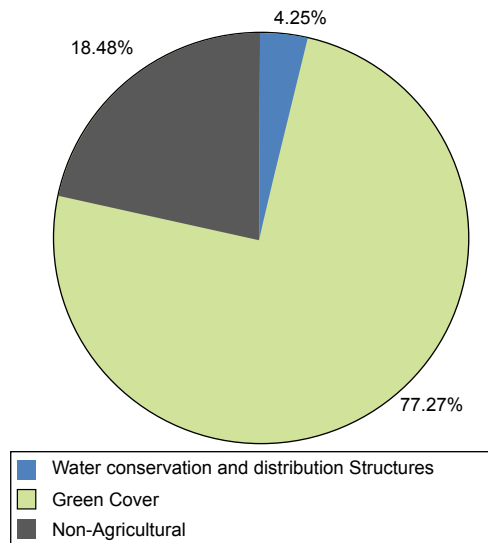
Jain Watershed Land Use

The success of watershed is judged by the quantity of water it adds to the ground aquifer through natural percolation. We can also resort to artificial methods for augmenting the groundwater availability. Such measures are described as artificial recharging measures. Augmentation becomes imperative when draft and extraction of groundwater exceeds the rate at which it gets recharged. This is the present state of affairs in almost all parts of the country. In order to balance the availability with the requirement, we are required to aggressively pursue watershed development as well as artificial recharge techniques, and use the harvested/percolated water through modern irrigation methods so as to improve water-use efficiency.

It will be observed from the Graph 10.1 and Table 10.1 that even while undertaking developmental works, including civil construction for factories, warehouses and office buildings, only a minimal area (19%) has been used for non-agricultural purpose.

The land use for the purposes of creation of land and soil conservation structures is of course an unavoidable necessity. It is obvious that, but for these structures which have occupied 13% land, no development of green-cover and/or agro-forestry is conceivable/thinkable. The area under green/shade houses and nursery, generally described as controlled agriculture, is, of course, a part of agriculture. Similarly, the landscaped areas and gardens not only form an integral part of the green cover, but also add to the beauty and aesthetics of the area.

A conventional watershed may not have all these features, because it may lack a commercial dimension. However, the Jain Watershed area is not merely a model watershed. It is a model of wasteland reclamation and watershed development combined with a modern development concept – an effort towards the protection of the environment in tandem with economic viability and sustainability. It, therefore, has become a creative partnership between the age-old cry for protection and advancement of environment and ecology and the overbearing compulsions of a materialistically self-centred modern world.



Graph 10.1 : Jain Watershed land use



Table 10.1 : Jain Watershed Physical Area Statement			
S. N.	Land Use / Purpose	hactares	acres
I. Water Conservation and Distribution Structures			
a)	Land & soil conservation measures		
	1. Surface trenches	0.94	2.32
	2. Gully plugs	0.62	1.53
b)	Eight rainwater harvesting structures including bunds	9.09	22.45
c)	Water recovery & artificial recharge structures	0.42	1.04
d)	MIS water distribution tanks (9 Nos.)	0.11	0.27
	Sub Total (I)	11.18 (4.25%)	27.61
II. Green Cover			
a)	Agro-forestry		
	1. Fruit trees	122.9	303.56
	2. Forest trees	50.09	123.72
	3. Open field crops	14.98	37.0
	4. Protected forest	9.1	22.5
	Sub Total IIa	197.07	486.78
b)	Other Green cover		
	1. Greenhouses/Shade houses/Tunnels	2	4.96
	2. Nursery	1.62	4
	3. Landscapes / Gardens	2.85	7.0
	Sub Total IIb	6.47	16.0
	Sub Total (II)	203.54 (77.27%)	502.78
III. Non-agricultural			
a)	Built-up	30.81	76.1
b)	Roads	14	34.4
c)	Open spaces / Grounds	2.23	5.5
d)	Stone quarries	1.62	4
	Sub Total (III)	48.66 (18.48)	120.0
	Grand Total (I+II+III)	263.38	650.54

Genesis

Wayback in 1988, when I made the first purchase of the hillock (a hilly non-cultivable wasteland) admeasuring 1.6 ha (4 acres) at an average price of about Rs. 8,887/ha (Rs. 3,555/acre), there was no water available even for drinking. Nor was there any approach road to the hillock. I had to therefore immediately purchase the adjoining 2.4 ha (6 acres) piece of land lying between the hillock and the main road at an average price of Rs. 87,437/ha (Rs. 34,975/acre). I had to pay almost 10 times the price just within a short period of two months for access and the probable availability of water. This was, however, a rainfed cultivable land.



The newly acquired land had one dilapidated old well. I, however, was dismayed to discover that this well, after clean-up, could hardly yield 200-400 litres of water per day. Jain Watershed development since 1989 till date has, however, created water sufficient to bring a total of 91 ha (225 acres) of land under well irrigation. This transformation has been achieved where, in 1989, we were struggling for adequate and dependable water source to keep alive around 780 trees planted in 1.6 ha (4 acres) out of this land. Moreover, the available water is also catering to the non-agricultural needs which run into lakhs of litres/day. These include requirements of Jain Gurukul, residential quarters, guest houses, landscaped areas, etc.

Water Balance

With the success of watershed development works planned and executed in this area, we are happy that we have become nearly self-sufficient in irrigation water requirements as well as other requirements of domestic use. However, the journey was not without its ups and downs, or smiles and tears. With herculean efforts we have blissfully arrived at a balance between the requirement and availability. Table 10.2 shows the water balance from 1998-99 to 2008-09.

Year	Agri-Irrigation		Domestic & Other		Total deficit	Water Availability	
	Required	Supplied	Required	Supplied	%	Jain Watershed	From adjoining Watershed (s)
98-99	157	153	25	25	2.5	54	124
99-00	179	173	13	13	3.4	72	114
00-01	115	90	9	9	21.7	53	46
01-02	95	74	18	18	22.1	55	36
02-03	119	108	13	13	9.2	92	29
03-04	88	82	58	58	6.8	81	59
04-05	92	82	64	64	10.9	69	77
05-06	99	89+10*	76	76	10.1	78	87
06-07	103	90+13*	89	89	12.6	83	96
07-08	95	76+19*	104	104	20.0	80	100
08-09	86	70+16*	103	103	18.6	78	95
09-10	88	70+18*	95	95	20.4	80	85

* Additional quantity is reuse of waste-water generated through process plant.

The figures have been taken from the daily water use records. In order to be precise, water meters have been installed on the pipelines conveying water from dug wells and borewells since 1997. Detailed records of water being used for irrigation are being maintained since 1998-99.

As a solution to this problem of unpredictable availability of water from the watershed, I decided to change the cropping season as well as relocate some of



the activities which consumed large quantities of water round the year. Thus, for example, we discontinued taking field crops in the available open field area during kharif season and instead took green manuring crops which could sustain even on irregular and/or scanty rainfall. This is why the irrigation water requirements have also reduced.

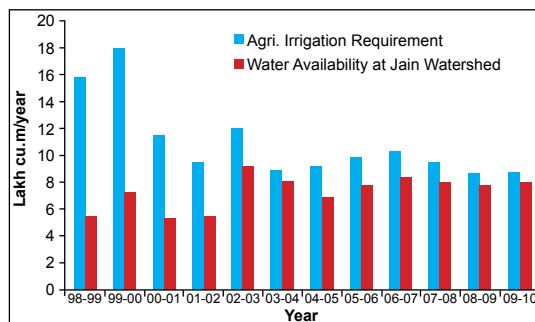
There were some more overwhelming reasons for discontinuing kharif field crops. The weed management and crop protection costs were found to be exorbitant. It was also observed that the crop yields were far below optimum because of poor soil. Under these circumstances, using irrigation water to irrigate field kharif crops even during monsoon gaps was discovered to be an economically unviable proposition. I, therefore, thought it fit to leave the soil open for solarization after the green manure crop was buried. The new cropping pattern also provided the much needed relief to the already exhausted soil.

Secondly, the shade houses used for secondary hardening of tissue cultured banana plantlets were shifted to other locations so as to save the available water for horticultural and other agroforestry plants. These secondary hardening operations needed about 10 lakh litres of water per day. This quantity of saved water could thus be made available where needed most, that is, for irrigating the horticultural and agro-forestry plantation.

Moreover, the soil and water conservation efforts such as surface trenches and recharging of wells, deepening of existing wells and excavation of additional wells were intensified.

The domestic requirement and supply quantities are equal. This may seem queer. However it is not the requirement that has been met but it is the available quantity of water that has been economically utilised. We toned down our requirement by reducing the activities such as training programmes, farmer visits, conferences, exhibitions, seminars etc.

Graph 10.2 depicts the irrigation water requirements vis-a-vis water availability from the watershed development efforts. It is heartening to note that these efforts have started paying back. In 1999-2000 water availability from watershed improved (72 crore litres/7.2 lakh cum) in comparison to that in 1998-1999 (54 crore litres/5.4 lakh cum). The water availability appears to have reduced in 2000-2001 (53 crore litres/5.3 lakh cum) and 2001-2002 (55 crore litres/5.5 lakh cum). However,



Graph 10.2 : Irrigation water balance

‘Only after the last tree has been cut down. Only after the last river has been poisoned. Only after the last fish has been caught. Only then you will find that money cannot be eaten.’

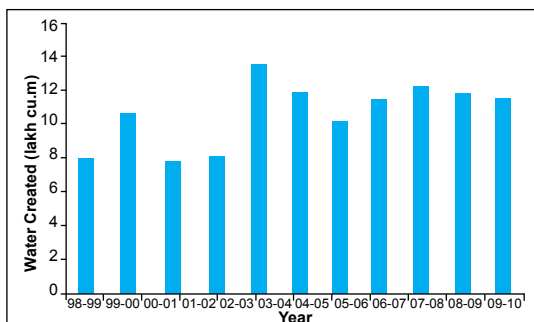
– Native Cree Prophecy



this is with a background of a drought-like situation during these two years. The available water quantity has already risen to 78 crore litres (7.8 lakh cum) in 2008-2009 in a normal monsoon.

Supplementing Water Requirements

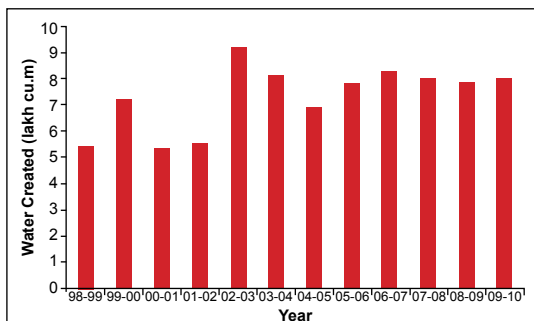
As can also be seen from Table 10.2, we import water through pipe lines from sources outside Jain Watershed, namely: Jain River Face (Nagzari), and Jain Dadi (Shirsoli). The total quantity of imports has been certainly going down – from about 124 crore litres (12.4 lakh cum) in 1998-99, it has gone down to 29 crore litres (2.9 lakh cum) in 2002-03. However, from 2003-04 onwards the quantity of water imported from adjoining watershed has been increased. This is mainly because of the manifold expansion of both production units since the last three years. This is shown in Graph 10.3.



Graph 10.3 : Import from adjoining watershed

‘The time to repair the roof is when the sun is shining’
 – John F. Kennedy

Happily, the total availability from Jain Watershed has been growing, thus reducing the total quantity of water availed from these piped sources. During 1998-99, from the Jain Watershed, we could harvest only 54 crore litres of water. This has reached almost 78 crore litres in 2008-09. This is also seen in Graph 10.4. We expect that this figure of availability of water from Jain Watershed is likely to stabilize around minimum 100 crore litres average in normal monsoon years.



Graph 10.4 : Water created in Jain Watershed

The peak requirement for agriculture irrigation in 2008-09 is, however, 86 crore litres. Thus, currently there is a deficit of 16 crore litres. To meet the deficit in the long term, from 2005-06, we started reutilising a part of waste-water generated by the Fruit & Vegetable Processing Plants for agriculture purpose. About 10 to 20% of waste-water generated is reused after treating it through effluent treatment plant (ETP). This has helped to fulfil the irrigation requirement to a great extent.

As a short-term measure, during the summer months we virtually discontinue water supplies to crops like neem, tamarind, aonla and also control releases of water required for landscaping and domestic use. Similarly, we reduce non-farm activities



such as Farmer Melas and training courses to avert an emergency. However, in due course of time, as Jain Watershed gets stabilized, we hope to balance the water requirements with availability in totality.

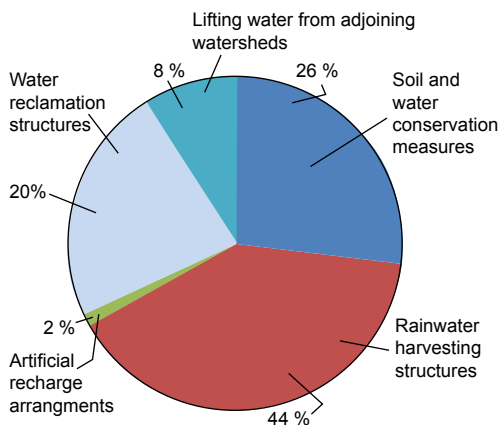
Jain Watershed is not like any other conventional watershed in village areas having agricultural farmlands and wastelands, but is an area with well-equipped training halls and hostels, guest houses and residences of associates as part of it. A large quantity of water is required for domestic purpose. Naturally, water created within it has demands apart from agricultural use. Three consecutive drought years have taught us the proper water management techniques. With precise management and less wastage, we are trying to reduce and stabilize domestic and non-agricultural use.

Jain Watershed Development Financial Statement

Table 10.3 gives details of expenses/investment on different components of Jain Watershed. It is observed that our investment on soil and water conservation measures works out to about Rs.29,000 per ha (Rs.12,000 per acre). The investment of construction of rainwater harvesting structures accounts for Rs.46,000 per ha (Rs.19,000 per acre). The investment for water recovery structures such as dug wells and borewells including artificial recharging arrangements totals to Rs.26,000 per ha (Rs.11,000 per acre). The investment in arrangements for lifting the water from adjoining watersheds works out to about Rs.9,000 per ha (Rs. 3,600 per acre). Thus, in totality for development of watershed, our investments aggregate to Rs.1,09,000 per ha (Rs.44,000 per acre). This has been presented in Graph 10.4.

Table 10.3 Details of headwise investment till 2009				
S. N.	Expense Head/Component	Investment (Rs. Lakh)	Cost /ha (Rs. Lakh)	Cost /acre (Rs. Lakh)
1	Measures for soil and water conservation through regulation and infiltration of rainwater trenches, bunds, terraces and levelling.	77.42	0.29	0.12
2	Structures for rainwater harvesting through collection and storage of excess run-off for the purpose of natural recharge of ground aquifer: Gully plugs, bandharas and check dams, underground bandhara's and water storages such as reservoirs and percolation tanks.	121.96	0.46	0.19
3	Artificial recharging arrangements for sustainability	4.2	0.02	0.01
4	Structures and equipment for reclaiming harvested/ stored /percolated water through dug wells, borewells.	62.26	0.24	0.10
5	Arrangement of lifting water from adjoining watershed	24.21	0.09	0.04
Total		290.05	1.10	0.46





Graph 10.5 : Headwise investment %

This is way above the governmental/ official permissible limits and guideline for investment/expenditure on development of community watershed. The government procedures rarely permit, even as an exceptional case, a maximum of total investment/ expenditure of Rs.20,000 per ha (Rs.8,000 per acre). We believe that these kinds of official limits on expenditures and provisions are far from realistic. Of course, they do not consider the cost on the element of

recovery/reclamation structures. However, even if this component is not considered, our cost works out to Rs.78,000 per ha (Rs.31,000 per acre) against Rs.20,000 per ha (Rs.8,000 per acre) given as the maximum limit. Anyone working within such grossly inadequate limits of expenses may not reap the intended benefit of the watershed in the manner we have. As mentioned earlier, we have included micro irrigation as an integral part of the Jain Watershed concept. However, in the financial statement, pertaining to cost of water created, we have not added the micro irrigation cost component. This is mainly because the cost of micro irrigation is essentially a cost of distribution of water rather than a cost of creation of water.

We certainly hold the view that even at the cost of Rs.1,09,000 per ha (Rs.44,000 per acre), the experiment such as the one carried out in Jain Watershed is economically viable, socially imperative and nationally a highly desirable phenomenon. It is so because, as Albert von Szent-Gyorgyi has said: ‘Water, the Hub of Life. Water is its matter and matrix, mother and medium. Water is the most extraordinary substance! Life is water dancing to the tune of solids.’

Cost per Unit of Water Created

Table 10.4 gives calculations for water created at Jain Watershed. Water storage capacity created in Jain Watershed is through three large and five small reservoirs.

Table 10.4 : Details of water storage and recharge calculation:							
Type of storage	No. of structures	Submergence, (cum)	Storage capacity (cum)	Evaporation losses @20% (cum) D=Cx0.2	Effective storage (cum) E=C-D	Recharge @ 1.5 x storage (cum) F=1.5xE	Water conserved (cum) G = E+F
	A	B	C				
Large Cap ≥50000	4	10.42	318000	63600	254400	381600	636000
Medium Cap <50000	6	4.82	98700	19740	78960	118440	197400
Total	10	15.24	416700	83340	333360	500040	833400



This capacity adds to over 3.8 lakh cum. The degree of percolation, recharging levels and evaporation rates also affect the overall availability of the created / recoverable water. Hence, for calculating water conserved, factors for all these parameters have to be used.

Table 10.5 gives the details of cost per unit and water availability per day. Considering the total cost of water created, the per

Total investment (Rs. Lakh)	Water conserved (cum)	Cost/unit		Water availability	
		Rs./cum	Rs./litre	cum/day	litres/day
288.75	833400	35.0	0.035	2283	22,83,000

litre cost of water as created in Jain Watershed works out to 3.8 paise per litre. The governmental/official cost of agriculture irrigation water in this area is 0.85 paise per litre. This cost being charged to the farmers is obviously and grossly subsidized. Thus, the cost of water created in Jain Watershed is over 4 times the subsidized official cost. However, for a dry land farmer, availability of official water for agriculture irrigation is a distant dream – nearly an impossibility. Though costly, therefore, this kind of watershed planning and development can generate a ray of hope for him. Maybe, he is able to irrigate at least one-fifth of his dry land and cross the threshold of being a marginal, impoverished, debt-ridden farmer and become someone who can stand on his own feet and get two square meals with self-respect. He may be able to cross the poverty line on his own.

Payback Period of Investment at Jain Watershed

The Table 10.6 gives financial projections for years from 2002 to 2010. The break-even point is already reached in 2008. For working out the payback period the following simplifications have been made:

- 1) All the investment on Jain Watershed up to 2002 have been clubbed together and considered as investment done in 2002. Yearwise expenditure is then added till 2010.
- 2) Maintenance cost is considered to be constant. In practice this may, however, reduce every year.
- 3) Only the cost of water saved has been considered as the return. Prevailing water rates are used for the calculation of profit. It must be recognised that Jain Watershed development has evolved through experimentation and error, starting with only faith and a capacity to work hard. We believe that with the experience thus acquired, designing of watershed and planning the work prior to undertaking such a project will more likely reduce the payback period.



Table 10.6 : Calculations for payback period of watershed development										
S. N.	Particulars	1989 to 2002	2003	2004	2005	2006	2007	2008	2009	2010
A	Fixed Cost									
A.1	Measures for soil and water conservation through regulation and infiltration of rainwater trenches, bunds, terraces and levelling.	47.14	2.08	5.52	9.18	5.15	1.66	2.06	2.42	2.21
A.2	Structures for rainwater harvesting through collection and storage of excess run-off for the purpose of natural recharge of ground aquifer : Gully plugs, bandharas and check dams, underground bandharas and water storages such as reservoirs and percolation tanks.	87.64	0.00	7.10	3.10	0.00	3.10	20.60	0.00	0.42
A.3	Artificial recharging arrangements for sustainability	1.60	0.18	0.14	0.28	0.40	0.60	0.35	0.65	0.00
A.4	Structures and equipment for reclaiming harvested/ stored /percolated water through dug wells, borewells.	35.40	3.90	8.10	5.53	2.49	3.38	2.37	1.09	0.00
A.5	Arrangement of lifting water from adjoining watershed	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A.6	Total (A.1+A.2+A.3+A.4+A.5)	195.78	6.16	20.86	18.09	8.25	8.74	25.38	4.16	2.63
B	Repayment of fixed cost	0.00	31.71	31.71	31.71	31.71	31.71	31.71	31.71	31.71
C	Balance Capital loan	195.78	170.23	159.38	145.76	122.09	99.12	92.79	65.24	36.16
D	Calculations of water storages and profit earned by saving the water (assuming normal monsoon)									
D.1	Cumulative storage capacity of all the structures (cum)	459500	459500	475400	486800	486800	486800	493800	493800	493800
D.2	Less evaporation losses @ 20% in cum	91900	91900	95080	97360	97360	97360	98760	98760	98760
D.3	Effective storage in cum (D.1 - D.2)	367600	367600	380320	389440	389440	389440	395040	395040	395040
D.4	Recharge @ 1.5 times effective storage in cum (D.3 x 1.5)	551400	551400	570480	584160	584160	584160	592560	592560	592560
D.5	Total water stored, recharged and reclaimed in cum (D.1 + D.4)	919000	919000	950800	973600	973600	973600	987600	987600	987600
D.6	Water Rate of Irrigation Dept. (Rs. In Lakh)	6.20	7.15	8.20	8.20	8.20	9.50	10.90	10.90	11.90
D.7	Profit earned by saving water (D.6 x D.5 /100000)	56.98	65.71	77.97	79.84	79.84	92.49	107.65	107.65	117.52
E	Variable costs									
E.1	Maintenance cost @ 1.5%	2.94	3.03	3.34	3.61	3.73	3.87	4.25	4.31	1.41
E.2	Depreciation cost @ 2%	3.92	4.04	4.46	4.82	4.98	5.15	5.66	5.74	1.88
E.3	Total variable cost (Rs. in Lakh) (E.1 + E.2)	6.85	7.07	7.80	8.43	8.71	9.02	9.91	10.05	3.29
F	Net income (Rs. in Lakh) (D.6 - E.3)	50.13	58.64	70.17	71.40	71.12	83.47	97.74	97.60	114.23
G	Cumulative net income (Rs. in Lakh) [D.6 -(C + E.3)]	-145.65	-111.59	-89.21	-74.36	-50.97	-15.65	4.95	32.36	78.07

The break-even point is in the year 2008.

Note : 1) The above calculations are based on the prevailing water rates of irrigation department.

2) Earnings from agriculture, horticulture and/or agroforestry or appreciation of value of land etc. are not considered for calculation of the payback period.



11. Agro-forestry & Ecology - A Happy Marriage



Deforestation

Deforestation is causing the progressive destruction of the storehouse of trees and is accelerating the degradation of soil, and reducing its capacity to feed and employ people. Deforestation triggers desertification. In India, as much as 80 per cent of the forests are being cut or burnt as firewood.

Agro-forestry

Agro-forestry is a sustainable land management system. It increases the productivity of land, the production of crops and forest plants. This happens simultaneously or sequentially on the same unit of land by applying management practices that are compatible with cultural practices.

Agro-forestry in Jain Watershed is mainly aimed at proper utilisation of waste and slope lands, improving their productivity, reducing soil erosion and raising the water table.

In Jain Watershed area, we have developed agro-forestry systems on agricultural lands, forest lands, marginal and submarginal wastelands, as well as on lands where cultivation of arable crops is practically not possible or economically not viable.

The purpose was to conserve and improve the land area and enhance the land use as well as optimise combined productivity of forest and agricultural crops and irrigation water. Road boundary, nalla sites, hill terraces, waste and fallow lands as well as other sites such as built-up structures, cattle sheds, landscapes, etc have been used for agro-forestry.

In Jain Watershed area, we have integrated farming with forestry practices and established a symbiosis among agricultural crops, horticultural plants, other tree species as well as livestock raising. We have experienced that all these elements are complementary and beneficial to each other. We are producing food, fruits, feed, fodder, firewood as well as timber.

Tree growth prevents soil erosion, conserves soil moisture, improves soil fertility, enriches it with organic matter and nutrients. Trees absorb carbon and release oxygen in the atmosphere. Trees even act as dust collectors, increase atmospheric humidity, serve as a sink for gaseous pollutants, act as a live storage for water and reduce pollutants in water. Trees also protect field crops against the scorching of

‘The real conflict of the beach is not between sea and shore, for theirs is only a lover’s quarrel, but between man and nature.’

– G. Soucie



Aerial photograph of Jain Watershed area.





Part of Jain Watershed prior to development (1991)



Same part of Jain Watershed after development (2002)

the sun and the desiccating effects of winds. Agro-forestry is thus protecting and purifying the ecosystem.

We have adopted a multi-disciplinary approach under which Soil Science, Agronomy, Horticulture, Forestry, Meteorology, Economics etc. have all been considered and attended to. We have evolved the technology of agro-forestry in Jain Watershed to suit our local conditions. Research efforts are underway to find ways and means of enhancing the productivity of land, water and plants as well as human resources.



Weather station

‘It is not merely that the world is bettered by saving, replacing, and multiplying trees. It is that an aim of this kind becomes an impulse towards developing a mood and an outlook which will increasingly make it natural to think for the future, for other people, for generations yet unborn. Planting a tree is a symbol of looking-forward kind of action: looking forward, yet not too distantly.’

– Richard St. Barbe Baker



Plantation in Jain Watershed Area

Jain Watershed area development really took off only after December 1994, because out of a total of over 263 ha (650 acres) of land, over 235 ha (580 acres) was purchased thereafter.

Fruit Tree Plantations:

During the first few years, beginning 1989 till 1995, we could hardly rear in all about 1150 fruit trees. Out of these, over 1000 were planted in the year 1989 itself. The main constraint was lack of irrigation water. We had received permission for laying a 4.7 km pipeline of 160 mm dia from river Girna via Nagzari village to our site in Dec 1990. However, due to non-reliability of power supply, and poor and erratic availability of water from the bed of river Girna, whatever quantity of water we received via the pipeline was used for the purposes of irrigating these fruit trees plus irrigation of banana, grapes, and sugarcane as well as other demonstration plots.



Aonla plantation



Shri. Sompalji having the feel of mango crop with Bhau, Shri. L. M. Singhaviji, and J. E. Mahajan

Initially, we planted mango, custard-apple, lime and guava trees. In addition, a few sample trees of sapota as well as orange were planted. The underlying idea was that we must get some farm-fresh fruit in every season, if not every month throughout the year, at least for domestic use. Moreover, in planting 200 trees of lime, there was a vague feeling that some day we may be able to use lime-skin for the manufacture of pectin. There was another manufacturer doing that in the village Utran nearby.

As things stand, presently these mango, lime, guava and sapota trees are being used as mother trees for vegetative propagation by various methods such as grafting, layering, top-working, etc. They have therefore become a source of genuine material for our nursery section. The orange trees have been uprooted because of poor fruit bearing.





Custard-apple plantation



Guava plantation

The custard-apple trees were originally planted in 1989 by R.B. Jain by using triangular planting method to cut cost of drip lateral tubing. It did result in saving of about 15% cost of laterals. However, the change in geometry created problems and hurdles for inter-cultivation and inter-culturing practices. We finally discarded the experiment and transplanted these trees in the conventional pattern. Most of the lime trees, by now, appear to be nearing the end of their life-cycle. The coconut trees were planted on the roadside mainly for forming an avenue. However, surprisingly two trees out of these yielded as many as 540 coconuts in the year 2000.

As Table 11.1 shows, the real fillip for plantation of orchards came in 1996, the year in which we undertook planting of over 9,000 mango trees. This is the year in which we got permission to lay a 6.3 km pipeline of 315 mm diameter from river Girna via village Dhanora to our Jain Hills and the problem regarding availability of irrigation water was eased. At that time Girna was supposed to be a semi-perennial river and we used to get regular water through this pipeline almost round the year. Encouraged by this, we kept on increasing the plantation every year and took the figure to over 72,500 fruit trees in the year 2008. As the years passed, a few other sample fruit trees including kavath, karwand, bael, jambul, ber, etc were added to the list. The mortality rate was as high as 15% in the beginning. Every year the gap filling had to be done.



Ultra High Density Guava Plantation



Ultra High Density Mango Plantation



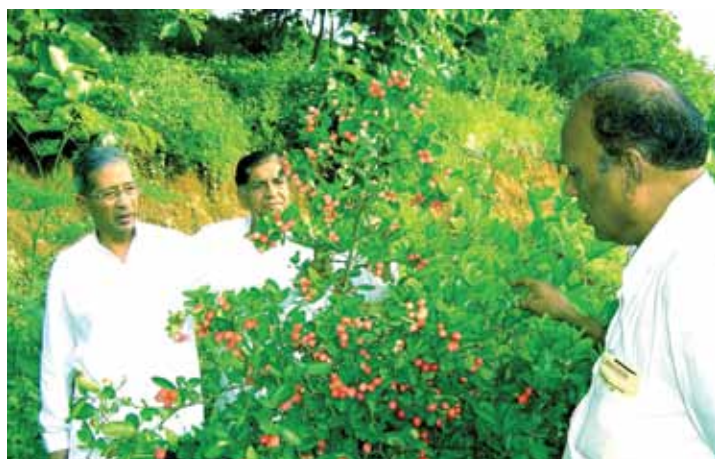
In recent years, we decided either to reduce or not to increase the water requirement during peak summer. With this objective, we started experimenting with new crops like pomegranate which do not require much water during summer and also generate good income. To increase productivity of watershed, new and improved methods of cultivation like Ultra High Density Plantation of mango and guava are undertaken on experimental basis.

Table 11.1 : Yearwise planting data for fruit trees																							
Tree	Botanical name	1989	1990	1991	1992	1993	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Present pop.
Cus Apple	Annona squamosa	323	0	0	0	0	0	1770	402	0	0	8158	5850	0	0	1000	626	880	8	0	0	19017	2092
Mango	Mangifera indica	217	0	0	0	0	9187	10105	3240	0	0	2149	0	0	0	2695	264	1887	2250	2954	509	33457	23104
Lime	Citrus medica	199	0	0	0	0	0	0	0	0	0	0	0	135	0	0	2	0	0	0	2	338	152
Guava	Psidium guajava	152	0	0	0	0	0	569	1610	19	0	0	0	0	0	11	137	0	3657	0	46	6201	3988
Orange	Citrus reticulata	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	0
Sapota	Achras zapota	19	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	46	0	0	91	83
Coconut	Cocos nucifera	87	0	0	0	0	0	0	0	0	453	0	0	0	0	518	0	0	0	0	0	1058	642
Aonla	Emblica officinalis	0	85	0	0	0	0	0	1039	4109	485	679	1700	0	2355	19	729	1100	0	0	0	12300	3109
Ber	Zizyphus jujuba	0	5	0	0	0	0	0	0	0	147	0	0	0	0	0	0	0	0	0	0	152	89
Karvand	Carissa carandas	0	0	12	0	0	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	50	0
Jambul	Eugenia jambolana	0	0	0	12	2	0	0	0	0	38	0	0	0	0	0	0	0	0	0	15	67	15
Kavath	Feronia elphantum	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	0	37	0
Bael	Aegle marmelos	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	12	0
Pomegranate	Punica granatum														0	0	837	115	0	844	1549	3345	2965
Sw. Lemon	Citrus limonum														0	0	0	0	272	0	142	414	414
Total		1024	90	12	12	2	9187	12444	6366	4140	1123	10986	7550	135	2355	4269	2595	3982	6233	3798	2263	76566	36652

Forest tree plantations :

Between 1990 and 1991 neem and teak were planted on the barren rocky hill, because it was felt that nothing else will ever survive there. Encouraged by their growth, we kept up the planting of teak and neem trees taking the number to about 3400 teak and 2100 neem trees by the year 1995. The number included some of the native neem trees which was their natural habitat in this area. Someone suggested planting of sesum and that was also undertaken as an experiment. In 1996, however, we planted over 2700 neem trees in a given area which came to be described as “Neem Valley”. Our experience had taught us that wherever nothing else survives Neem does.





Padmashri N. D. Mahanor explains 1st Karvand crop to Bhau & Dr. Doshi



Neem Plantation

In the same year, over 300 bakkam trees were also planted. Similarly, planting of bamboo on the farm boundary was started in 1998, mainly as a hedge acting as wind barrier for protecting the orchards. In the year 2001, someone suggested planting of Australian teak, botanically known as *Acacia mangium*. I was thrilled to know that the adult teak tree can grow as high as 30m (100 ft) and that upto about 15m (50 ft) its bole will be straight. It was also reported to yield high quality fibre with high bio-mass and hence a preferred choice for pulp industry.

I planted about 1000 *Acacia mangium* saplings. They are developing very well. In 24 months these trees have grown to 3.8m (11.5 ft) height and 15cm (6 in) girth. This experiment revealed that *Acacia mangium* is difficult to grow here without irrigation support in this agroclimate. However, trees like teak and neem are able to grow without irrigation support after initial 2-3 years. After the irrigation support was taken out after four years, 97.5% trees of Australian teak died and only 24 trees are alive now.

I am always conscious of the fact that Jain Hills is after all not a commercial farm, but is basically an R&D farm and that we must conduct all such experiments so that the farmers can benefit from such trials. The farmers can neither afford nor should they be required to undertake such costly experimentation. In July 2000 we have also planted 97 tissue cultured teak. This variety is supposed to be fast growing and reportedly responds very well to drip irrigation. In the past 36 months they have reached an average height of 4m (12.5 ft) with 20 cm (8 in) girth.

As shown in Table 11.2, as on date we have in all over 37,685 agro-forestry trees. The number consists of over 23,000 neem, about 8,500 bamboo and around 3,000 teak and a few other varieties like hybrid tamarind. It is to be noted that around 200 Australian teak plants are growing from tissue culture plantlets. The other plants include sesum, palas and bakkam trees.

'The sky is held up by the trees. If the forest disappears, the sky-roof of the world collapses. Nature and man then perish together.'

– Dr. M.S. Swaminathan





Australian Teak



Bamboo Plantation

Table 11.2 : Yearwise Planting data: Forest Trees

Trees	Botanical name	1990	1991	1992	1993	1994	1995	1996	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Present Pop.
Teak	Tectona grandis	200	600	-	900	600	1300	-	-	-	189	-	-	-	-	-	284	200	-	-	352	4625	1059
Neem	Azadirachta indica	500	-	-	1600	-	-	2750	7661	-	-	-	7460	-	-	-	626	2405	-	-	10701	33703	17614
Sesum	Dalbergia latifolia	-	-	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	3
Palas	Butea monosperma	-	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	125	3
Bakkam	Melia azadirach	-	-	-	-	-	-	329	-	-	-	-	-	-	-	-	-	-	-	-	-	329	11
Bamboo	Dendrocalamus strictus	-	-	-	-	-	-	-	2628	722	1279	425	1690	-	-	238	-	1500	65	-	-	8547	2145
Amaltas	Cassia fistula	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-	-	11	11
Tamarind	Tamarindus indica	-	-	-	-	-	-	-	-	-	437	-	-	-	-	-	-	-	-	-	-	437	147
Karanj		-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
Aus. Teak	Acacia mangium	-	-	-	-	-	-	-	-	-	-	893	-	39	-	-	-	-	-	-	-	932	24
Mahue		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250	-	-	-	-	250	50
Total		700	600	29	2500	600	1425	3079	10289	733	1905	1318	9150	39	-	238	1160	4105	65	-	11053	49015	21067

During 2003 and 2004 a lot of work on oilseed bearing plants specially jatropha (*Jatropha curcas*) and karanj (*Pongamia pinnata*) was done to utilize the steep slopes having rocky soil. *Jatropha* grew well on rocky soils and had a luxuriant growth. The yield was also comparable to that on medium soil. The performance of karanj was also found very satisfactory and after four years they started bearing the first crop. Mixed plantation of *jatropha*, as short term and karanj as long term on hills and hill terraces has been very encouraging.





Sentinels of watershed



Ashoka avenue

Ornamental & temple trees:

Gliricidia, about 2000, and Ashoka, over 500, have been planted apart from a few kanchan, banyan, pimpal and almond trees. Ashoka trees have been used for avenues, while Gliricidia is being used as wind-breaker hedges. Pimpal and Banyan trees have been planted at strategic locations because they occupy a large space in course of time. Ornamental almond (badam) is yet another tree used for shade. Recently we realized that some other native tree species like Buch (Akash Neem, Melingtonia hortense) and Peltophorum (Peltophorum pterocarpum) are efficient like neem in the Jalgaon climate. Table 11.3 given here gives the details.

Table 11.3: Yearwise Planting Data: Ornamental & Temple Trees																			
Trees	Botanical name	1990	1991	1992	1997	1998	1999	2000	2001	2003	2004	2005	2006	2007	2008	2009	2010	Total	Present Pop
Ashoka	Polyalthia longifolia	400	0	0	0	0	0	150	0	0	210	0	0	0	0	0	0	760	395
Desi Badam	Terminalia catapa	0	0	20	0	0	0	100	0	0	0	25	3	0	0	0	0	148	63
Kanchan	Bauhinia purpurea	0	0	11	0	0	30	0	0	10	0	0	0	0	0	0	0	51	50
Gliricidia	Gliricidia sepium	0	0	0	1900	0	0	0	0	0	0	0	0	0	0	0	0	1900	350
Pimpal	Ficus-religiosa	0	0	0	6	0	75	0	8	0	4	0	2	0	0	2	0	97	65
Banyan	Ficus bengalensis	0	0	0	0	37	0	0	0	0	0	0	0	0	0	5	0	42	42
Buch (Akash Neem)	-	0	0	0	0	0	0	0	0	2	8	2	10	8	15	10	0	55	69
Rain Tree	-	0	0	0	0	0	2	0	0	0	0	25	0	0	0	0	0	27	25
Total	-	400	0	31	1906	37	107	250	8	12	222	52	15	8	15	17	0	3080	1059

Medicinal plants :

More recently, the planting of medicinal plants has caught my imagination. Indeed, this is my old love. In the late 1970s, I had taken a fancy for export of medicinal herbs. I built a good sized library on the subject. But the project never took off. I have deep faith in the Ayurveda system of medicine and wish to encourage its usage. So far I have planted over 18 varieties of medicinal plants, shrubs and herbal trees.

Table 11.4 gives details regarding medicinal plantation. This season I plan to add some more trees, shrubs as well as creepers and climbers. I believe, some day these will become very valuable trees. I am proposing to plant a large number of medicinal trees even in the reserved forest area. For me, encouraging cultivation of medicinal plants and herbs is a matter of passion and faith.

Trees	Botanical name	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Present Pop.
Shivan	Gmelina arborea	6	0	19	0	0	0	0	0	0	0	0	0	0	0	25	0
Hirda	Terminalia chebula	0	12	0	0	0	10	0	0	5	0	5	0	0	0	32	0
Kashid	Cassia siamea	0	9	0	12	0	2	15	0	9	0	4	0	0	0	51	10
Umber	Ficus glomerata	0	8	0	67	0	0	14	0	10	0	4	0	5	0	108	14
Behada	Terminalia bellerica	0	0	3	12	0	0	0	0	4	0	0	0	0	0	19	2
Sagar Goti	Caesalpinia bonduc	0	0	0	11	0	0	0	0	0	0	0	0	0	0	11	0
Safed Musali	Chlorophytum arundinaceum	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0
Total		6	29	22	102	5	12	29	0	28	0	13	0	5	0	251	26

In Reserved / Protected Forest Area, there are native Medicinal plants which have grown naturally. These have not been censused & accounted for in the above table. Years mentioned above covers period from July to June.

Protected Forest Area

Between the two hills, there exists a valley with steep slopes which at the ridge has an old stone quarry, now in disuse. This area is upstream of the percolation tank, 'Jain Sagar'. One can only see or feel this area from a distance and though planned, we have not yet erected raised platforms (machans). The idea is that those who have interest can climb the raised platform (machan) to watch the animals and birds without disturbing them. This gives the interested soul an opportunity to watch the fauna at leisure and with pleasure. I personally don't get disturbed by them, nor do I disturb them. It is for this reason that I have chosen to leave this area as 'protected forest' (अभयारण्य) where no bulldozers, excavators, trenchers, and tractors have found their way. Consequently, since these modern earthmoving equipment have not reached there,



Protected forest area of Jain Hills



human beings also find it difficult to wend their way through the thicket of shrubs, bushes and trees. There are many medicinal bushes, shrubs and plants which have grown there naturally. They have not all been censused or accounted for. We have only put two pipelines to chute down cereals to feed the animals and another for water in case this dries up. I am now planning to plant some fruit trees which will be reserved specially for the vegetarian animal world. The total area covered by this reserved forest is about 9 ha (22 acres), which has become a home for several local flora and fauna.

This protected forest area exemplifies the importance of and close relationship between forestry and ecology.

Training & Extension

The model is also serving as a focal point for the local people and visiting farmers for acquainting themselves with the latest in technology and a live model of transformation of wasteland into an impressive agro-forestry monument. The experiment also helps us carry out extension services where farmers can select suitable species and see for themselves the miracle watershed development can create.



Farmers' Visits



Training of farmers from Manipur

Last but not the least, agro-forestry creates and enhances the aesthetic value of everything surrounding it. The green foliage, varying colours and shapes of flowers and fruits and their enchanting fragrance – all add value, apart from serving a purpose. The forestry plantation also becomes a natural habitat for animals, birds, reptiles and insects. This helps in rejuvenating the ecology.

There are two more gullies on the Jain Valley site. They have also been left untouched by humans. In time to come, they will also take the shape of a natural forest habitat. These are the areas where birds and animals feel at home. This becomes a safe haven for them, away from 'civilised' human beings – whom they

'Without habitat, there is no wildlife. It's that simple.'
– Wildlife Habitat
Canada

probably dread and consider their adversary. I feel that if we need a safe haven, we are obliged to provide a safe haven even for them, don't we?

Impending Catastrophe Averted

The first pipeline from the river Girna (160 mm, 4.7 km) was laid in Dec 1990, while the second one (315 mm, 6.3 km) was completed in March 1996. In between in 1993, yet another pipeline (250 mm, 3.75 km) from Mehrun Tank was laid. (However, it had to be subsequently discontinued in Feb 1997). Notwithstanding these consistent, intense efforts for development of such external water sources, I was acutely conscious that excessive dependence on availability of water from the Girna pipeline(s) can never be a long-term solution to the water scarcity problem of Jain Hills. By 1996, I had already planted around 20,000 trees and was hoping to plant more as the years rolled by. I, therefore, took simultaneous steps for the development of a watershed in and around the presently described 'Jain Watershed' area.

As mentioned elsewhere, the story began with the creation of a polylined pond in 1989. The first earthen bund was constructed in 1991. The first percolation tank was completed in 1993. The 1995 spectre of famine heightened the pressure and I undertook the rebuilding of two percolation tanks originally constructed by the Zilla Parishad. In all, between 1991 and 2002, ten water storage reservoirs were either created or reconstructed, just as a long term investment and a far more reliable alternative to the supply of water through pipelines from the river Girna and Mehrun Tank.

As luck would have it, my worst fears came true and the availability of water from the river Girna kept on dwindling. As a result of three consecutive drought-like years, the year 2001-2002 saw virtually no supply of water from the river Girna during the summer months. By now we had almost 60,000 trees and they were getting adversely affected for want of water. It was the water conservation structures which came to our rescue. But for the development of Jain Watershed, all the green cover would have just dried up and died. The foresight and planning saved the ecology and the environment.

'When the soil is covered with grass, the fiercest whirlwinds will not easily blow it away, even if it is sandy. But when the soil becomes a desert place, it is very easily conquered.'

– Stefan Cardinal Wyszynski, Primate of Poland

Trees	1989 to 1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Present pop.
Fruit plants	22771	6366	4140	1123	10986	7550	135	2355	4269	2595	3982	6233	3798	2263	36652
Forest plants	8933	10289	733	1905	1318	9150	39	-	238	1160	4105	65	-	11053	21067
Ornamental & temple	2337	37	107	250	8	0	12	222	52	15	8	15	17	0	1059
Medicinal plants	6	29	22	102	5	12	29	0	28	0	13	0	5	0	26
Total	34047	16721	5002	3380	12317	16712	215	2577	4587	3770	8108	6313	3820	13316	58804

This kind of ecological degradation would invariably lead to erosion in quality and sustenance of human life. No progress or economic development can be sustained without environmental and ecological regeneration. Through Jain Watershed, we



have endeavoured to establish and maintain an optimal self-perpetuating and self-upgrading equilibrium between natural resources, and human and animal life. We have succeeded in structurally integrating these resources in a functional manner.

For our survival, we don't, for example, eat mud or sunlight, but we eat fruits, vegetables, cereals which draw their sustenance solely from the soil, water, air and sunlight. Thus if we wish to survive, we will have to see to it that our ecology is also preserved, regenerated and protected. It is not always possible to balance the demands on environment by the human race on the one hand and that of birds and animals on the other. We, at Jain Watershed, strive to realise and achieve this symbiosis between human progress and environmental protection. We have taken steps to preserve, regenerate and protect it. Hence we can justifiably say that we love this land. It is only because we have worked together that, we believe, we have been able to create a masterpiece.

*'We made,
from water,
every living
thing.'*

Local Flora and Fauna

The scores of peacocks which are seen dancing, the droves of wild boar that keep trotting, the herd of deer that is occasionally seen, the gangs of monkeys which keep gamboling and the flocks of birds of numerous species which keep flying and singing! All these are in harmony with the little boys and girls who go smartly dressed to the farm school and the groups of colourfully clad ladies who work on the farm. What is more, quietly tucked into this environment are three modern temples – a tissue culture laboratory which produces millions of plantlets (superior planting materials),



Peacock in protected forest area



Monkeys at Jain Watershed



Boys and girls in School at Jain Hills



Women planting saplings in field





Spring of life : Ecological balance



The flock of cranes at Jain Watershed

and two food processing facilities which process thousands of tonnes of onions, vegetables, mangoes, guavas and bananas. Most of these products come from the same soil and are processed with the same water that Jain Watershed has created.

‘Paradise on Earth’

Jain Watershed has thus performed and perfected a happy union of plant, animal and human life. It is for this reason that it creates and leaves an everlasting impression on everyone’s mind. The surroundings mean different things to different people. So, different people have expressed themselves with different emotions! Recording their impressions through such glowing terms as ‘Paradise on Earth’ (नंदनवन), ‘Heaven on Earth’ (स्वर्गभूमी), ‘Meditation Home’ (नंदनवन), ‘Hermitage’ (ऋषीभूमी, ऋषीपंढरी), ‘Pilgrimage Shrine’ (तीर्थक्षेत्र), ‘Dreamland’ (स्वप्ननगरी), ‘Temple of Modern India’ (नवभारत का यशोमंदीर), ‘Work Field’ (कर्मभूमी), ‘Celestial Abode’ (यक्षनगरी).

‘The loss of every species and gene limits our options to shape our future.



Rabbits cautiously listening





*‘What is the
use of a house
if you don’t
have a decent
planet to put it
on?’*

*– Henry David
Thoreau*

A temple of modern India: Jain Gurukul



Dreamland 'Gauri' originally Guest House No1





Meditation Home: the pier at Jain Sagar

*‘How quickly
we can poison
the earth’s
lovely surface
- but how
wondrously
it responds to
the educated
caress of
conservation.’
- Donald E. Carr*



Weaver birds make numerous nests in the Jain Hills trees.

*‘If the
environment
can’t support
beavers, ducks
or moose,
how long
will it be able
to support
people?’
- Stamp Bulletin,
Canada*





The teak grove : vast treasure-trove

12. Bio-Diversity and Carbon Foot Printing



The area of Jain Watershed has been transformed from a barren hill to a green zone. Today, it has a lot of diversity of plants and associated fauna. It is evident from the adjoining areas that the efforts towards soil erosion control, water management and planning have had the desired effects for sustainable resource management. The floral diversity is also maintained in the plantation and thus this area is home to a variety of insects, birds, reptiles and animals. This is possible because we are able to restore the ecology beyond the bio-capacity of barren land. In order to study the complex behaviour of flora and fauna our sustainability team carried out the biodiversity mapping, conservation and restoration work for Jain Hills and Valley. The attempt was also made to calculate the sequestration of carbon by this green cover in Jain Watershed. It is a felt need that this kind of Jain Watershed should be replicated in this part of India so that we can march towards a sustainable path of agricultural production, water use and energy efficiency to feed the burgeoning population.

Biodiversity at Jain Hills and Jain Valley

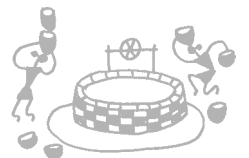
Biodiversity is the range of variation in living organisms in a given area. It is a classification of the variety of life forms, and associated eco-processes on the land (Wildcove & Samson 1987, Keystone Centre 1991). Biodiversity has to address a continuum of ecosystems, successional stages and (standing) condition of the landscape. Biodiversity is the variety of life at all levels, genetic, species and ecosystem levels. For convenience, it is studied on the basis of the number of species in an ecosystem. Rapid expansion of human activities across the earth and subsequent modification of natural systems into systems managed for human benefits, has led to the decrease in biodiversity at all levels and extinction of species. This has raised numerous concerns, including the possibility that the functioning and stability of earth's ecosystems might be threatened by this loss of biological diversity (Ehrlich and Ehrlich 1981, Schulze and Mooney 1993). Biodiversity has contributed in many ways to the development of human culture, in terms of goods as well as services. Knowing the importance of biodiversity and its associated ecological processes, it was felt that proper documentation of Jain Hills and Valley has to be done. As a methodology it was decided to do 'Ecological assessment' during all season's viz. monsoon, winter and summer to record the entire spectrum of diversity. An eco map of the whole area is prepared showing various features like streams, slopes, plateaus and its diversity, and ecologically sensitive areas. Study of biodiversity will serve as a first stage inventory of biodiversity in this area. It could also serve as a reference document for students, researchers, planners to know what kind of biodiversity such semi arid areas can ultimately have.





Jalgaon being a part of semi arid area in Khandesh has a harsh climate, experiences high temperatures and has low rainfall. The land belongs to bio-geographic zone of Khandesh in Maharashtra, which is characterized by deciduous forests with dominant grasslands or savannas and extensive plains with shallow and wide valleys. Due to the dry climate, the hills and plateaus are less wooded and very barren. Vegetation can be described as dwarf, thorny and interspersed with grasslands. But due to years of intense human interference these areas are further degraded to only grasslands and scrub. Major areas are rocky with fractionated rock (murrum), growing inferior quality grasses and thorny vegetation. This was the case with Jain Hills and Valley. But since much work is done for soil and water conservation along with plantation, the green cover has increased. Eighty per cent of the area is under some kind of plantation which includes horticulture, Neem and Teak. But biodiversity of these plantation areas is not much. Rest of the area has mainly shrubs like ‘Rui’ (*Calotropis giagentia*), ‘Henkel’ (*Gymnosporia montana*), ‘Ber’ (*Ziziphus nummularia*), ‘Pandharphali’ (*Fluggea and microphylla*) with inferior quality grasses. Some areas have trees like ‘Khair’ (*Acacia catechu*), ‘Neem’ (*Azadirecta indica*), ‘Palas’ (*Butea monosperma*), and ‘Bartondi’ (*Morinda pubescens*).

In Jain Watershed area a patch of 22.5 acres is preserved as a natural forest. This particular patch is rich in diversity as compared to other areas. Some plants, which are locally rare, are found in this area like ‘Bel’ (*Aegle marmalos*), ‘Kinhai’ (*Albizia procera*), ‘Anjan’ (*Harwickia binata*), ‘Bondara’ (*Lagerstroemia parviflora*), ‘Ain’ (*Terminalia elliptica*), ‘Beheda’ (*Terminalia belirica*) etc. Large woody climbers of *Combretum Albidum* is a good indicator of better forest cover. This patch of 22.5 acres has a good microclimate for regeneration and also conservation of original native flora.





Also faunal diversity in this patch is significant. One herd of wild boar resides here permanently. Ecological value of this area is much higher due to the existence of a stream and being the catchment of a dam downstream. Biodiversity of this area as well as the entire area can be increased slowly with the help of restoration techniques. Some species that are in composition of dry deciduous forests can be re-introduced in some patches with better soil and moisture condition while degraded areas can have a year wise strategy to restore the original flora and fauna.

For the purpose of study, biological diversity is measured at genetic, species and ecosystem levels. Thus, measurement of total biodiversity of a region will include quantification of different ecosystems and habitats in the region, measurements of species diversity and also of genetic diversity within the species seen in the region. As seen from this, the biodiversity in its complete sense is a very complex term, requiring extensive studies of all taxa and habitats. High value of biodiversity is considered an indicator of health of the environment within a region. It also indicates the robustness or ability to sustain in face of adverse changes. Thus, high value of biodiversity is considered a positive sign in regional studies of environment.

In a limited span of time, it is not possible to survey the entire range of organisms within an ecosystem. Hence, most studies measure diversity of some important groups of species which serve as indicators of general biodiversity. Plants, being the producers in an ecosystem are one of the most important indicators of biodiversity. Diversity of plants is positively correlated with diversity of other dependent taxa including insects, birds and even soil microflora. In the present study of Jain industries, plant diversity is measured and compared between various landscape elements and restoration areas. This will serve as a basis of future planning of restoration measures and management of habitats.



Factors of Plant Diversity

- A) Species richness is the primary measure of plant diversity. It is simply the number of species observed in the area. It is thus subject to variation based upon the sample size.
- B) The second measure is of diversity index, where relative abundance of species is taken into account, providing a measure for comparing between samples of different sizes.

Also, it is a measure of relative distribution of species within the sampled area and indicates whether vegetation is dominated by a few species or is composed of many species.

Methodology : The project area was divided into zones, based upon the man-made structures and natural divisions of the land. In each zone quadrates were laid to enumerate the details of plant diversity. Broadly, the following points were considered while conducting the field survey:

- 1) Document and sample areas under different land uses
- 2) Record species richness
- 3) Quantitative study of species diversity by calculating Shannon's index
- 4) Identification of the vegetation types
- 5) Study of government forest with typically unmanaged vegetation
- 6) Comparison and comment on the species diversity of different zones

S. N.	Zones	Tree/Woody Species (H.)	Woody Species (Number)	Herbs (H.)	Herbs Species (Number)
1	25 acres	3.96	21		
2	500 acres	4.22	41	1.191	30
3	Around bungalows	3.985	26	0.761	7
4	Gaushala	2.902	11	0.854	8
5	Government forest	4.525	40		
6	Green hills	3.441	21	1.131	21
7	Helipad	2.447	9	1.129	18
8	Mine	2.983	13		
9	Natural forest	3.666	18	0.879	12
10	Office area	4.107	35	0.914	16
11	Stopes	3.811	32	1.267	36
12	Terrace	1.986	9	0.932	10
13	Tower	2.844	14		



Calculation of diversity indices

Species richness is the primary measure of biodiversity. It is simply the number of species observed in the area. Diversity index is a ratio between number of species and number of individuals present in a sample. Shannon Diversity Index has been used for estimating the diversity between the sampled zones in order to compare diversity. Shannon index is a measure of the average degree of uncertainty in predicting to what species an individual chosen at random from a collection of 'S' species with 'N' individuals will belong.

It is expressed by the formula:

$$H' = - \sum [(ni/N) \log (ni/N)] \text{-----} (\text{Magurran, 1988})$$

Where,

H' = Shannon index,

ni= number of individuals of each species

N = total individuals of each species, (Log to the base 2 is used)

The number of birds observed is too less for calculation of the Shannon index hence N/S is used as a measure of avifaunal diversity.

N= total individuals of each species,

S= total number of species.

Vegetation data was collected by a team of researchers. In the initial phase of the project, this team was trained to collect specimens of plants, identify, lay out and enumerate vegetation quadrates for herbs, shrubs and trees. The methodology to be used for data collection and the purpose of the project was explained in detail. The vegetation was sampled by employing standardized field ecological survey methods. Stratified random sampling was employed for collecting the data for diversity indices and phytosociological characteristics of the various elements of the vegetation. In the different zones a total of 128 quadrates were laid out. The quadrates cover various land use types and are representative of the landscape of the region. For the woody vegetation quadrates of 10 m X 10 m were laid out in the field. Each was permanently marked using plank markers along corners. This way, the data collection could be repeated over time to monitor the status of plant diversity in the area. In each quadrant all the woody species above 10 cm GBH (Girth at Breast Height) were noted down. The GBH was marked using a tape measure, and height was noted down. The number of individuals of each species was separately noted. This data is used for Shannon index calculation. The shrub clumps and all woody species below 10cm GBH were also noted down in the same quadrates. For enumerating herb diversity, quadrates of 1m x 1m were laid out within the large



quadrants. Ground cover of each individual species was noted using a grid frame. This is used for Shannon index calculation. All the species unidentified on the field were photographed. Herbariums were made and identified using reference literature like flora and handbooks of plants

Floral Diversity		Faunal Diversity	
Trees	75 species	Birds	91 species
Herbs	41 species	Insects	19 species
Shrubs	18 species	Reptiles	11 species
Climbers	14 species	Mammals	20 species
Grasses	10 species		

Note: in the case of floral diversity 112 species are indigenous and 23 are non-native.

The overall diversity of the region varies from low (less than 1) to moderate (2 - 4) and high (above 4). Woody species number is highest in the 500 acres area and is comparable to the government forest area. The natural forest patch, has low number of woody species, being dominated by a select few colonizers. The vegetation around offices and slopes also has a high species number as diverse species have been planted in this heavily managed area. Correspondingly H' is highest in 500 acres, office areas and is comparable, although slightly lower than the unmanaged government forest with its completely natural growth. Herbaceous diversity counts were made at only one time, and hence are only indicative. 500 acres area and slopes have high species richness and H' of herbs. This is followed by the helipad and green hills area. However, long term protection has led to formation of dense canopy in certain areas and good shrub growth which is important for the bird and insect diversity.

At this stage, it is also pertinent to mention that through our bio-diversity activities, the Painted Stork (*Mycteria leucocephala*) which is a nearly threatened Species in India has been conserved. One of the major trend in these activities is the bird conservation programme. It aims at the following:

- 1) Birds are indicators of the state of environment.
- 2) Birds and their natural habitat should be conserved as a part of biodiversity in Jain hills.
- 3) We are involved in the identification of natural sites located in our area or related to our neighbourhood specially the marshy region. Our main focus areas are Jain Sagar and Zilla Parishad dam, which attracts plenty of birds.
- 4) We have planned to grow wild rice near Zilla Parishad dam and Watershed area which will serve as food for birds and also harbours loads of bio-organisms in and around the root zone.



Jain R&D farm as a shelter for birds and bio-organisms



Oriental White Ibis (*Threskiornis melanocephalus*)



Common Tailor bird (*Orthotomus sutorius*)



Brahminy Shelduck (*Tadorna ferruginea*)



Cow with Calf (Cattle) (*Bos primigenius indicus*)



Chameleon (*Chamaeleo chamaeleon*)



Argemone mexicana



Flower of Bakam Neem (*Melia azedarach*)



Lahan (*Tricholepis radicans*)

It is worth mentioning that in our R&D farm, national birds of three countries have been conserved. These are:

- 1) National Bird of India – Peacock (*Pavo cristatus*)
- 2) National Bird of Israel - Common Hoppoe (*Upapa epops*)
- 3) National Bird of Latvia - White Wagtail (*Motacilla alba baicalensis*)

5) We are also planning to develop duck weed which can be used as a food for birds.

6) Plans are also being drawn to develop shelter for birds made up of wooden cartons termed as bird nesting.

7) Rising public awareness and appreciation programme for the value of local wetlands

8) We should plan for bird festival

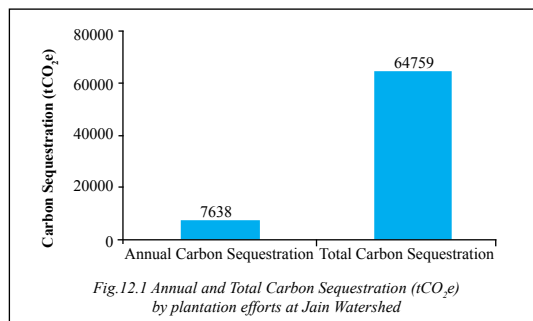
during winter season at our watchable bird site; the main theme is connecting people with birds and nature by conducting programme with local and state level NGO'S.

9) We wish to establish “Society for the conservation and the study of Khandesh Birds”

10) These activities are being undertaken under the able guidance from Shri Maruti Chittampalli, a noted Nature Expert.

Carbon Footprinting of Jain Hills and Jain Valley

Preventing deforestation seems an obvious way of reducing the amount of greenhouse gases in the atmosphere. There are many other benefits of preventing deforestation, including benefits to indigenous people and local communities living in and near forests. JISL has been carrying



out a number of plantation activities since the past 15 years which are resulting in reduction of 7638 tonnes of CO₂ eq. on an annual basis for Jalgaon and Udumalpet. Also the absolute CO₂ sequestration till date due to the plantation activities diligently being carried out by JISL stands at 64759 tonnes of CO₂ eq. in these two locations.

Field measurement and Calculation of sequestration by vegetation

Tree biomass estimation methods vary widely. It is frequently estimated employing allometric models, which express the tree biomass as a function of easily measurable variables such as diameter at breast height (dbh), total height (h) and/or basal area (BA). The basic method involves calculation of volume using girth and/or height using allometric or volume equations established by actual measurements in long



term studies. This is then used further to calculate above ground biomass (AGB) using species specific constants. AGB is used to calculate below ground biomass (BGB) and then carbon sequestered in the total tree can be calculated using constants developed through experimental procedures.

Average DBH and average height of a sample of individuals was provided by field team based on the fruit tree plantation records. Based on the sample data average diameter at breast height and average height was calculated for each species. This was used in further volume calculations.

Above ground biomass in tCO₂

$$Ca = A * V * D * BEF * CF$$

Where,

V= merchantable tree volume in m³/ha

D= basic wood density for species in t.d.m/m³

BEF= biomass wood density for species K to convert merchantable volume into above ground biomass.

CF = Carbon Fraction in Biomass

Below Ground Biomass

$$Cb = Ca * RS * CF$$

Where,

RS= Root Shoot ratio

Total Carbon Sequestration,

$$Ct = (Ca + Cb) * (44/12)$$

Plants take up carbon in the form of carbon dioxide in the air and convert it into biomass. Hence, estimation of carbon sequestered by a plant includes estimation of plant biomass and then calculation of amount of carbon stored in the biomass. Various studies across the world have been carried out to establish standardized procedure for calculating carbon sequestered by vegetation in a study area. Most studies deal with forest biomass. In case of forests, biomass consists of above and below ground biomass of trees, shrubs and other non-woody plants. The carbon stored in the biomass of dead wood, leaf litter, and soil has to be added to the carbon stored in plant biomass to calculate the total amount of carbon sequestered in the forest vegetation. In case of plantations, there is continuous removal of dead wood and litter and ground cover keeps changing as cleaning activities are carried out making calculation impossible without long term studies of biomass. Owing to this, the carbon sequestered in this biomass is not added to the total carbon sequestered. Thus, in plantation areas, carbon sequestered by planted trees (including their above and below ground biomass) can be calculated by employing standard methods for per tree biomass estimation. (Table 12.2)



Table 12.2. Input details required for carbon sequestration calculation				
Species Name	Average Age	No of Trees	Average GBH(cm)	Average Height (m)
Mango	9.7	23438	34	5.6
Aonla	8.1	13533	31	4.9
C Apple	6.4	3424	19	8.3
Guava	2.7	4773	12	3.1
Coconut	7.3	1493	55	18
Ber	8.2	105	21	15
Bamboo	10	6067	10	8.0
Teak	16	7557	52	8.8
Neem	7.8	12778	70	5.3
Jatropha	4.6	8399	21	4.3
Ashok	10	835	17	6.5
Sapta parni	5.3	261	25	7.1
Tamarind (Chinch)	6.8	162	13	4.5
Badam	7.7	117	35	7.5
Jamun	8.9	38	45	6.3
Rubber	4.8	52	36	7.8
Umbar	7.9	16	50	8.0
Palas	8.9	11	58	5.0
Pheltophorm	6.0	22	26	8.9
Glyricidia	6.0	258	10	4.1
Ficus Bengallensis	5.6	432	34	8.0
Ficus religiosa	4.0	253	85	30
Bottle palm	4.0	105	30	8.0
Acacia mangium	9.0	356	22	10
Karanj	4.2	2113	27	6.0
Australian teak	10	252	25	11
Others	3.7	1695	22	5.0
Total		88545		

Conclusions

There would be but a few Organizations in the field of Agriculture who have developed such a deep understanding and respect for the relationship between Land, Water, Soil, Crop and, above all, Environment, as Jain Irrigation has. With Jain Irrigation, Agriculture is not merely a Profession, it is an Article of Faith. Jain Irrigation has an enviable track record for developing down-to-earth solutions for farmers by way of technology transfer and make them progressive. At the root of all these activities and achievements, is the personal and organizational commitment to upliftment of farmers at large. It has taken up corporate social responsibility project as a part of service to society and to address socio-economic impact in a very humble manner.



13. Conservation of Energy in Jain Valley Watershed area which is adjoining the Watershed of Jain Hills.



Water, energy & food security is of utmost importance to all living beings. Mere storage of water will not help at all. Energy is essential for effectively using water. Water and Energy together will lead to food security. We have taken various important steps for conserving energy in the best possible ways. Sun and Wind are worshiped as Gods in Hindu mythology. The energy that we receive from these two sources, is being utilised in one way or the other for years. Though conventional, these energy sources are called “non-conventional” or renewable/new energy sources. For JAINS, this was a forward integration in keeping with the company’s mission. We harness the sun energy in the best possible way and utilize the same for many applications including cooking, water heating, lighting, pumping, etc. Since the last one year, we have been successful in carving out a separate area of 62 acres. This area is called “Green Energy Park”. Hybrid system is a new concept, which is a combination of the energy sources. We have installed systems with a combination of solar and wind energy for running pumps and lighting applications in the watershed area.

Volume wise, the current production capacities of this division are as follows :

Table : 13.1 Production Capacities	
Plant	Capacity (per annum)
SWHS	12.0 lac litres
SPV Appliances	24000 units per item
SPV Modules	25 MW
PCB Manufacturing facility	16800000*

Notes : 1. For SPV appliances, the production capacity is for each unit: Solar Lantern, Solar Street Lighting & Solar Home Lighting separately.

* 2. For PCB Manufacturing, the above capacity indicates component mounting capability on the PCB per annum.

Energy Conservation Facts

The ultimate aim of using any renewable energy system is reducing the load on conventional electrical energy. Various steps pertaining to installation of renewable energy systems in due course of time have helped us to reduce our electricity bills. Following data reveals these facts:

Table 13.2 Energy Savings	
Head	Total savings (Rs.)
SPV (Lighting)	5,12,265.60
SWHS	77,96,250
SPV (Pumping)	17,82,000
Bio-Gas	41,73,180



Bird’s eye view of Green Energy Park

Table 13.3 Chronological Data	
1994	Operation of Solar division. commenced with fully imported SWHS
1995	Indigenisation began by manufacturing our own MS tanks
1996	Switched over to SS tanks. Collector & stand manufacturing began
2004	SPV products introduced (system integration)
2005	DPR on establishment of module manufacturing facility was first presented
2006	Manufacturing of SPV electronics began.
2008	Manufacturing of SPV modules began. (Initial capacity = 5 MW), Introduced solar pump systems. Study / trials on solar drip irrigation began.
2009	Enhanced R & D capabilities. Module manufacturing capacity increased to 25 MW.
2010	Cutting edge manufacturing plants for SWHS and SPV applications.

Solar Water Heating Systems

This is the oldest department in the energy division which was established in 1994. We have state-of-the-art technology for producing these water heating systems.

We have two types of systems :

- Flat plate collector (FPC)
- Evacuated tube collector (ETC)

Tanks and collectors are produced in-house. Tanks are available in MS & SS and are supplied as required. Systems are available in open loop (OL) and closed loop (CL) OL are for soft water and CL for hard water.

The following chart shows capacity (Ltrs) for FPC and ETC systems

Table 13.4 Capacities of FPC and ETC	
FPC (Domestic)	100,125, 200, 250, 300, 375, 500
FPC (Ind/Commercial)	750, 1000, 1250, 1500, 1750, 2000
ETC	100, 200, 250, 300, 375, 500,



Hot plate collector



Evacuated tube collector



Solar Water Heating: Production Unit





Solar Photovoltaic Appliances: Production unit

Till date, we have been successful in selling 14324 SWHS systems, accounting to total energy savings of Rs. 31.4 crores.

SPV Appliances

This is the second largest department. Various appliances are produced. The major ones are lighting appliances. Earlier all the lighting appliances were CFL based systems. Recently, LED based lighting applications are also added to our range.

Till date, we have been successful in selling 40528 SPV appliances, accounting to total energy savings of Rs. 45.8 lacs.

Different models are available in each of the above product categories. The following tables show details.



Solar Lanterns



Solar Home lighting Systems (SHLS)



Solar Streetlighting systems (SSLS)

Table 13.5 A - CFL based systems	
System	Wattage
Lanterns	3W, 5W, 7W, 9W
SHLS	model 1 to 5
SSLS	9W, 11W



Solar Blinker



Solar Power pack

Table 13.5 B - LED based systems	
System	Wattage
Lanterns	up to 4W
SHLS	4W, 8W
SSLS	8W

Table 13.5 C - Other important products	
Product	Wattage
Blinker	
Power Packs	150, 250, 375, 500, 750, 1 KW
Ad Boards	22W

Solar Pumping Systems

The latest introduction in the SPV product range is the solar pumping systems. This will be very much useful for irrigation, drinking water, etc. Solar pumps are available in surface and submersible types.

Following tables show the capacities/models with max head and max discharge (at minimum head) for Surface Pumps & Submersible Pumps

Table : 13.6 - Surface Monoblock Pumps			
Pump Model	JSP 150 Boost	JSP 600 BADU - Top 12	JSP 1800 POOL - 36
Max. vertical lift (metres)	120	14	12
Max. flow rate (lph)	900	15000	37000
Nominal Vtg. (Solar) V DC	12-24	48-72	72-96

Table : 13.7 - Helical Rotor (HR) Submersible Pumps					
Pump Model	JSP 200HR	JSP 600HR	JSP 1200HR	JSP 1800HR	JSP 4000HR
Max. vertical lift (metres)	50	180	200	250	350
Max. flow rate (lph)	2500	2600	2700	1500	2500
Nominal Vtg. (Solar) V DC	24-48	24-48	72-96	72-96	230-375

Table : 13.8 - Centrifugal (C) Submersible Pumps								
Pump Model	JSP 150C	JSP 200C	JSP 600C	JSP 1200C	JSP 1800C	JSP 4000C	JSP 9K	JSP 15K
Max. vertical lift (metres)	20	20	25	40	90	170	150	150
Max. flow rate (lph)	4000	9000	19000	20000	45000	47000	63000	70000

Solar Powered Drip Irrigation

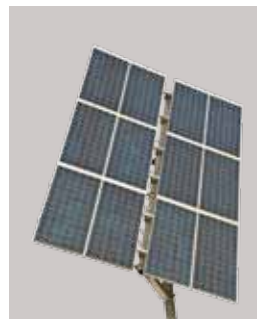
This is a very innovative solution for the burning problem - “Electricity”. Today electricity outages prohibit the farmer from using his irrigation system effectively. This is even worse, where grid supply is not available. Farmers, unfortunately opt for diesel or kerosene operated pumps, which are too costly to operate.



Solar Surface Pumps



Solar Submersible Pumps



Solar Trackers



JAINS have been successful in overcoming this problem with an effective solution - “Jain Solar Powered Drip Irrigation System”. This revolutionary user friendly irrigation system is a combination of Jain Solar Powered Pump & the Drip Irrigation System. The principle, though simple, is beneficial in the present scenario. The system starts its operation as soon as solar radiation occurs in the morning. At this time, because the solar radiation intensity is low, the pump runs at a slower speed. But since the evaporative losses are also minimal, this is acceptable. As the radiation increases, so also do the evaporative losses and the speed. Thus, the speed of the solar pump, as a function of radiation changes with time and compensates the evaporative losses. Hence, the system is favourable. On an average the system run for 6-8 hrs. a day

Advantages

- Slow application of water & Fertilizer over a longer period of time gives better root zone environment and results in higher growth rate and yield.
- No manpower required to operate the system. System starts automatically with the first rays of the sun and shuts off when the sun sets.
- Suitable for survival irrigation during drought period or even in case of failure of rains.
- System is designed to save water and provide better application efficiency.
- No dependence on conventional energy sources.
- No power and/or fuel cost to operate the system.

Advantages

- Low capital repairs and maintenance cost
- Suitable for use up to 50 metres
- When solar energy is not available water can be drawn through a hand pump
- The water that will be available is uncontaminated, safe, potable and hygienic since it is drawn from the deeper level.



Installation of solar pumps for Drip Irrigation Systems



- Overall savings in electricity and water.
- Over exploitation of water could be minimized.
- Suitable for agricultural purpose also. Mostly for drip irrigation with family drip kit.

Applications

- Potable/Drinking water scheme.
- Village water supply schemes
- Gravity drip irrigation systems

Jain Hand+Solar Pump

Availability of water predominates the very existence of human beings. We all know that water is becoming scarce day by day. In the present rural scenario, people have to run after water. Due to non-availability of electricity, pumping ground water has become difficult. One of the solutions to this was the hand pump. But still, people have to exert, to get the water to their homes. JAINS have come up with a novel idea of integrating solar submersible pump to the existing hand pump. This setup will surely assure supply of water to the homes.

Salient Features

- The system is useful to provide piped water supply in remote villages where grid power is not available.
- The submersible pump is operated on energy generated by the solar PV modules.
- No batteries are required in most cases.
- The solar powered submersible pump is installed in the same hand pump borewell.
- The pump delivers water directly to an overhead tank for storage and distribution.
- The stored water can be used as and when required in the absence of power from the solar PV modules.



Installation of Jain Hand+Solar Pump



- The complete system is eco-friendly.
- No operational cost
- Low maintenance

System components

- Hand pump assembly
- Solar submersible pump with controller
- Solar PV modules
- Solar tracker / stand
- Plastic tank and its stand.
- Pipes, fittings, structure, etc.

SPV Module Manufacturing

This is yet another important activity in the division. We manufacture mono & multi crystalline PV modules. We have an annual capacity of 25 MW.

Jain Photovoltaic Module Features

- IEC 61215 & MNRE certified mono & multi crystalline PV modules.
- Cell efficiency range is 14% to 18%.
- Module efficiency range is 12% to 16%.
- Cells are encapsulated in a low iron, high transmission, toughened glass using UV Stable Ethylene Vinyl Acetate (EVA) Sheets. This ensures durability.
- Premium quality back sheet protects the module from environmental conditions.
- Laminate is framed with a strong and anodized aluminium profile with multiple holes for ease of installation.



Solar PV Modules



View of solar photovoltaic module manufacturing plant



- Fitted with terminal box with IP65 protection, cables and connectors.
- Module Capacities : from 8W to 280 W

Biogas

In 1994, JISL set up world class food processing facilities for dehydration of onions, vegetables and production of fruit purees, concentrates and pulp. These plants are ISO 9001 & HACCP certified and meet International FDA statutory requirements. These units were set up at Jain Valley which is adjoining Jain Hills.

The fruit processing plant has the capacity to process nearly 600 tonnes/day fruits. While processing different type of fruits, some material come out as waste. In case of mango, the outer peels, mango stones, rotten mangos come out as waste material. In case of banana and guava, the peels and grit comes out as waste. All this and waste puff puree from the plant can be used as feed material for biogas plant.

Before setting up the biogas based power generation plant, we processed this waste in a prototype aerobic composting unit to produce organic manure. But while studying and by doing the lab trials, we came to know that this waste is also having a good potential for biogas generation because the fruit waste is rich in sugar, carbohydrates and other micronutrients. So after taking several trials for more than two years, we decided to set up the biogas based power generation plant for the efficient disposal of the organic waste. Coincidentally, in this process, this will also generate biogas. This biogas is then used as a fuel for generating electricity. Likewise, the residual slurry coming out from the biogas plant is used as rich and good source for producing organic manure.

The liquid separated from the slurry is also used as nutrients for the plants. Thus, we utilize the plant's solid waste for generation of biogas and the liquid waste for preparation of high value organic compost. The remaining liquid is either sprayed



View of Biogas power plant



on the compost heaps or used as liquid fertilizers. In this manner, we give back to the soil what we take from it in toto. We achieve sustainability along with creation of wealth from waste.

For generation of power from biogas, we have installed two engines of 834 KW capacity each. The total power generation will be about 1.7 MW. The expected gas generation from this plant is nearly 15000 to 16000 m³ per day which is sufficient to generate this power. The generated power is supplied to the internal grid of the Company for captive consumption.

Four Biogas plants totalling to 147 m³/day have been installed.

Solar Power Fencing

This is an electrical fencing system. The basic principle of this electrical fence is the generation of short pulses after a regular time frame. The system actively controls the entry of animals and human beings by giving them a short, sharp, but safe electrical shock, as and when the animal/human being comes in contact with the fence.

The electronic system consists of an energizer, controller battery and PV panel. Energizer produces a short, high voltage DC pulse of the order of 5-10 KV at a regular rate of 1 pulse per 1.2 s. and lasts for only 300 millionth of a second. This electrical shock is completely safe, but sufficient for an intruder to be prohibited from crossing the fence.

Special Features :

- Reliable system
- Easy to operate
- Low maintenance
- Cost effective
- Centralised alarm system facility
- High safety design



Different Installations of solar power fencing



Advantages :

- Protection of the property
- No electrical connection required
- Automatic operation
- Safe with effective deterrence and detection capabilities

Applications :

- Protection against animals
- Economical cover for residential, industrial & commercial centres.

S. N.	Location	Length of Solar Fence
1	Jain Hills	2 km
2	Jain Valley	1 km
3	Biogas power plant	0.8 km

It needs to be clarified that this section on energy conservation through generation from renewable sources is and can be an integral part of development of watershed. Once a watershed is fully developed, it

will generate huge amounts of biomass. Likewise, if there is processing activity based on agri-products, the residual waste can also be a very efficient source of generation of biomass. This way, the whole concept of renewable green energy can be described as a forward integration of a fully developed watershed.



14. Replicability



Watershed development is indeed location-specific, problem-specific, and need-based. In that sense, it cannot be replicated, much less duplicated. Even the structures, their type, design will differ. However, as far as its application is concerned, it can be applied and used with benefit in varying situations. The benefits of watershed planning and development are generally long-term in nature. These watershed measures which go hand-in-hand with soil conservation measures are capital intensive, and also need regular upkeep and maintenance. They may not require very sophisticated technology and/or equipment. However, experience can play a major role in selection of the structure and its design. Similarly, study of climatology, lithology, soil, hydrology, do play a considerably important role. We would do well to have a fair knowledge of these before we embark on planning development of watershed on any site.

*'Everyone lives
downstream
from someone
else.'*

*– An American
Saying*

We, at Jain Irrigation, have for long been studying this subject and have also implemented some of the textbook ideas and added to them a few of our own. We have dealt with differing soil types, topography, and hydro-geologically quite distinctly separate watershed areas. At least three sites, which belong to the company, in themselves are very different. Each one of them needed a different treatment. Accordingly, we have planned and executed a variety of structures.

Learning from the bitter sweet experiences of Jain Watershed Development, we have repeated the concept in other farm areas. In fact areas which are barren and need reclamation are purchased and developed. Owing to continuous effort of watershed development we succeeded in such areas. Brief information on two of these projects is given below.

Orient Vegetexpo, Dindori, Nashik, Maharashtra

Orient Vegetexpo is an onion dehydration factory near Dindori in Nashik District of Maharashtra. The factory was taken on lease by us in 2002. In the initial phase there was acute shortage of water to run the plant. It was run on the water purchased at the rate of about Rs. 5.00/cum. Around Rs. 1.50 lakh per month was the expense to procure the water for the plant. In spite of all these difficulties I was confident that we would be able to run the plant with our own and sustainable water source. Experience of Jain Watershed and knowledge of our team of watershed experts was the major strength.

After carefully studying the topographical features of the area, an initial plan was drafted. There was a small stream with about 20 ha (50 acres) of catchment area flowing through the North-East side of the premises. River 'Kolwan' runs near the Southern side of the area. There were seven bore wells in the premises out of which only two were functional, each yielding about 5,000 litres per day. A small percolation tank of the capacity of about 2500 cum (25 lakh litres) was constructed



in a record period of only eight days. After the construction of this percolation tank, the scenario changed. An open well, constructed downstream of this tank, yielded about 40,000 litres/day through the summer, and the yield of the bore well, which is in the vicinity of the tank, increased to four times i.e. about 20,000 litres/day.

A small farm pond was also constructed in the Southern side of the premises having a storage capacity of about 1000 cum (10 lakh litres). Another open well was tried in the bed at river Kolwan but it failed. After studying the hydro-geological condition, another open well was dug in the South-East side of the percolation tank. This well is yielding 50,000 litres/day. An underground storage tank of 1000 cum (10 lakh litres) was constructed to store the roof water of the plant and the post monsoon runoff. Thus, the plant which was run entirely from outside water is now almost self-sufficient in water needs. Even the villagers of Dindori have been inspired by our efforts and the results of the watershed development works.

Orient Vegetexpo, Nasik - Changing Landscape



Site situation prior to percolation tank



Site clearance work in progress



Construction of earthen bund



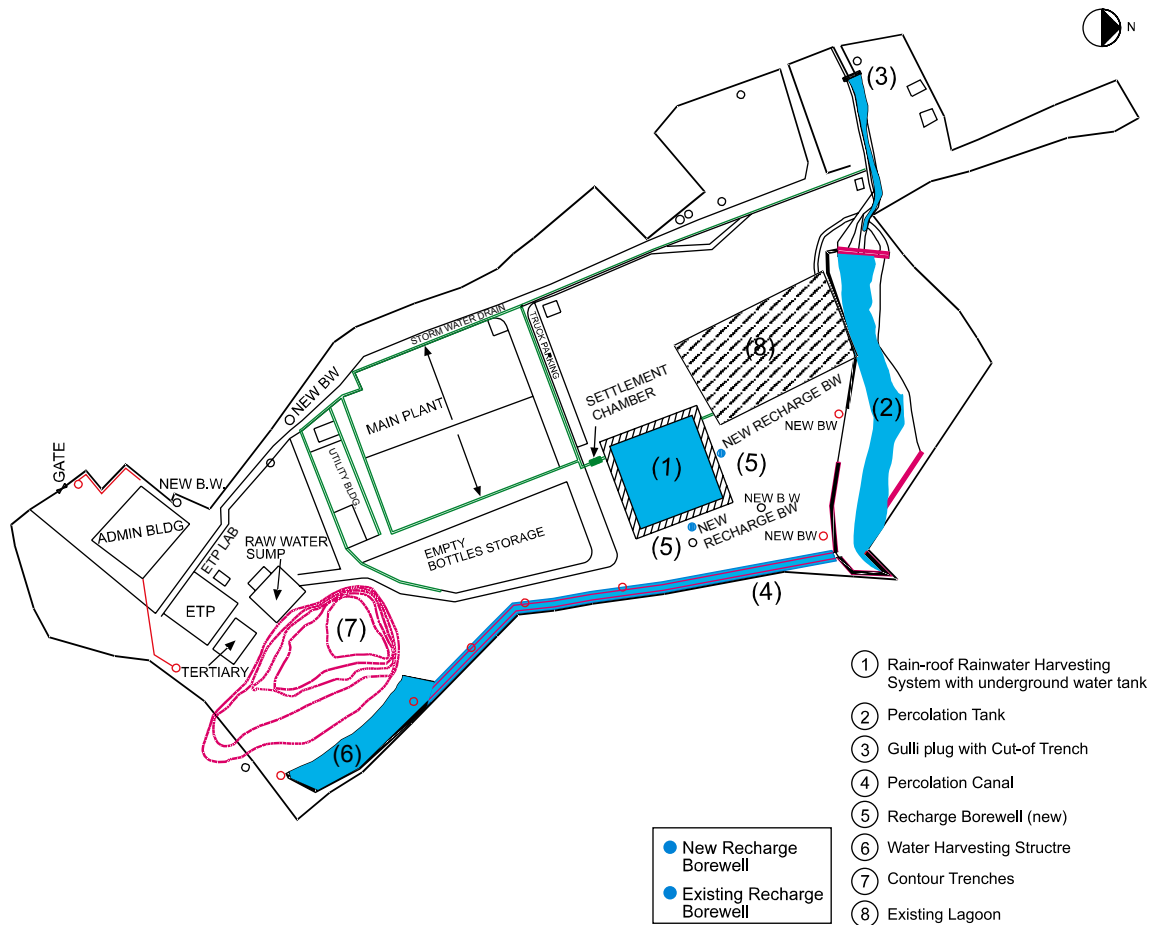
Percolation tank filled with water

Watershed development at The Hindustan Beverages, Kudus, Wada

We have carried out watershed project work of Hindustan Beverages Pvt. Ltd. Wada, Dist. Thane, in Maharashtra. The project area including the factory premises is about 28 ha (70 acres). Hindustan Beverages showed its concern for environment protection. Execution of the watershed project also helped them to fulfil their water requirement partially.



Map 14.1 Watershed planning at Hindustan Coca-Cola



Before introduction of the watershed development project, a substantially large quantity of surface water from the catchment area and from the roof top of the plants was running off without much percolation to the groundwater table.

After careful study of topographical and hydro-geological condition of the area, the following measures were taken to tap maximum possible runoff:

1. Roof-top rainwater harvesting system with underground storage tank – to store the rainwater falling on the roof of the buildings to recharge the aquifer of the borewells,
2. Percolation tank – to store the water flowing out from the stream passing through the premises,
3. Gully plug with cut-off-trench – to trap the understream by filling impervious material in the cut-off-trench and store the water flowing down from percolation tank.



4. Percolation canal – to connect and artificially recharge the borewells so as to increase their yield.
5. Recharge borewells – to recharge the confined aquifer and augment ground water storage.
6. Water harvesting structure – to store runoff water from the small hillock on South-East side of the premises.
7. Contour trenches – to reduce the runoff velocity and increase the moisture level in the plantation area.



Percolation Canal

Around 84,000 cum (840 lakh litres) of water can be expected to be available through recharge and storage within the said premises. This is estimated to meet about 28% of their demand for process water.

Hindustan Beverages, Wada, Thane, has become a model for the neighbouring industries and farmers to introduce similar watershed techniques.

Encouraged by Wada, Thane experience, Hindustan Beverages decided to implement similar projects for their other beverage units in India. Other companies from all over India have offered us jobs to plan watershed projects in the premises of their manufacturing units. We are negotiating with them for taking up these jobs on a commercial basis.



15. Sustained Employment Generation



Watershed development as an activity is, by its very nature, labour-intensive. Jain Watershed was developed out of hilly, sloppy wasteland. This topography added few more dimensions and provided a lot more opportunities for gainful work than would be otherwise possible in many watershed works on plain or semi-hilly areas. Moreover, since the wastelands of Jain Watershed had to be converted into cultivable agro-forestry land, the task had to be conceived and executed over an extended period of time. The character of Jain Watershed, therefore, provided employment opportunities with the following distinctive features:

- i) The employment generated was essentially confined to local population, local talent/skills.
- ii) It covered broad spectrum of people from different disciplines including civil engineering, agronomy, soil sciences, geo-hydrology, agricultural engineering as well as simple menial labour, semi-skilled farm operators, etc.
- iii) The employment generated was not short-term in nature. Instead, it steadily grew and has been sustained for 19 years. The nature of employment generated kept varying. The skill requirements also changed. However, since the watershed area kept on growing, those who were originally hired, contracted even as manual labour continued their roles, though for working on different aspects of farm operations, watershed and agro-forestry development.
- iv) As time passed by, roles changed. Over 70% of the people – both male and female – were imparted training in operating skills and they easily absorbed many trades and became quite versatile. Thus, the working hands were empowered and the exercise for their capacity building continued unabated.

This situation particularly arose because we set up agro-based industries as well as carried out hi-tech agricultural activities such as the following:

(a) Micro Propagation of Plantlets: This activity started through bio-technology method such as tissue-culture. Tissue culture of Banana plantlets grew from a mere 0.45 lac plantlets in the year 1994-95 to 200 lac plantlets in the year 2009. Additionally, commercial production of new crops like pomegranate has also been introduced since 2008. Table 15.1 will make interesting reading about the nature and number

‘The purpose of conservation: The greatest good to the greatest number of people for the longest time.’

– Gifford Pinchot

Year	Permanent	Job Work	Others	Total
1991-92	-	-	-	-
1996-97	5	1	4	10
2002-03	31	6	10	47
2007-08	94	30	-	124
2008-09	90	27	-	117
2009-10	87	25	-	112



of people who got gainfully employed in this activity. More particularly notable, is the number of female employment in this sophisticated activity of micro-propagation. The young girls who had to otherwise either do menial work or sit idle at home, found themselves engrossed in this activity. This number is likely to swell to almost triple in the coming 2-3 years.

Plantlets, once out of the Tissue Culture laboratory, have to be first acclimatised in the primary hardening unit of the greenhouse and subsequently, after change of media, in the secondary hardening unit of shade houses. While in green house the plantlets are in plastic trays, then they are transferred into polybags while being placed in the shade houses. We normally need about 0.4 ha (1 ac) area to shade house 1 lac plantlets. The Tissue Culture laboratory currently produces over 3 crore plantlets per annum. At every stage one needs trained manpower to care for these plantlets as if these were test-tube babies. They therefore need mothers. Obviously, for such careful and consistent handling, female employees are preferred. Table 15.2 gives combined strength of greenhouse and shade house human resource.



Ladies grading tissue culture banana plants in green house

Table 15.2: Summary Data of Manpower: Primary and Secondary Hardening Unit				
Year	Permanent	Job Work	Others	Total
1991-92	-	-	-	-
1996-97	1	5	-	6
2002-03	18	-	-	18
2007-08	25	6	-	31
2008-09	28	8	-	36
2009-10	29	8	-	37

(b) Onion Dehydration for Exports: Onion and Vegetable Dehydration, on the



Associates sorting and grading onions at Dehydration Plant

face of it, appears to be a run-of-the-mill processing activity. However, when one is dehydrating onions/vegetables for export to highly advanced countries such as USA, UK, France, Germany, Australia, New Zealand, etc, the activity poses serious challenges which unskilled rural people find difficult to cope with. Their attitudes and



operative skills need to be continuously honed. Behavioural changes in keeping with the high level of hygiene and sanitary requirements are not easy to imbibe or inculcate. (Over 90% of the total strength of workers comes from the adjoining rural areas, whether on regular payroll or contract/casual basis.) Table 15.3 gives a summary of the manpower employed for the dehydration activity.

Table 15.3: Summary Data of Manpower: Onion Dehydration				
Year	Permanent	Job Work	Others	Total
1991-92	-	-	-	-
1996-97	30	119	12	161
2002-03	222	96	15	333
2007-08	394	24	-	418
2008-09	355	24	-	379
2009-10	400	24	-	424

(c) Fruit Processing: Fruit processing for export is also an equally challenging and difficult task. GMP, HACCP, and Kosher certification is a pre-condition for export to advanced countries. Likewise, ISO accreditation is also a must. These cannot be achieved without creating, practising and perpetuating very high standards of personal, plant and environmental hygiene. Most of the fruits processed are packed aseptically. We don't need great many people for that part of the activity. However, unloading, grading, sorting, cleaning, inspecting of fruits do need very specialized and skilled personnel. These are mostly provided by way of contract labour by specialized agencies from outside the State. Table 15.4 gives an idea of the extent and type of people and skills that are employed for the above activity.



Banana peeling banana for puree making in Fruit Processing Plant

Table 15.4 :Summary Data of Manpower: Fruit Processing					
Year	Permanent	Job Work	Saldars	Others	Total
1991-92	-	-	-	-	-
1996-97	8	352	-	20	380
2002-03	156	370	-	25	551
2007-08	296	47	-	-	343
2008-09	283	41	-	-	324
2009-10	293	44	-	-	337

(d) Principal Agricultural Activities: As far as employment in agriculture is concerned, it will include the following principal activities which can be categorized into 3 classes: (1) Agro-forestry (2) Open Field Agriculture and (3) Horticulture.





Onion seed production



Ladies planting tissue culture banana plantlets

All these three classes presuppose most of the following steps: Soil bed preparation, sowing, planting, inter-culture, crop protection, irrigation, fertigation, and harvesting. Such employment is normally seasonal in nature. However, in the case of Jain Watershed area, these activities go on round the year. It is so because, we go for intercropping as well as multi-cropping, and many times also engage in research activities which call for a different set of operations in addition to the traditional ones listed above. Table 15.5 gives the data on manpower engaged in this activity.

Table 15.5 :Summary Data of Manpower: Agriculture				
Year	Permanent	Job Work	Others	Total
1991-92	4	62	6	72
1996-97	7	34	21	62
2002-03	82	77	68	227
2007-08	115	54	35	204
2008-09	114	53	60	227
2009-10	116	56	78	250

(e) Ancillary Agricultural Activities: Agriculture would also presuppose the following ancillary activities: (1) Live stock rearing (2) Organic Farming and (3) Seed Processing. All these activities are part of Jain Watershed development.

(1) Livestock Rearing : I believe that modern agriculture need not mean or suggest adoption of only mechanization or sophistication. It is true that if it is to be modern farming, it will have a place for adoption of technology, and employment of gadgets, implements, tools and machinery. However, the cows, buffalos and bullocks can well co-exist and



D. R. Mehta Gomata Ashram





Towards life sustaining source : Water

contribute very significantly. Indeed, if we choose to opt for organic farming, they become all the more relevant and imperative. In the Jain Watershed area, for our agricultural operations, we provide employment to look after both these categories i.e. machinery as well as livestock. Today we have, in the Jain Watershed area, livestock numbering in all 271 (Cows, bullocks and buffalos). Combination of tractors, implements, threshers, grass-cutters, sprayers and computer controlled irrigation equipment on one hand and livestock on the other, provide employment to skilled drivers, operators and engineers for machinery as well as the unskilled 'saldars' for the livestock. Table 15.6 gives the number of persons involved in this activity.

Table 15.6 :Summary Data of Manpower: Gomata Ashram				
Year	Permanent	Job Work	Others	Total
1991-92	-	-	-	-
1996-97	-	-	-	-
2002-03	1	-	-	1
2007-08	2	1	10	13
2008-09	2	1	11	14
2009-10	2	2	9	13

(2) Organic Farming : Preparation of organic manure including vermicompost and pot-mixture for shade houses and plant nurseries as well as for agro-forestry is another ancillary activity undertaken in the Jain Watershed. We prepare organic manure / compost by mixing various agricultural wastes as well as other organic compounds as detailed in Chapter 5. The



Organic manure preparation



farmyard manure from the cattle-shed is used as one of the important components for organic manure as well as pot mixtures and tissue culture media to be used in the Green and Shade Houses.

We have installed a biogas plant to generate biogas which is used in Jain Gurukul for cooking – an energy efficient eco-friendly way of life.

(3) Seed Processing : Onion Seed Cultivation, R&D and Seed Processing is yet another hi-tech activity going on in the Jain Watershed. Since we are dehydrating onions in our onion/vegetable dehydration plant, onion seed cultivation, R&D and processing have become a major ancillary activity providing employment opportunities to many people (Ref. Table 15.7). It is more so for technically qualified graduates, postgraduates and doctorates (Ref. Table 15.10).

Year	Permanent	Job Work	Others	Total
1991-92	-	-	-	-
1996-97	-	-	-	-
2002-03	17	-	2	19
2007-08	17	-	-	17
2008-09	17	-	-	17
2009-10				

(4) Energy Park : In the Energy Park, activities related to green energy i.e. non-conventional sources of energy are undertaken. It includes, biogas, solar photovoltaic, solar water heater, wind energy etc. Manpower allocated for these activities are tabulated in Table 15.8

Year	Permanent	Job Work	Others	Total
2008-09	133	55	-	188
2009-10	199	64	3	266

Employment Profile

The Table 15.9 and Table 15.10 give character and profile of employment generated in Jain Watershed area for agriculture, ancillary and Agri-processing activities.

In the year 1989, I began this mission with only these handful of crusaders:

Civil Engineering staff - 2, Agricultural graduates - 2, Fitters -3, Contract labourers - 5. Total 32 noble Souls. As against this, today in 2010, the number of gainfully engaged associates is 2120.

The land which did not produce enough to sustain about 32 families in the beginning (1989) is today able to provide a decent living and gainful employment to over 2100 associates on whom their respective families depend.

‘Water, like religion and ideology, has the power to move millions of people.’

– Mikhail

Gorbachev,

President of Green

Cross International



Function	Permanent	Job Work	Others	Total
Tissue Culture	87	25	-	112
Primary/Secondary Hardening	29	8	-	37
Onion Dehydration	400	24	-	424
Fruit Processing	293	44	-	337
Agriculture	116	56	78	250
Gomata Ashram	2	2	9	13
Onion Seed Proceeding	17	-	-	17
Admn. and Support Services, JH	242	80	-	322
Admn. and Support Services, JV	249	129	3	381
Jain R&D Farm	74	6	-	80
Contract Farming	44	7	-	51
Energy Park	199	64	3	266
Total	1752	445	93	2290

Function	Doctorate	Postgraduates	Graduates	Diplomas	Others	Total
Tissue Culture	1	12	1	2	96	112
Green/Shade Houses	1	2	3	2	29	37
Onion Dehydration	-	19	44	23	331	417
Fruit Processing	-	21	56	15	228	320
Agriculture	2	9	7	27	184	229
Goshala	1	-	-	2	10	13
Onion Seed Processing	1	4	1	2	09	17
Admn. and Support Services, JH	4	19	49	31	219	322
Admn. and Support services, JV	1	44	66	18	275	404
Jain R&D Farm	5	26	19	3	27	80
Contract Farming	-	1	2	48	-	51
Energy Park	1	41	69	36	201	348
Total	17	198	317	209	1609	2350

It is the same piece of land. What has changed is the character of the land. What has made it happen is nothing but water. It is therefore, as mentioned earlier, ‘Water is life’s matter and matrix, mother and medium’. But for the watershed development, these barren hills and wastelands would still be waiting like a bride with a garland



in her hands for the bridegroom to come on the stage. The bride (the barren hills) would probably have been waiting in that posture for the past over 8000 years or more. Finally the bridegroom came in 1989 and the marriage was solemnised. A new world came into being. The environment and development were happily wed. The Jain Hills created by the Jain Watershed is the outcome of this marriage.





The 'Pola' celebrations : Homage to bullock-power

16. Changing & Changed Landscape ...



Jain Watershed - 1990



Jain Watershed - 1993



Jain Watershed - 1995





Jain Watershed - 1998

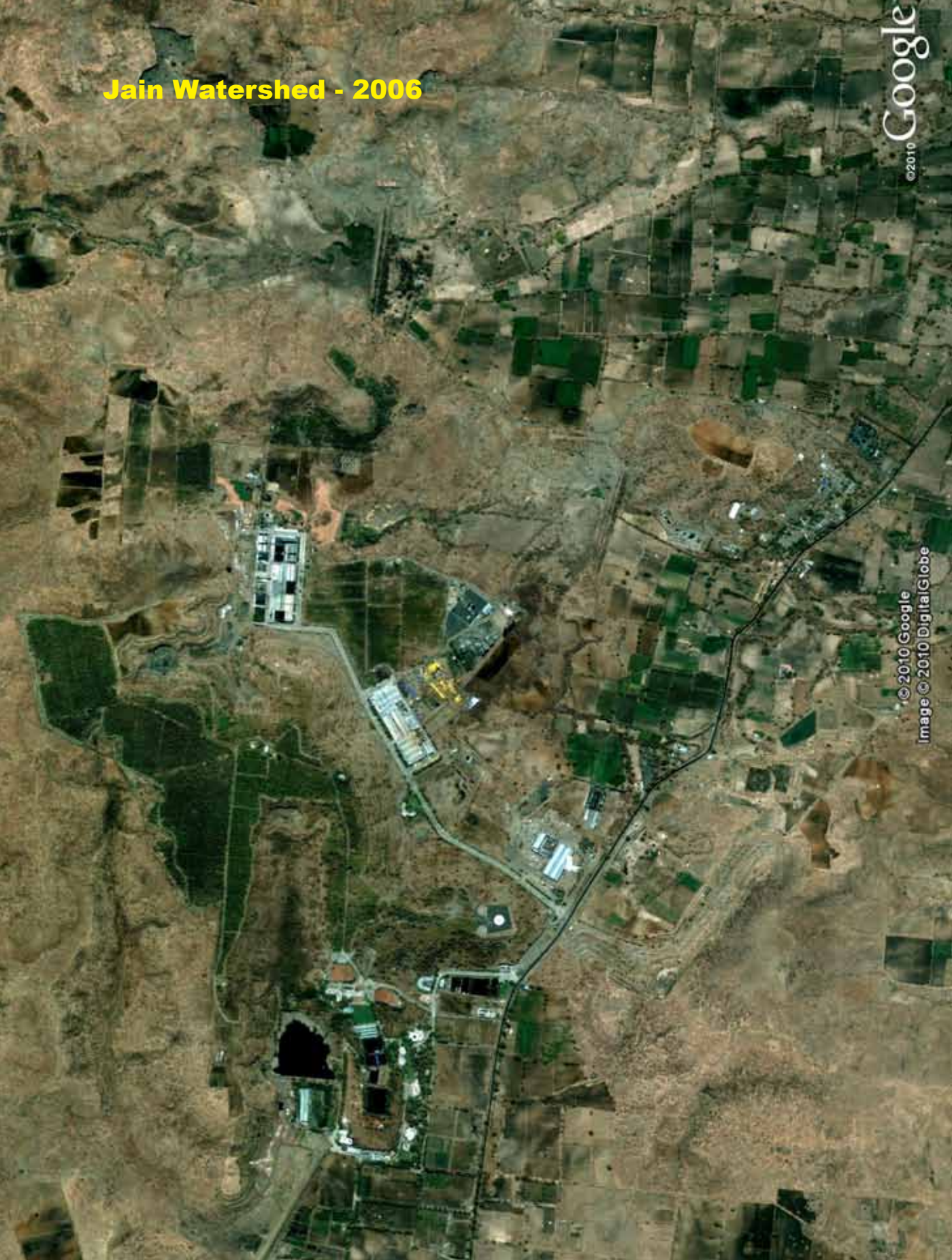


Jain Watershed - 2010

***A promise fulfilled ! A pledge redeemed !!
.... Thanks to Watershed Development !!!***



Jain Watershed - 2006



Jain Watershed - 2007

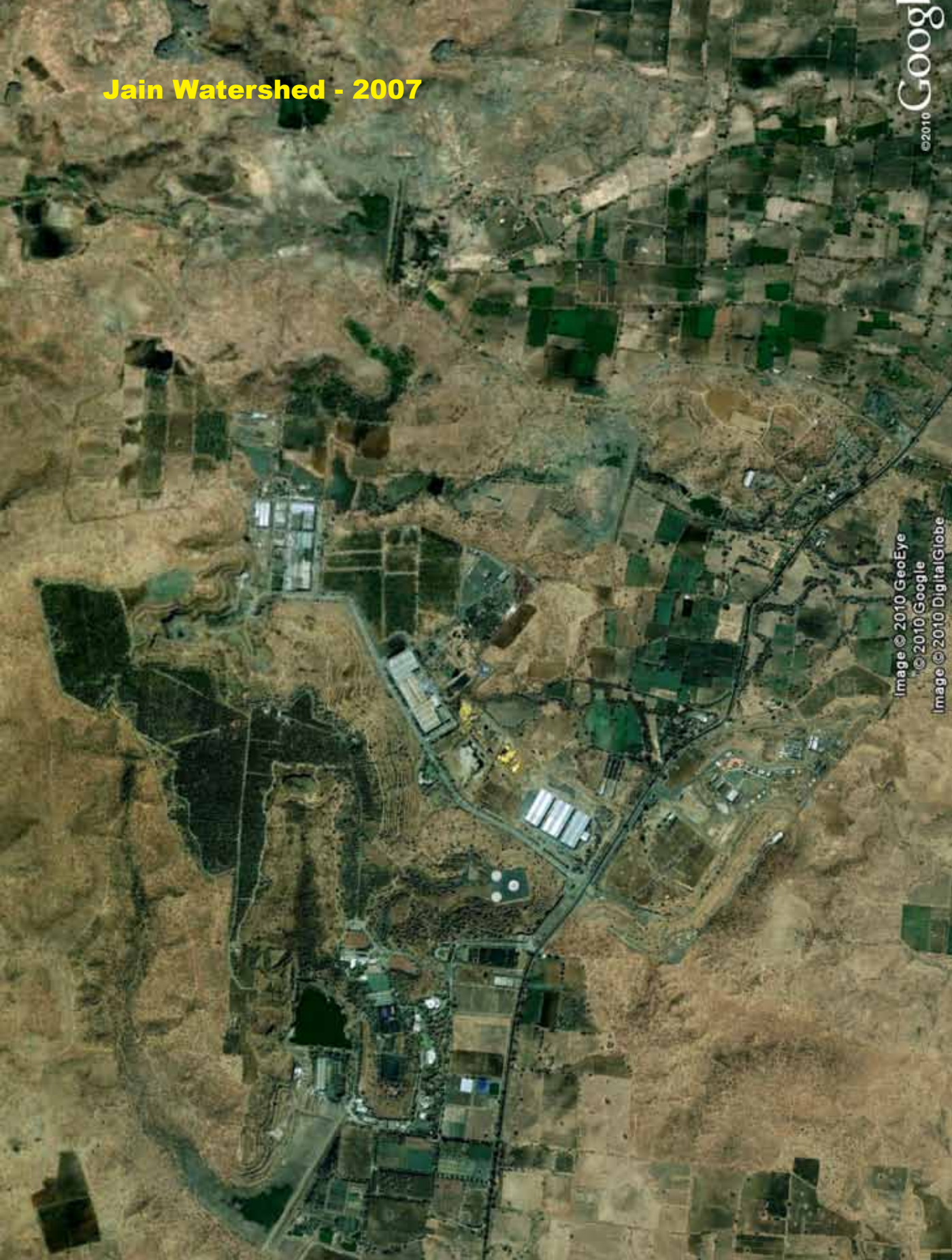


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Jain Watershed - 2010

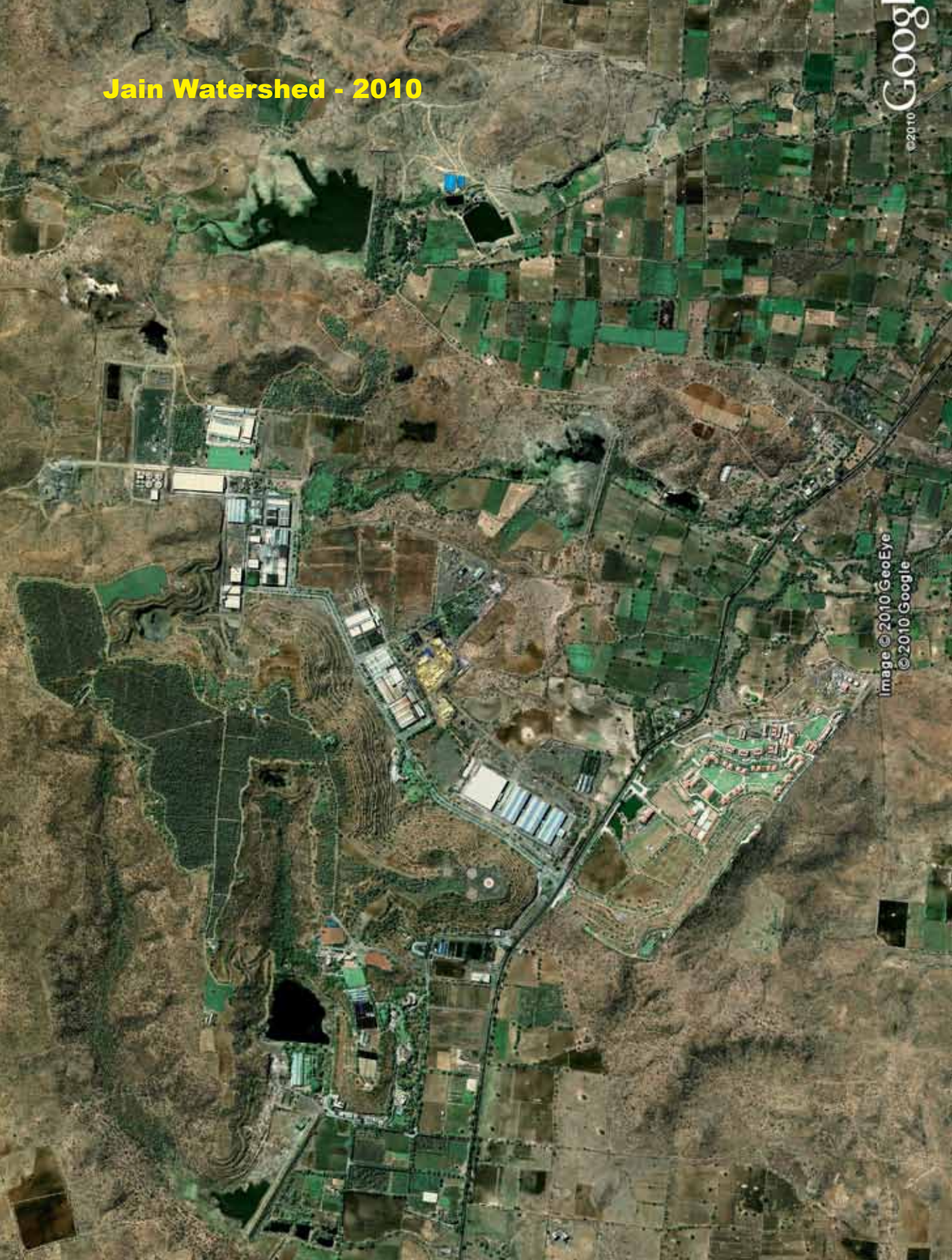
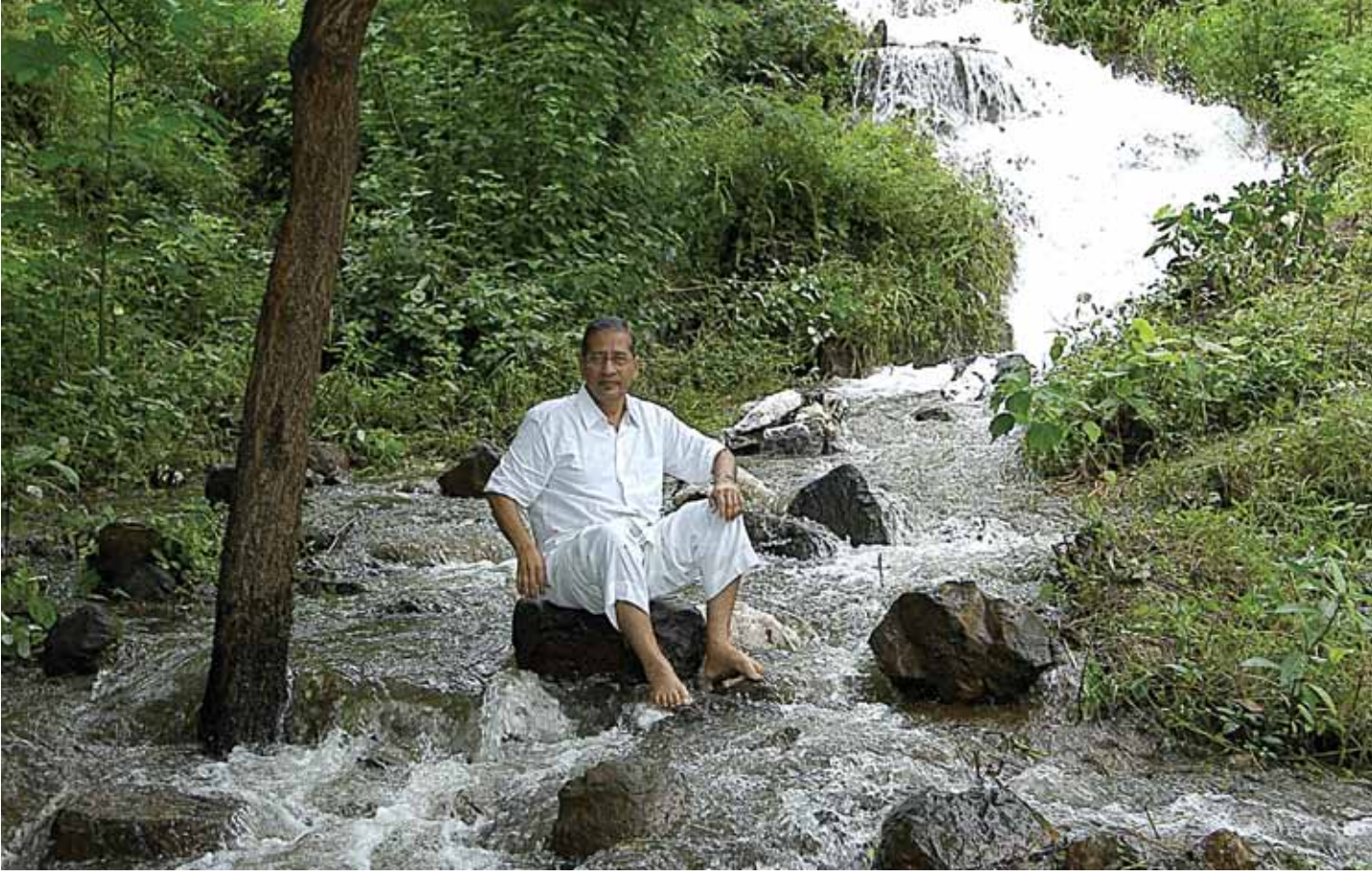


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॥ भवरजी, तुम्ही निर्मिले पाणी ॥

मूर्त जाहली इथे विराणी
आज ही स्वप्नातली कहाणी
भगीरथाचा पुत्र होउनि
तुम्ही निर्मिले पाणी ॥

उजाड डोंगर, खडकमाळ हा
जेव्हा पाहिला तुम्ही
हुरहुरले काळीज कराया
नंदनवन या स्थानी
स्वहस्ते वेचूनि दगड ते
अर्घ्य दिले घामानी
तुम्ही आणिले पाणी ॥

वृक्षांच्या रोमांचे हिरव्या
सजले डोंगर इथले
आम्र,सिताफळ, पोरुंनी
हा आसमंत डोले
ठायी ठायी वन दाट जाहले
मोर नाचती हर्षे
आनंदाने पक्षी गाती,
सुस्वर जीवनगाणी
कारण तुम्ही राखले पाणी ॥

तळ्या तळ्यांच्या बिलोरी आयनी
रुप पाही घनराई
अगा नवल हे कसे घडले?
चकित होती पशु गाई
मेघ थबकुनि जाती बरसुनि
मानवंदना देवोनि
तुम्ही अडविले पाणी ॥

बळीराजाच्या उध्दारास्तव
पाझर तुमच्या मनी
इथे सर्व साम्राज्य उभविले
कृषिस्तव ध्येयासाठी
रात्रदिन तो ध्यास जीवाला
त्यातून ही अमर कहाणी
तुम्ही निर्मिले पाणी ॥

सोन्याचे हे हात तुमचे
सोने केले दगड मातीचेही
पुरुषार्थाची गाथा आणि
कथा उज्ज्वल ध्येयाची
दृष्टी जोखते भविष्याला
वर्तमान तेजस्वी घडविला
या मातीच्या कणाकणावर
पत्थर आणि या काळावर
कर्तृत्वाची तुम्ही कोरली,
अमिट, मनोहर लेणी
तुम्ही जपूनि पाणी ॥

नकोत आत्ता ताज आम्हाला
नको नवी मंदिरे
हवीत अशी राष्ट्रासाठी
आधुनिक तीर्थक्षेत्रे
जैन हिल, व्हॅली, गुरुकुले
तुम्ही उभविली जनहिते
पाणी पाणी करणा-यांना
दिलेत पाऊस पाणी
भवरजी, तुम्ही निर्मिले पाणी ॥



A Telling Tale

- Bhavarlal H. Jain

