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CIPT
Centers for International Projects Trust

CIPT Sandesh

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In this issue...

Editorial

Dear Friends,

We are happy to present the second issue of Centers for International Projects Trust (CIPT) newsletter – CIPT Sandesh. We are encouraged by the suggestions and feedback received on our inaugural issue. CIPT will continue to highlight best practices concerning water, environment, energy and livelihood sustainability to build up a strong knowledge base and contribute to a meaningful discourse amongst relevant stakeholders.

A new government has taken charge in New Delhi amidst a lot of expectations, riding on a decisive mandate. It is heartening to note that the Central Government has indicated water resource management as an important area of the policy making agenda. We hope that the collective experience of all water practitioners, academicians, technocrats, bureaucrats and citizens will come handy in developing a roadmap in addressing major concerns facing the water sector.

The release of the second issue of CIPT Sandesh comes at a time when India is grappling with the crisis of a scarce monsoon.The present scenario calls for making agriculture in India drought resistant. There is also a need to employ methods to increase water use efficiency in agriculture to realise the objective of more crop per drop. Working with our partners, CIPT has undertaken the development and pilot testing of various low cost innovations which have reduced the usage of water for the production of cereals – rice and wheat.

The current issue of CIPT Sandesh provides a snapshot of our work. It outlines measures for scaling up groundwater sustainability strategies based on our work in Punjab, being carried out in close collaboration with the Punjab Agricultural University. We strongly believe in promoting the use of information technology for disseminating information to farmers. It is with this idea that CIPT, in collaboration with Punjab Agricultural University has developed a web based decision support system providing information to farmers on cultivation of major crops in Punjab. In addition, we have created an android based mobile application for nitrogenous fertiliser application. We have also enumerated some of the measures we want the new government to undertake for planning and management of water resources in India.

We hope that you find the content of this newsletter useful and look forward to hear from you.

Kamal Vatta and Romit Sen
Editorial Team

Food production and natural resource sustainability in Punjab: some thoughts

Suresh Kumar, Financial Commissioner Development, Government of Punjab

Food security has always been one of the most important concerns for the developing world. Ever rising population and limited contours of cultivable land along with limited knowledge and resource base of the small holders have made the accomplishments of national food security always difficult.

India marched towards attaining the goal of food security by successfully reaping the benefits of green revolution. However, the success of green revolution remained confined only to Punjab, Haryana and Western Uttar Pradesh (lying in Indo-Gangetic Plains) and also in the crops of paddy, wheat and sugarcane. The success of green revolution in these regions brought a significant reduction in human poverty.

Intensive agricultural production systems in Punjab have led to the emergence of many issues of productivity, profitability and natural resource depletion. The irrigation water demands for such a system have far exceeded the sustainable levels of supply resulting into alarming rates of fall in the groundwater table. Against the sustainable supply of 3.04 million ha meter, the current demand has touched 4.45 million ha meter. While almost 80 per cent of the blocks in Punjab are over-exploited in terms of groundwater (where water drawn exceeds the recharge), the situation is more critical in central Punjab where the figure is about 90 per cent.

As a result, the water table is falling at alarmingly high rates. Climate change has further aggravated the situation with reduced availability of surface water which meets nearly one-fourth of the total irrigation water requirement of Punjab.

Continuous increase in the area under paddy and fall in water table have also contributed to a significant increase in the power consumption in agriculture in Punjab. The power consumption in agriculture has exceeded 11 billion units during 2010-11. As power supply to agriculture is free, it has inflated the state power subsidy bill to extremely high levels of about Rs. 60 billion in the last year.

The intensive agriculture has also resulted into increasing incidences of nutrient deficiency in the soils of Punjab. There has been an overuse of nitrogenous fertilizers by the farmers. In the recent past, the micro-nutrient deficiency has increased, which may be an important reason in the stagnation in yield enhancement. About 20 per cent of the tested soil samples have shown zinc deficiency, 18 per cent have shown manganese deficiency and 12 per cent have shown iron deficiency.

Decline in crop diversity has also emerged as an important issue in Punjab agriculture. Almost 80 per cent of the gross cropped area is under wheat and rice crops. Declining crop diversity has caused nutrition inadequacy and it is also hindering the prospects of value addition and the overall objective of faster increase in the farm incomes.

Burning of paddy straw is another important issue in Punjab agriculture. Almost 20 million tonnes of paddy straw is produced in Punjab (annually) and almost 85 per cent of this is burnt in the fields. As a result, almost 80 per cent of carbon, nitrogen and sulphur from paddy straw get lost into the air. Other nutrients are also lost partially into the air. It causes significant pollution of the air and may contribute to acid rain in the days to come.

There has been stagnation in food production and productivity in the recent decade. Punjab, which always led the growth story in agriculture in India, has been able to reach just half the levels of national growth rates of food production and productivity in the last decade. It has serious implications for food security of the nation.

Do the earlier relations between food production and natural resource degradation point towards very strong trade-offs? The answer may be no. There have been many synergies between the food production and natural resource sustainability. The evidences have been many and well documented, though they are scattered. However, intensive agriculture resulting in food security has definitely caused some imbalance and disturbance in the existing bio-systems. This has given rise to persistent demand for sustainable agriculture, which is more natural and based on use of bio-energy and bio-fertilizers. It also emphasises more judicious use of chemical inputs, if these cannot be totally eliminated.

Some important measures to address the issues of natural resource sustainability being pursued in Punjab include: a) Crop diversification; b) Resource conservation technologies and practices; c) Strengthening/building of value chains in agriculture; d) Promotion of agro-processing; e) Institutional and organizational innovations for promoting resource conservation and enhancing productivity; f) Promoting climate resilient agriculture; and g)Promoting precision-agriculture.

Punjab can sustain only 1.6 million ha of paddy with the traditional cultivation practices. Crop diversification will not only check the groundwater depletion but can also add to the farm incomes.

Resource conservation technologies and practices such as laser land levelling, direct seeding of rice, use of tensiometers, etc. can bring significant reduction in water use in agriculture without any adverse impact on crop productivity. The challenge is to device strong strategies for capacity building of the farmers and other stakeholders in promoting such technologies.

The development of business viable and more efficient value chains for alternative crops in Punjab such as fruits and vegetables, which can ensure better margins to all the stakeholders in the value chains including the farmers, can go a long way in realizing the overall objective of crop diversification. In addition to the value chains, promoting agro-processing will also help in crop diversification and enhancing farm incomes.

Finally, for promoting climate resilient agriculture, precision agriculture and to promote more efficient agricultural practices, including intelligent irrigation systems, we need innovations in

institutional mechanisms, organizations and strategies to reach large number of smallholders in agriculture. For that, we will have to focus on the following areas:

1. Identifying/documenting specific capacity building needs (training needs) of the farmers and other stakeholders to make the desired changes in agriculture policy, planning and implementation;
2. Re-orienting the R&D efforts with a special focus on resource conservation. We have to shift from increasing production per unit of land to increasing production per unit of natural resources;
3. Involving farmers' cooperatives and producer groups in the capacity building and devising scale up strategies. It will reduce the cost of outreach and will speed up the adoptions;
4. Developing innovative decision support systems to promote resource conservation and make more efficient farm production decisions. These may include the use of ICT in agriculture and developing more innovative methods to use the traditional forms of multimedia;
5. Formulation and adoption of policies, programmes and regulations in such a manner that sustainability of agriculture is improved and maintained without compromising on livelihood of farmers achieved by them with rigorous efforts over the years;
6. Introduction and adoption of Intelligent Water Management Systems.
7. Pursuing effective post harvest management of crops; and
8. Development of proper and effective market support systems and linkages.

Setting the 'BLUE' agenda: priorities for the new government

Romit Sen and Nikunj Parekh

India successfully completed the biggest exercise of electing its new government recently. Spanning across nine-phases in a month-and -a-half long schedule, an unprecedented 66.38 per cent of the total 814.5 million electorate cast their vote to choose their representatives for the 16th Lok Sabha – the lower house of Indian Parliament.

Water has always been a sensitive political issue; with political parties sounding concerns to meet the needs of potable and irrigation water in particular. Political parties in their manifesto for the 2014 general elections listed out several measures they will undertake in the areas of water management and governance. Some of these include the launch of an on-farm conservation of water programme; interlinking of rivers based on location specific needs; promote rainwater harvesting for recharging groundwater; cleaning of rivers- mainly the Ganges; developing inland water transport corridors; augmenting treatment capacities for municipal and industrial wastewater; and provision of drinking water facilities to all.

A new government took charge in New Delhi amidst forecast of below normal monsoon in the current season. A weak monsoon can spell trouble for the new government by adversely affecting the agricultural production and hence a slowdown of the economy. As the new government sets its agenda for governance, there are certain items which need to be in the priority list in respect of water resource management. Some of these include:

1. Comprehensive assessment of water resources: The last time a comprehensive assessment of water resources for the entire country was done was in 1999-2000 when the National Commission on Integrated Water Resources Development (NCIWRD) and Sub-Standing Committee of Ministry of Water Resources brought out figures on water availability, use and future demand across various sectors. Thereafter, it has been a period of 14-15 years since an all India assessment has been undertaken. The planning of water resources needs to be based on updated data and it is high time that the Central Government undertakes a complete assessment on water availability, use and future demand for the country.

2. Groundwater management: Groundwater is the major source of irrigation and drinking water in India. Groundwater depletion has become a serious problem with aquifers across the county moving into over-exploited zone. It is time that the Central Government revises the Model Ground Water Act of 2010 to address the fundamental problem of limiting groundwater extraction. Groundwater management has to be implemented through a mix of regulatory interventions (such as water rights or permits) and economic tools (such as abstraction tariffs and tradable water rights). The implementation of the interventions has to be done by a high level of user participation. This will require strengthening mechanisms to regulate over-withdrawal and encourage management of groundwater through decentralized bodies like the gram sabhas.

3. Water pricing: Water has an economic value in all its uses and thus should be recognized as an economic good and therefore suitable pricing mechanisms need to be developed. Pricing for water has always been a politically sensitive issue but it is high time that we recognize the need to bring financial stability to water utilities. An important prerequisite would be to set standards for water pricing according to ability to pay. This should be done in a way which does not reduce a person's ability to buy other essential goods and services (in case of domestic water use) or retard the growth of business or incur operational losses (in case of industrial use). Within this framework, it is essential to develop systems for designing, monitoring and controlling charges by water utilities to various institutions. Water pricing should be looked upon as a means of increasing the financial stability of water projects.

4. Water footprint: Estimation of water use is an absolute essential precursor to regulate and manage water use across various sectors. There needs to be compulsory measures for estimation of water use and calculating of the water footprint for all water using sectors and utilities. This can be done by identifying water intensive sectors (and units) and evolving a mechanism for reporting their water consumption patterns. Measures for budgeting the use of water and audit will help improve efficiency and encourage demand management.

5. Improving water use efficiency: Improving water use efficiency is the need of the hour and is crucial for reducing the dependence on freshwater sources. Agriculture accounts for more than 85 per cent of the total water use and therefore resource optimization in this sector is vital. Water use efficiency in agriculture can be brought about by low cost technologies which are not resource intensive and at the same time have the potential to save a lot of freshwater use. It is also important to undertake measures for brining efficiency in the urban and industrials sector. The initiative of setting up a Bureau of Water Use Efficiency (BWUE) is an innovative step as part of the National Water Mission. The Ministry of Water Resources (MoWR) has been working for the past three years to set up a National Bureau of Water Use Efficiency (NBWUE) under the Societies Registration Act and the new government must realize its setting up.

6. Municipal wastewater management: India is facing two important problems of lack of infrastructure and an ever-increasing urban population. The urban population in India has jumped from 25.8 million in 1901 to about 387 million in 2011.This has thrown up two problems, viz. shortage of water and sewage overload. Moreover, public services have not been able to keep pace with rapid urbanization. Water supply, sanitation measures and management of sewage and solid waste cover only a fraction of the total urban population. There is clear inequity and disparity between the public services received by the inhabitants, depending on their economic strata. The Central Government should undertake research based findings and start implementing measures for treatment of wastewater for each municipal corporations involving preservation of water resources, reutilization of treated sewage wastewater for irrigation and industrial use and regular integrated water-energy based audits of each municipal corporations.

7. Managing industrial water risks: Indian corporations, their investors and policy makers have significant responsibility to treat water with the strategic importance it deserves. The demands of rapidly industrializing economy and urbanizing society come at a time when the potential for augmenting supply is limited, water tables are falling and water quality is deteriorating. In order to achieve sustainable water development for industries, regular water audits for industrial users and water footprint for each company should be mentioned in annual reports. For water intensive industries such as paper and pulp, textiles, food, leather, chemical/pharmaceutical, oil and gas and mining the water audits should consider both quantity and quality of water. The Central Government should work towards developing a water disclosure framework within the ambit of the current reporting mechanisms for industries. There is also a case to enhance the water cess. Currently, the Water (Prevention and Control of Pollution) Cess Act of 1977 is the only instrument to impose a fee for wastewater discharge from industrial units. There is a strong need for revisions in the Act and provision should be made for re-examination of water charges and incentives for water conservation. This will help in improving the financial health of the State Pollution Control Boards and enhance their delivery.

8. Incentives and penalty: There is a need to develop methods to incentivize conservation and penalize wastage. Incentives can be provided to communities, utilities, states and industry associations that have gone in for water harvesting and conservation measures. Incentives can be in form of priority and speedy implementation of development works and schemes, relief in taxes amongst others. The principle of penalty is to prevent wastage of the resource. It may consist of charging one price per unit for the use of small amounts of water and raising the price per unit for the use of larger amounts of water. Penalties can be levied on panchayats, urban local bodies, Resident Welfare Associations, industrial units for polluting water resources and generating wastage.

9. Increased storage and basin-transfer: Water storage should be enhanced considering the social, environmental and economic concerns. The same should be applied for devising mechanisms for inter-basin transfer of water from surplus to deficit regions. A well-developed decision support system using latest technological improvements needs to be developed for better planning of water resources, its allocation amongst various users and forecasting in times of stress. It is equally important that the Central Government introduces procedures for addressing disputes among states concerning inter-state rivers through a single tribunal by modifying the Inter-State Water Dispute Act and set appropriate time frames for the redressal of complaints by the states.

10. Research and development: The Central Government should undertake basin-wise research on water related issues through joint efforts of ministries dealing with water resources like Ministry of Water Resources (MoWR), Ministry of Rural Development (MoRD), Ministry of Urban Development (MoUD), Ministry of Environment and Forests (MoEF) and Planning Commission. The data and research be made available in public domain for further studies. The states should be asked to undertake the development and dissemination of research on water related issues through joint efforts of various departments dealing with water resources and the state planning board. There lies the potential for engaging with educational institutes across states for research activities and increasing the knowledge base. The improvements in the water sector would require professionals with different skills, expertise and a revamp of the old departments. A plan for capacity building of staff across departments and institutions would have to be taken up.

Initiatives at the level of the Central Government across the past few years have indicated some forward looking measures to address challenges relating to the water sector. The Prime Minister has outlined water resources as an area of priority for the new government. The government has a tough task cut out in balancing the competing water needs across states, sectors and users. People will look up to the government to fulfil the expectations pertaining to one of the most fundamental resource – Water!

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Sustainability of groundwater resources in Punjab: scaling up strategies

R.S. Sidhu and Kamal Vatta

Introduction

Natural resources play an important role in agricultural production and productivity comprising essential ingredients of the production process by transforming inputs into outputs. Water is critical for any biological process and has rainfall, surface water and groundwater as its three important components. Agriculture in any region draws water for production through diverse combinations of these three sources. There has been a consistent decline in rainfall in Punjab during the past and the availability of surface water has also fallen considerably. Groundwater is a finite source and cannot be considered completely renewable. The sustainability of groundwater resource depends heavily on pattern and extent of its use and recharge. It is therefore extremely important to encourage the efficient use and conservation of natural resources and aim for their long-term sustainability.

Punjab is an agrarian state which accounts for 18 per cent wheat, 10 per cent rice and 7 per cent cotton production of the country. Agriculture sector is an important driver of growth for its economy, especially in the rural areas. The sector contributes about 28 per cent to the gross state domestic product and employs more than 30 per cent of the workforce. Agricultural growth in the state was largely steered by the assured availability of water resources. The area under assured irrigation increased from 54 per cent in 1960-61 to 98 per cent at present. About 76 per cent of the area is irrigated by groundwater which shows its significance in the state's agricultural production. The over-dependence on groundwater resource has led to its over-exploitation.

While the fall in groundwater table in Punjab was about 23 cm/year during 1980s, it was alarmingly high at 70-80 cm/year during 1995-2005. Almost 80 per cent of the blocks in Punjab are categorised as over-exploited.Frequent deepening of tubewells and later shifting to submersible pumps have resulted in indebtedness of the farmers. The state's power subsidy bill has risen to Rs. 35 billion in 2010-11. In nutshell, the conservation of groundwater resources is essential to ensure the long-term sustainability of agricultural production system of the state.

Options for conservation

The options to conserve the groundwater resources can be broadly classified into policy options and technological options. The important components of policy options are as follows:

- Pricing of electricity for the agricultural sector,
- Pricing of water for irrigation,
- Promoting crop diversification through output pricing mechanisms,and
- Water allocation and water rights.

The promotion of water saving technologies and practices can bring about significant reduction in agricultural water use in Punjab. Some important technological options are indicated below:

- Irrigation scheduling on scientific basis (through soil moisture sensors, tensiometers and panipipe),
- Mulching,
- Drip and sprinkler irrigation,
- Laser land leveling, and
- Direct seeding of rice.

While some of the technological options such as laser land levelling have been widely adopted by farmers in Punjab, the others, though not used at a wider scale have significant water conservation potential. Hence, it is important to device strategies for faster and wider upscaling of these technologies and practices to ensure long-term water-energy-food sustainability in Punjab agriculture.

Factors affecting scale up

Despite water saving potential of various technologies, their upscaling is complex and not uniform. Three important factors affecting the pattern and extent of adoption of these technologies are outlined below:

Economic advantage: This is the most important factor. The farmer, as an individual, compares the monetary benefits associated with the technologies in comparison to its cost. The risk associated with the technological adoption is also taken into consideration. Groundwater being free, owing to the provision of free power for agriculture, its saving does not lead to any reduction in the variable cost and hence does not add to the monetary benefits. There may be some reduction in the fixed costs in the long run, which are usually ignored by the farmers. Hence the technology, without any significant yield advantage over the traditional methods of cultivation, will usually have lesser probability of adoption and its scale up in the long run. Faster adoption of laser land levelling due to its yield advantage can be easily explained on this premise. The policy options of introducing unit pricing for power and water in agriculture can have a positive impact on the large scale adoption of such technologies.

Operational issues: While some technologies (laser land levelling) might be very easy to use, others such as drip/sprinkler irrigation, tensiometers and direct seeding of rice may be relatively more difficult to practice. These may require specialized knowledge and skill building which is important to boost the adoption process. A renewed focus on the extension activities to develop the specialized training modules for these technologies may lead to faster adoption in the long run.

Other factors: The technologies must also fit in the cultural ethos, values and practices of the intended users. The conflict may seriously affect the adoption. The strategies based on the strengths and weaknesses of the socio-cultural system of the society may yield better results. Apart from these, there are age, education and other socio-economic factors which have a significant influence on adoption and need to be properly understood for successful implementation of the scale-up strategies for natural resource conservation.

The way forward

For a faster scale up of water saving technologies and practices in Punjab, a comprehensive strategy has to be chalked out. Till now, the research and extension system in Punjab has largely focused on enhancing productivity per unit of land. Turning towards enhancing productivity per unit of water is a challenge, which is more so when the use of water and power in agriculture incurs no costs. In such a situation, it becomes important that the emphasis lies on introducing low-cost technologies which can be easily adopted by even the smallholders.

The costs can be lowered even by providing subsidies or promoting these technologies through farmer cooperatives or producer organizations. The water conservation technologies must be easy to operate. The complexities must be reduced with continuos research efforts for simplification. It must be followed by a strong capacity building mechanism, which introduces these technologies to the end-users and promotes their adoption at a larger scale.

While the farmers are unable to factor in the long-term benefits of these technologies in their decision making, there must be efforts for generating awareness about the long-term issues associated with sub-optimal use of water in agriculture and its adverse impacts. This is possible through field demonstrations, use of media and social networks. There is need to highlight that social costs of over-exploitation of groundwater resources in Punjab in the long-run far exceed the short-term personal benefits. While there is no economic incentive to save water for an individual farmer, there is need to develop innovative packages of incentives which may allure the farmers to adoption.

The provision of useful information on weather parameters, markets and important farm inputs regarding their use and benefits may be wrapped with the promotion of water saving technologies. It may induce the farmers initially to test the water saving potential of these technologies on their farms. Some other measures such as legislation on prohibiting early transplantation of rice in Punjab have also proved successful in the checking the rate of groundwater depletion. There is need to examine the impact of further enhancement of the rice transplantation date in future on rice productivity and groundwater depletion.

In nutshell, a concerted effort is required to ensure long-term sustainability of groundwater resources in Punjab. There exist a large number of technologies and practices which can help conserve water. The strategy to promote such technologies at a larger scale needs special attention. The results will be encouraging and long lasting.

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Climate change and its impact on Jharkhand agriculture

A. Wadood

Jharkhand is 28th Indian state which came into existence on November 15, 2000. With total geographical area of 79.7 lakh hectares and net cultivated area of about 24 lakh hectares, the forest cover extends to slightly over 23 lakh hectares with the remaining land falling under barren, cultivable waste, pasture and other categories. The average annual rainfall amounts to over 1,300 mm, of which more than 80 per cent gets instantly lost through high speed surface and sub-surface run-off causing loss of fertile soil and gully formation. In absence of adequate water management practices, crop failure due to prolonged dry period in the rainy season, inability to cultivate crops during rabi season and drinking/domestic water crisis during March-mid June have become a common feature in Jharkhand.

Changes in rainfall

Despite rainfall consistently remaining about normal over long-term, indicating no meteorological drought, the agricultural droughts have become quite frequent in Jharkhand. It owes to the reason that the distribution of rainfall has become very erratic in recent years. The seasonal distribution of rainfall has also remained favourable in the state with kharif season getting around 1,150 mm, North-east monsoon season (October-December) getting 90 mm, winter season (January-February) getting 50 mm and summer season (March-May) getting over 100 mm of average rainfall. However, in recent few years, the rainfall distribution, over the months, has been found to have marked variations, often causing agricultural drought.

Of the three agro-climatic sub-zones of Jharkhand, sub-zone V is the rain-shadow area where monsoon reaches late and starts receding earlier. The average annual rainfall in sub-zone V has decreased considerably, the worst situation being in Garhwa and Palamu districts with annual average rainfall of only 975 mm and 878 mm, respectively. In sub-zone IV, variation in rainfall is more pronounced.

Sub-zone V, being a rain-shadow area, situation becomes even worst in aberrant monsoon years witnessing dry spells of longer duration (more than 15-20 days) which puts a threat to the fate of standing crop and crop coverage. The sub-zone VI comprising only 3 districts, receives about 1,237 mm of annual rainfall.

Jharkhand is facing lack of pre-monsoon rain (situation-I) quite often in recent years affecting the tillage /land preparation and delaying the sowing of kharif crops even under timely arrival of the monsoon.

Early-season draught (situation-II) and mid-season draught (situation-III) never occur simultaneously in Jharkhand within a year. In case of early-season drought, the crop coverage is adversely affected, whereas in case of mid-season drought the standing crop in uplands and medium land suffers and transplanting in medium/low lands is withheld. Rainwater harvesting is the only option to address the

Impact of rainfall anomalies on agriculture

Situations	Impacts on agriculture
Situation I Lack of pre-monsoon rain	Tillage/land preparation problem. Kharif sowing delayed even under timely arrival of monsoon.
Situation II Early season drought (less often) (mid-June-mid July)	Drastic reduction in crop coverage. Limited option of short duration crops if there is rainfollowing the dry situation.
Situation III Mid-season drought (very often) (mid-July- end August)	Almost complete failure of standing direct sown crops. No rice transplantation.

problem of mid-season drought. The use of such water saved during the period of plenty as supplemental/life-saving irrigation during its scarcity can boost the productivity and cropping intensity, improving the farm incomes. During early-season drought, the farmers have limited option of resorting to short-duration crops, which could be produced during period the dry spell.

Changes in temperature

Over time, maximum temperature in Jharkhand has increased while minimum temperature has decreased. In other word summers have become hotter and winters have become colder. Maximum temperature in the month of May-June has reached up to 46-48^{o}C in many cities of Jharkhand whereas minimum temperature has gone down to 1^{o}C in December-January. The rise in temperature during summers and fall in the temperature during winters has been reported to have significant adverse effect on the productivity and quality of rabi crops.

Impact of climate change

Climate change, in terms of rainfall and its distribution, pre-monsoon/summer rainfall and temperature, relative humidity, etc. has been found to have an adverse impact on Jharkhand agriculture. Some important adverse impacts identified under the All India Coordinated Research Project (AICRP) on agro-meteorology are given below:

- Increase in maximum temperature during emergence to 50 per cent flowering of paddy had significant negative correlation with its final yield. Increase in minimum temperature, at grain filling stage, had significant positive effect on the yield. Increase in evening relative humidity at emergence to 50 per cent flowering also had significant negative correlation with rice yields.
- Higher rainfall at flowering stage caused brown spot disease and chaffy grain (lesser grain yield) of paddy, while higher rainfall at grain filling stage was beneficial to the crop.
- Rise in maximum as well as minimum temperatures at anthesis to milking stages of wheat crop had significant adverse impact on wheat yield.
- Exposure to higher temperature regimes (due to delayed sowings) caused shrinkage in total crop growing duration as well as in intermediate stage-durations of wheat crop resulting in reduced yield.
- Some diseases and insect-pests were reported to appear in new host plants for the first time in Jharkhand, which may be due to climate change. Examples are; bristle beetle in arhar, sheeth blight and rust in kharif maize, powdery mildew in lentil, swarming caterpillar in rice, alternaria blight in rapeseed and mustard and root knot nematode in rice.

Conclusions

Climate change is showing impact on Jharkhand agriculture. Despite no meteorological droughts in the long run, agricultural droughts have become more frequent. Lack of pre-monsoon rains, early-season drought and mid-season drought are frequent incidences and adversely affect the crop productivity. Rising summer temperature and falling winter temperature also have adverse implications for productivity of rabi crops.

The efforts for long-term sustainability of food production and rural livelihoods in Jharkhand will have to address the challenges of climate change in order to secure better results. The research and development activities should aim to mitigate the climate change impacts on agriculture to improve rural livelihoods in Jharkhand.

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Android application for nitrogenous fertilizer application

Surbhi Jain

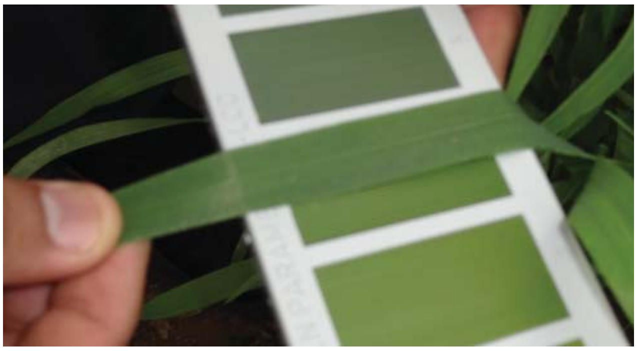
Nitrogen is one of the most important nutrient for crop growth, second only to water. It exists in many different chemical forms and passes around natural and agricultural ecosystems in a cycle. Nitrogen is also one of the basic components of chlorophyll, the compound by which plants use sunlight to produce sugars during the photosynthesis.Plants use nitrogen by absorbing either nitrate or ammonium ions through the roots. Plants deficient in nitrogen show yellowing symptoms in older leaves due to the under-development or destruction of chloroplasts and an absence of the green pigmented chlorophyll. Using too much nitrogen, however, can be just as harmful to plants as too little. When there are high levels of nitrogen present, plants may not produce flowers or fruit. Higher doses of nitrogen can result in plant burning, which causes them to shrivel and die. The supply of usable nitrogen and the rate of losses from the soil affect the sustainability of production. Mis-managed, it can result in economic loss to the producer and have environmental repercussions, or both.

Fertilizer application needs to be based on the crop nutrient status as excessive application may lead to sub-optimal production and may also lead to leaching of the nutrients in the soil, further resulting into increased costs and pollution of the ground water resources. Usually, the farmers apply fertilizers on the basis of growth parameters without considering the nutrient status of the soil as well as plants.

Leaf Colour Chart

Leaf Colour Chart (LCC) contains six green colour strips which are of different colour intensity and can be used to assess whether there is a need to apply nitrogenous fertilizer dose to the crops namely rice, wheat, maize, cotton and sugarcane. Different strips are used as benchmark for decision making in different crops. The colour strips are fabricated with veins resembling those of the leaves. The assessment of the nitrogen content is based on comparison with each window as each window represents different nitrogen status. For example, the leaves of rice and wheat are matched with the fourth strip and the leaves of maize and sugarcane are matched with the fifth strip.

If the leaf colour is lighter than the benchmark strip, the farmer is advised to apply the fertilizer dose, otherwise not. It has been observed from the field experiments that such a practice leads to a significant reduction in fertilizer use, thereby reducing the environmental pollution as well as the cost of production. The use of LCC is highly dependent on the person's relative colour perception



and is limited within the time range from 8-10 am in the morning and 3 pm onwards in the afternoon for reliable reading. In addition, it has been observed that the cost of LCC has increased rapidly in recent times and it is expected to rise further in the near future. The increased cost works against the overall objective of low cost technologies for agricultural development and may adversely affect the adoption rates and the distribution of benefits of such technologies.

Centers for International Projects Trust (CIPT) is working to develop an android application which identifies the leaves on the basis of the critical value i.e. window number four of the LCC and tells whether to apply fertilizer or not.

The android application was developed to automate the LCC using image processing techniques such as pixel wise Red, Green, Blue (RGB) extraction and Bayesian classification algorithm. It is expected to be distributed amongst the paddy and wheat growing farmers at very low cost and benefit large number of farmers, especially small and marginal farmers. It will help in more efficient use of nitrogenous fertilizers and reducing the cost of production for rice and wheat.

A dataset of wheat leaves of different colour intensity were collected and were classified into two categories. The first set included the leaves above the threshold colour of the fourth strip of colour chart and the second set contained the leaves below that threshold. In all, the dataset contained 80 leaves below the threshold value and 80 above that.

Algorithm Implemented

A. Pre-processing - Image acquisition device for the application is in-built camera of the android phone. The lead images from the wheat fields were collected using digital camera. Out of the 160 images, 120 images were used for training and the rest were used for testing of the algorithm. All the images were noise free.

B. Feature Extraction - Greenness index of the colour image yields an estimate of the amount of N in the plant. So features related to colour component were assumed to help in identifying and recognizing the labels. Various features were extracted like HSV values as well as the RGB values using the EmguCV (OpenCV wrapper) in visual studio 2010. RGB model describes the red, green and blue colour light combination in an image. The three lights are components of the RGB model which are superimposed at different intensities and form various patterns. HSV values describe the cylindrical-coordinate representations of points (pixels) in an RGB color model in which includes the hue, saturation and brightness values of an image. Hue describes the visual sensation according to which an area appears to be similar to one of the perceived colours: red, yellow, green, and blue, or to a combination of two of them. Brightness describes visual sensation according to which an area appears to emit more or less light. Saturation describes the colourfulness of a stimulus relative to its own brightness.

First of all hue, saturation and brightness values of the leaf images were extracted. The brightness component was as it depends on sunlight and affects the colour classification. After that, the quantize values of the Hue and saturation were prepared according to the two different dataset. However, these values didn't provide a good classification set of the images. The RGB values of the images were also extracted and all three channels were also used together along with the only green channel as the feature set.

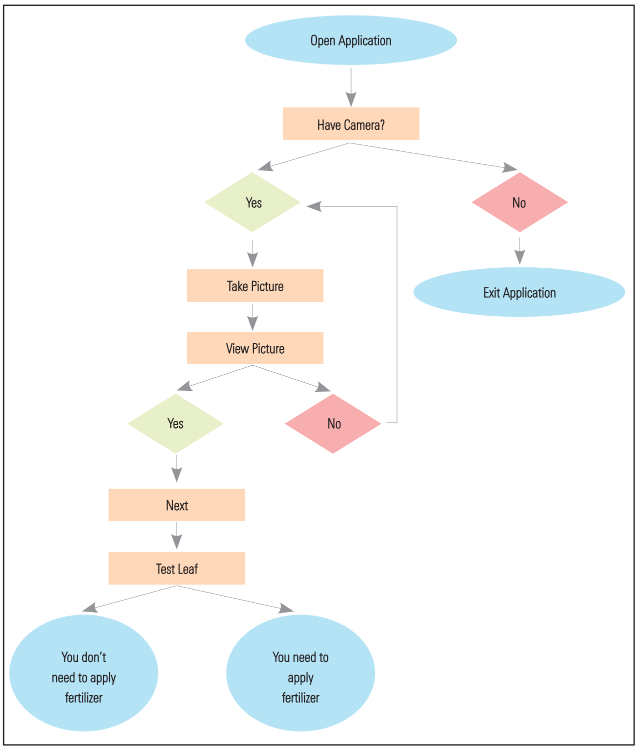
C. Classifier - Bayesian classifier was used for classifying the images into two labels above and below the critical value. Firstly we extracted the feature and using the feature set of RGB values as together and green channel feature set individually. In a Bayesian classifier our aim was to get the posterior probability on the basis of the prior, livelihood and evidence. So prior we assumed as 0.5 for both the classes. Livelihood values were calculated for both the dataset and stored in a matrix as well as evidence calculated. Then we evaluated univariate class conditionals using a threshold of 70 per cent.

Application scenario

The application was built on android platform. This application uses the in-built camera of the smart phone and using the picture of the leaf identifies its category. There are two screen of the application. On the main screen there are three buttons on the application "Take Picture", "View Picture" and "Next". To begin with the user will click on take picture and then inbuilt camera of the phone will open. The user will take a picture of the leaf from a very close distance. Then the screen will be change back to the main screen of the application. By clicking on "View Picture" user can view small thumbnail of the picture. After that if the picture is not perfect user can take another picture and view or he can click on "Next" button to go the next page.

On the next page, which is the second screen of the application, one gets to see a small thumbnail of the picture. On this page there is a single button "Test Leaf". By clicking on test leaf the application on back end will process the image will extract its green channel values pixel wise and then will calculate the posterior probability using the already stored values using the training part of the algorithm. In the end, Bayesian classifier classifies the image into one of the two categories by using a threshold of 70 per cent on the pixel count. Running the classification algorithm on the back end application gives the result whether to apply fertilizer or not.

The schematic diagram of the process is shown below



Results

The algorithm has shown an accuracy of 60 per cent on the dataset collected for training and testing. A testing of the application in which the inbuilt camera will be used is still under process. India has seen a huge jump in the number of cell phone users, including a high mobile density in rural areas. Such an increase in access to mobile phones calls for developing technology which can help in providing real time information to the farming community. CIPT will develop this application further to benefit larger number of farmers.

Surbhi Jain works as Research Assistant at CIPT

Decision support system in agriculture: integrating information technology to benefit farmers

Dharvinder Singh and Parmpal Singh Chouhan

A decision support system (DSS) can be broadly categorized as an administration of computer systems and applications which strengthen the decision making process of the end user. DSS can be efficiently used in planning, management and operations of the process in questions using information and communication technology (ICT).

Agriculture is dynamic entity which requires efficient resource planning and utilization to maximize the returns from land. An Indian farmer usually grapples with lack of well-timed information. Timely information on agricultural operations, is not only beneficial but also crucial for the farmers to take prompt and appropriate decisions.

To bring one to another i.e. farmers vis-à-vis DSS via information and communication technology (ICT), a suitable infrastructure is needed chiefly in terms of internet, cell phones etc. A report by Telecom Regulatory Authority of India (TRAI) puts Punjab in the top 4 states having highest tele-density.

Given the fact that Punjab is predominantly an agricultural state, the tele-density supplements the infrastructural presence to propagate the DSS to the farmers. In addition, the wireless and the wireline subscriber base in Punjab (January 2014) is 30,623,807 and 1,251,273, respectively.

Though a small proportion of farmers have access to such facilities at their places, the requisite infrastructure is already in place for such services to be disseminated and subsequently streamlined.

Centers for International Project Trusts (CIPT) has identified the need to strengthen the DSS in Punjab and is working towards developing a mechanism whereby reliable information can be made available to the farmer within a short span of time.

The modus operandi is based on the exploitation of ICT through the following channels:

1. Web interface, and
2. Messaging services to cellphones.

Web interface

A 'Farmer Page' has been created on the CIPTs website (www.cipt.in), where information on cultivation of rice is disseminated. Subsequently, this section of farmer page will be expanded for providing information on other main crops cultivated in Punjab. A screen shot of the website is indicated below:

Sections

1. Expert advice: It contains 'agro-advisory' informing farmers about the maximum and minimum temperature, prevalent heat wave conditions and rainfall expectation during the next 4-5 days. In addition, it also provides crop specific inputs such as:
   a. Applying light irrigation to rice nursery,
   b. Administering light irrigation to cotton crop, in case there's burning of crop,
   c. General inputs relating to mentha, spring maize and chilly plantation, etc.
2. Weather information: This section gives the district wise information on weather (average, maximum and minimum), wind speed and humidity.

3. Varieties: This section indicates the important varieties of paddy along with their average yield in quintals, time taken to mature and other relevant information.
4. Sowing and seed treatment: It informs farmers about correct amount of seed to be used and methods of seed treatment before sowing.
5. Time of sowing: This section indicates appropriate timing for sowing the paddy enabling the farmer to plan his farm operations accordingly.
6. Weeds and their control: It contains information about common weeds affecting the rice crop and instructions for controlling them effectively.
7. Information on fertilizers: This section highlights the right kinds and dosage of fertilizers.
8. Information on irrigation: It informs various types of irrigation such as flood irrigation, use of tensiometer etc.
9. Diseases and their control: This section contains information relating to various diseases affecting the paddy crop and the ways and means to deal with diseases affecting their crop.
10. Pests and their control:It contains information on adoption of correct approaches to control pests affecting paddy crop.

11 and 12. Ask questions and answer to the questions: Farmer can post a query onto the website, supplying his email address/ contact number.

Considering the advice of the experts, the farmer will be informed accordingly in a period of 48 hours.

Bulk messaging service: mVaayoo

The objective of using a bulk messaging service (both text and voice) is to provide crucial inputs to the farmers at the right time. These include weather based information, crop specific inputs, information on Kisan Melas held at Punjab Agricultural University (PAU), any important advisory issued by the government amongst others.

It can deliver text, picture and flash messages based on the mobile handset of the farmers. An excel sheet containing the name and number of the farmers can be uploaded onto the portal, from where customized messages can be sent to the required persons. This portal can be used to send customized voice messages to the farmers in large numbers. CIPT is collaborating with the Punjab Agricultural University to reach 10,000 farmers through text and voice messages during 2014-15. A total of 500,000 text messages and 2,000 voice messages will reach these farmers.

The strengthening of decision support system via ICT has a great potential in a predominantly agricultural state like Punjab, where farmers would greatly benefit from the timely information provided to them.

Considering the fact that mobile phones have become a necessity and are virtually in every household, it is paramount to make the resourceful use of the available technology so that significant and up-to-date information can be provided to the farmers, so as to enable them to take expeditious and wise decisions regarding their crop.

Dharvinder Singh and Parmpal Singh Chouhan work as Project Coordinator and Project Assistant respectively at CIPT

Interventions for water sustainability in Jharkhand

Sandeep Dixit

Jharkhand, carved out as a separate Indian state in 2000, accounts for 40 per cent of the total mineral reserves of India and has abundant opportunities for economic growth and development. In respect of water resources, Jharkhand has an average annual rainfall above 1,300 mm. However, most of the rain water is lost as run-off. Since the state receives a reasonable amount of rainfall and has undulating topography, there are opportunities to arrest run-off losses by creating water retention structures. This will not only check soil erosion but will also increase the physical availability of water. In addition, it will recharge groundwater which is a major source of drinking water for the people of Jharkhand. The drinking water scenario in the state is not very encouraging in terms of actual availability of water for rural population.

Data available with the Ministry of Drinking Water & Sanitation, Govt. of India indicate that out of 120,154 habitations in the State, 118,222 habitations (98.39 per cent) have access to a safe water supply as per norms (1 handpump or stand post for every 250 persons). However, according to the findings of a national study report on Existing Capacities in WATSAN Sector by the WASH Institute (2009), the State falls under low category of improved water supply and toilet coverage. Similar findings were reported in the District Level Health Survey (2007-08). About 54 per cent of rural households (a large portion of which are indigenous tribes) lack access to a safe drinking water source, since handpumps and piped water supplies are contaminated to various degrees. In terms of water quality, around 808 habitations are contaminated with fluoride, iron, arsenic and nitrate.

Multi-purpose R&D project

Given the above background, Columbia Water Center (CWC) launched an innovative Multi-purpose R&D pilot project for assessing the feasibility of cost-effective and sustainable technologies for drinking water storage and distribution in rural areas of Jharkhand. The project is supported by the Drinking Water & Sanitation Department (DWSD) of the Govt. of Jharkhand.

There are 4 key sub-themes, namely a) Feasibility of cost- effective sustainable technology for rain water harvesting; b) Feasibility of cost-effective and sustainable means of harnessing water stored in coal and stone pits; c) Feasibility of cost-effective technologies for providing rural population with safe affordable and sustainable water drinking water; and d) Feasibility to provide cost-effective and sustainable solar-based drinking water supply. The overall purpose of these four themes is to research and recommend sustainable, reliable and low-cost solutions for rural drinking water supply systems which could be scaled-up to provide maximum possible coverage to rural areas of Jharkhand, without any adverse impact on the quality of the drinking water.

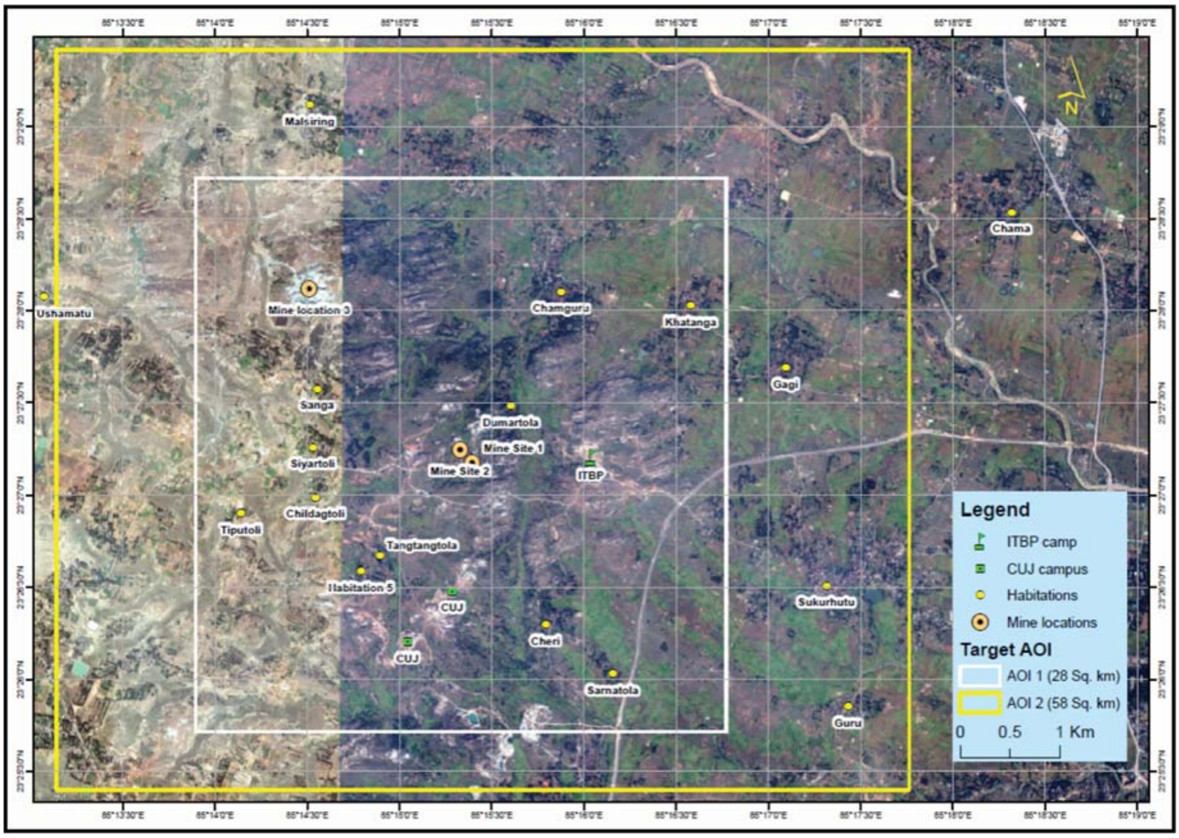
Sub Theme I: Assessing the feasibility of cost-effective sustainable technology for rainwater harvesting

Jharkhand lacks water storage and rainwater harvesting structures that can prevent run-off and store harvested water for subsequent use. It also faces severe drinking water shortages due to increasing incidences of drought and rising demand for public water supplies. To address this challenge, researchers/scientists of CWC, and Central University of Jharkhand (CUJ) have identified Kanke site in Ranchi district to design an innovative rainwater harvesting on the basis of infiltration trench system to recharge underground aquifers. The trench system is a significant innovation over conventional water-storage schemes such as open-air ponds that have low infiltration and are subject to evaporation. The team has been working to explore some other potential areas where a similar trench system could be pursued in contrast to conventional rainwater harvesting structures.

This pilot project aims at transforming the conventional and unreliable system being operational at small scale into a large scale water harvesting system that could sustain significantly larger irrigation and drinking water supplies in a sustainable manner. The project will also examine the options of low-cost operations of publicly capitalized system by using local labour, modern machinery and subsequent management through community participation at all stages. The infrastructural and resource requirement and capital costs will be worked out. It will also help in determining the costs of such infrastructural investments and feasibility of the same. A smaller- scale pilot may be set-up in partnership with the local NGOs, State/Central Government agencies and/or University and Industry partners.

Sub-Theme II: Assessing the feasibility of cost-effective and sustainable means of harnessing water stored in coal and stone mine pits

There are a large number of coal mines and stone quarries in Jharkhand with large water storage capacity. The state government



is keen to harness the coal mines and stone quarries for solving the crisis of drinking water shortages during summer and drought periods by storing water in them.

The abandoned open-cast mines/stone quarries have the potential to store freshwater and act as recharge areas once mining ceases. With diminishing freshwater resources, any large freshwater resource is worth investigation and development. However, such a development could face significant water quality problems that need to be assessed and properly resolved. There is a long history of water quality degradation in Jharkhand and other areas associated with coal mining, and this has to be kept in mind while exploring these sources as potential storage places for enhancing the drinking water supply.

A list of such mine pits/quarries and preliminary assessments of the topography, geological and mineral composition, and their accessibility to population settlements/industrial establishments has been undertaken in Ranchi, Dhanbad and East Singhbhum district. An abandoned mine near ITBP campus (approx. 15 km from Ranchi) has been identified for determining potability by assessing the chemical and biological composition of water and identifying treatment needs to meet drinking water quality standards of India. Subsequently, water samples from the identified open pits mines were collected to assess concentration of metals, toxicity, pH and total dissolved solids (TDS) in the water. Analysis of the water samples is underway.

Landscape modelling

Access to satellite data for landscape modelling and identification of ground surface was a challenge in the pilot project. In order to get 1m high resolution Digital Elevation Model (DEM), CWC in close cooperation with NECTAR (North East Centre for Technology Application and Reach), Department of Science and Technology, Govt. of India has been conducting an aerial survey for approx. 58 sq.km in the identified Kanke site of Ranchi district through unmanned aerial vehicles (UAVs). This will help in generating high resolution DEM to assess the feasibility of developing a water distribution network from mines to nearest habitations.

Alongside, CWC have been working with the scientists of CUJ to develop a water quality testing protocol for open cast mine sites being considered for water storage to ensure that initial and subsequent protection is maintained. The project will further lead to assessing the suitability of open cast mines as sources of water for agriculture and drinking water and their treatment strategies.

Sub-Theme III: Assess the feasibility of cost-effective technology to provide safe drinking water on a sustainable basis to majority of rural population

Out of the 2.9 crore rural population in Jharkhand, only about 7 per cent have access to drinking water through taps (DWSD, Jharkhand). As the habitations in Jharkhand are geographically scattered, the cost of transporting water is very high - about Rs. 5,000 per connection. The water collected through rainwater harvesting or conventional rooftop rainwater harvesting in schools and rural settlements could be used for drinking water, sanitation, and irrigation. A key aspect of this pilot is the identification of low-cost piped water supply and storage techniques for the community as well as enabling the village or panchayat levels and/or water user organizations for water supply schedules and infrastructure management.

CWC is working towards developing drinking water-sanitation-irrigation water supply options for an identified pilot area which is heavily dependent on rainwater for drinking and agriculture, as well as domestic use. Low cost technologies for piped water systems are the key research areas to focus under this pilot. The current cost of providing piped water in rural Jharkhand is Rs. 5,000 per connection; 75 per cent of the cost is for pipes and the balance is for creating a water tower which takes 2-3 years to construct and is therefore a serious concern. The research efforts are being undertaken to develop potential options for the integrated water supply plan and to explore low-cost pipe systems which would reduce the supply cost to about Rs. 1,000 per connection.

Sub-Theme IV: Assessing the feasibility of providing cost-effective and sustainable solar-based drinking water supply

In Jharkhand, about 32.5 per cent of the total population have access to electricity. There lies a potential for a solar water pumping system and/or photo-catalysis treatment pilot with the option of providing electricity (from solar technologies) and mobile based pricing mechanisms for water and/or electricity usage. In order to meet the objectives, low cost and effective solar-energy options are being researched for water supply and/or pumping. CWC would initially explore some potential areas and other ideas (including wind turbine pumping) where such a replication is feasible.

Options for scaling up will include a recommendation of appropriate technologies and procedures. When completed, the pilot study will provide innovative solutions to the Government of Jharkhand towards developing a long-term plan for drinking water sustainability.

Sandeep Dixit works as Program Manager at CIPT

About Centers for International Projects Trust

The Centers for International Projects Trust (CIPT) is the India Office of the Columbia Water Center. Affiliated with the Earth Institute at Columbia University in New York, the Center is uniquely positioned to apply rigorous, multi-disciplinary research to solve difficult on-the-ground water resources and climate-related water risk problems. In collaboration with government agencies, civil society and private sector partners, CIPT is developing new models and research paradigms for effective water and energy management in various States of India. We work towards providing rigorous, research-based knowledge as the foundation for various field based initiatives involving the local communities, government, non-government and private partners.

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