Water, Energy and Agriculture Sustainability in Punjab
Local actions for lasting impact
The Centers for International Projects Trust (CIPT) aims at bringing long term water sustainability and meaningful improvement in water quality. It works towards providing rigorous, research-based knowledge as the foundation for various field based initiatives in India.

CIPT has been working in Punjab since 2009 with support from various donors. CIPT gratefully acknowledges the support of PepsiCo Foundation, International Development Research Center (IDRC) and United States Agency for International Development (USAID).
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The state of Punjab, with around 4.2 million ha of net sown area and around one million operational land holdings, is a leading agricultural state of India. It comprises 22 districts with the population of 277.43 lakh living on the geographical area of 5,036 thousand hectare (96 per cent rural area and 4 per cent urban area). The percentage of rural population in the state is 62.52 per cent and the urban population is 37.48 per cent.

Agriculture sector is an important driver of growth for Punjab’s 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. The introduction of high yielding varieties of wheat during late-1960s and of rice varieties during early-1970s supported by assured irrigation, use of chemical fertilizers, agro-chemicals, farm mechanization and effective procurement policy for grains brought success of green revolution in the country.

Rice and wheat are the dominant crops of Punjab covering almost 80 per cent of the total cropped area. Cotton is also grown in about 6 per cent of the area. The prevalence of rice-wheat monoculture can be attributed to many factors but most important of them is high productivity which ultimately translates into comparatively higher profitability when compared to other crops.

The adoption of high yielding varieties with assured irrigation caused a substantial increase in input-use in agriculture. The current level of fertilizer use in Punjab state at 1,972 thousand nutrient tonnes is more than 40 times the fertilizer use in 1965-66. The intensity of fertilizer use also increased tremendously and the fertilizer use jumped from 12.1 kg/ha of NAS in 1965-66 to 249 kg/ha in 2010-11 (20 times). The use of agro-chemicals in Punjab also went up from 3,200 tonnes of technical grade in 1980-81 to 7,200 tonnes of technical grade in 1995-96 and then followed a decline to 5,535 tonnes of technical grade in 2010-11.

The production of food in Punjab was much above the consumption requirements of its own population. Most of the grains produced in the state contributed towards the attainment of national food security in India. Currently, The state of Punjab, with around 4.2 million ha of net sown area and around one million operational land holdings, is a leading agricultural state of India. It comprises 22 districts with the population of 277.43 lakh living on the geographical area of 5,036 thousand hectare (96 per cent rural area and 4 per cent urban area). The percentage of rural population in the state is 62.52 per cent and the urban population is 37.48 per cent.

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Punjab accounts for almost 19 per cent of wheat, 10 per cent of rice and 5 per cent of cotton production in India. The state has contributed almost half of rice and one-third of wheat to the central pool of grains with just 1.53 per cent of geographical land of India.

Punjab contributed only 0.13 million tonnes of rice and 0.57 million tonnes of wheat in 1966-67 but it jumped to 8.63 million tonnes for rice and 10.21 million tonnes for wheat in 2010-11. The state had contributed around 28.30 per cent rice and 43.43 per cent wheat to the central pool in 2013-14. Assured procurement with high remunerative prices of wheat and rice from Punjab has resulted in increasing productivity and has helped meet India’s food security goals. In this sense Punjab is rightly known as the ‘food bowl of India.'
Challenges facing Punjab agriculture

The growth in Punjab agriculture, achieved through intensive agricultural practices, started dwindling with time threatening the sustainability of farm incomes. In addition, it had serious implications for environmental sustainability. Intensive agriculture in Punjab led to the decline in crop diversity, depletion of natural resources, rising power use and power subsidy in agriculture and decline in profitability from farming.

Depletion of groundwater sources

The dependence of agriculture on groundwater resources increased significantly over time. Rainfall has also declined significantly in the past few decades. Increased use of groundwater resources and demand for irrigation water in excess of the sustainable supply, have led to the over-exploitation of ground water resources.

As a result, the groundwater table in Punjab has shown a serious decline. The problem of groundwater table is most severe in the central region, usually called sweet water zone, where rice is the main crop of the summer season. The government policy of providing free power for agriculture after 1997, accentuated the pace of this fall.

While the average annual rate of fall in the groundwater table was about 17 cm during 1980s, it was more than 25 cm during 1990s. However, the crisis emerged mainly during the period of 2000-05, when the rate of annual fall was about 91 cm. The rate of fall declined to 78 cm per year during 2005-10, which may be attributed to the restrictions imposed on rice transplantation in the Punjab farms before 10th of June through Punjab Rice Nursery Act of 2007.

Source: Central Ground Water Board reports
Imbalanced use of nutrients
The fertilizer use in Punjab is 249 kg/ha of the cropped area, which is much higher than the recommended levels of fertilizers use for the most dominant crops of Punjab. Apart from excessive use, the fertilizer use is highly imbalanced. Against the recommended levels of 4:2:1, the NPK ratio was 18.1:7.1:1 in 1980-81 which worsened further to 26.2:8.3:1 in 2011-12. Chemical fertilizers have been reported to account for 8-9 per cent of the gross value of production in Punjab and their excessive and imbalanced use points towards their sub-optimal use, which leads to an increase in the cost of production with a corresponding decline in crop productivity. The total micro-nutrient content of soils is of limited value. Of all the micro-nutrients deficiency of zinc is the most widespread problem in the state.

Climate change and variability
The crisis of Punjab agriculture is further worsened by climate change and variability. There has been a significant reduction in the average annual rainfall in Punjab since mid-1990s. While the annual rainfall averaged between 600-700 mm during 1970-97, it has considerably declined by almost 50 per cent to around 400 mm after 1997. Rainfall in the state is untimely and poorly distributed over space thereby showing temporal and spatial variations. Apart from rainfall, the abrupt changes in the temperature during winters and sudden rains at the time of maturity of wheat are severely affecting the wheat yields. These changes have impacted agricultural productivity by increased incidences of pest attack.

Climate variability has further aggravated the groundwater availability situation. Farmers’ investment in irrigation infrastructure and operation for pumping ground water has increased substantially. Due to lack of marginal cost pricing and ready availability of power for pumping irrigation water, groundwater is used indiscriminately. The marginal productivity of its use is much lower than its social cost. Unfortunately, due to the lack of use-based pricing, farmers do not care about the efficient and judicious use of water resources for its long-term sustainability. The policy environment in terms of free electricity is also distorting this situation.

Decline in crop diversity
The cropping pattern in Punjab has over the years changed towards rice-wheat monoculture. Despite many efforts for crop diversification in the past, there was a limited success in reducing the area under rice or some other crops to maize, pulses, vegetables, fruits. Comparatively lower levels of productivity and thus less profitability, greater production and marketing risk for the alternative crops are the major reasons for losses in crop diversity in Punjab. Efforts on crop diversification will not work until business viable value chains emerge.

Long term sustainability of water, energy and agriculture in Punjab requires holistic approach integrating intra and inter-sectoral concerns. It requires efforts on educating and disseminating information, capacity building of various stakeholders and dialogue with policy makers.
CIPT is working towards developing and implementing water and energy use efficient technologies in agriculture; improving farm incomes through better agricultural practices; promoting crop diversification; and developing decision making tools for climate change adaptation.

Initiatives undertaken include the development and testing of low cost tensiometers, promoting direct seeding of rice, developing business viable value chains for agriculture, developing water-energy-agriculture nexus models, real time weather forecasting and advisory services to the farmers through web portals and mobile applications.

**Outreach and impacts**

- Worked in 9 districts of Central Punjab reaching out to 15,000 farmers across 258 villages
- Promoted the use of tensiometer for irrigation scheduling in paddy
- Around 3 billion litres of water and 200,000 units of power saved
- Multi stakeholder partnerships involving government departments, agricultural university, academia, cooperative societies, educational institutions, corporates and farmers
- Developing soil moisture sensor for irrigation scheduling
- Developed an interactive decision support system for farmers to ensure rational usage of inputs
- Developed mobile application for application of nitrogenous fertilizers
- Use of mobile messaging system for information dissemination
CIPT and PAU identified the tensiometer as a small yet impactful device which has the potential to save huge volumes of water and in turn energy. Research and development by both the organizations led to the development of a low cost version of tensiometer with a unit price of Rs. 450. It was calibrated by PAU and field trials and large scale-on-field expansion was jointly undertaken by CIPT and PAU.

The journey of tensiometer started in the year 2009 and continues till date. The initial years focused on demonstration of the technology, capacity building and creating awareness with the farmers. This was followed by an improved scientific approach and concentrated extension leading to significant improvement in the adoption rate of the technology. The number of tensiometers installed across the past few years is depicted in Figure 1.

**Figure 1.** Number of tensiometers installed
All the farmers recruited under the project were classified into three categories such as adopters, non-adopters and those whose tensiometers did not work properly. Those farmers who successfully used the tensiometers after installation and irrigated the rice fields accordingly were classified as adopters. The non-adopters were those who never used the tensiometers even after the installation of tensiometers. The tensiometers did not seem to work properly in case of the third category.

The adoption rate increased considerably from 33 per cent in 2012 to 46 per cent in 2013 and to 51 per cent in 2014 and correspondingly the proportion of non-adopters declined from 55 per cent to 46 per cent to 39 per cent during the given years, respectively.

The step-by-step approach adopted for the tensiometer experiment is indicated below:

- **Identification of the project area:** The districts selected for the project lie in the Central Punjab which is the most adversely affected region with respect to the groundwater depletion. The number of villages covered was 44 in 2012 and the activities were confined to 28 villages in 2013 for more focused training, supervision and monitoring to achieve better assessment. During the year 2014, the activities were scaled up in 136 villages covering 8 districts. In 2015, a total of 50 villages have been taken up for installation of tensiometers.

- **Awareness and training camps at the farmers’ cooperatives:** The awareness and training camps were organized at the farmers’ cooperative of each village with the objective of sensitizing farmers about the depleting groundwater resources, apprising farmers of the project objectives and to identify the potential users of tensiometers in rice crop. All the camps were organized with active support of the Department of Cooperation, Punjab.

- **Installation of tensiometers:** After recruiting the farmers, the farmers as well as field workers were trained on the installation and use of tensiometer. The tensiometers were installed in the farmers’ fields by the field workers hired in the project.

- **Regular monitoring and data collection:** Every year, during the rice production period of June to October, field workers were hired to monitor the use of tensiometer by the farmers and to collect the information on water use in rice crop on a regular basis. A field worker is expected to visit each farmer after an interval of 10-12 days to monitor the use of tensiometers, address issues of its usage and to record the information on water use, energy use and other important parameters of rice production.

- **Comparing the water and energy use at farm level:** Experimental design was followed to estimate the impact of tensiometer on water and energy use. The fields of equal size (approximately one acre each) of each farmer were classified into tensiometer plot and control plot. While the farmer was expected to irrigate the tensiometer plot as per the tensiometer readings, the farmer was advised to irrigate the control plot as per the conventional practice of flood irrigation.
On an average, the use of tensiometer has brought down the water consumption in rice by 14-15 per cent. The year wise water and energy savings is given below.

```
2012  538,179 litres/acre
2013  372,042 litres/acre
2014  370,635 litres/acre
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```
2012  101kwh
2013  70kwh
2014  78kwh
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“Tensiometer is a useful instrument which has the potential to save around 20 per cent of water.”

Sukhwinder Singh, Farmer, Village Chauhanke Kalan, District Barnala
Direct seeding of rice (DSR) is a method of growing rice under aerobic conditions where seeds are sown directly in the field with the help of seed drill and water is not kept standing in the field. The crop is irrigated at relatively lesser frequency. DSR is a new initiative being promoted in order to address the problem of depleting groundwater resources. However, its impact on water usage is not widely tested on farmers’ field.

Field experiments were conducted on farmers’ field in four districts of Punjab namely Faridkot, Barnala, Sangrur and Muktsar. The number of farmers engaged in the experiment across different districts is indicated in Table below. Treatment and control plot design was followed under which one plot under DSR and one plot under conventional method was cultivated on the same farmer’s farm. The experiment was conducted for both non-basmati (non-aromatic) and basmati rice varieties.

The distribution of farmers across various land holding categories highlighted the concentration of farmers under medium and large categories. From a sample of 100 direct seeded rice growers, 72 per cent were large farmers, having operational area of more than 10 acres, 17 per cent belonged to medium category whereas only 11 per cent were small farmers having operational area of less than 5 acres.

The results from the DSR experiment indicate overall water saving to the extent of 29 per cent. In case of basmati (aromatic) rice varieties, the water saving was high and to the tune of 34 per cent. In case of long duration variety (Pusa-44), the water saving was very less at about 6 per cent. However, in normal duration varieties, the water saving was about 28 per cent. The details on the water savings are given in Table below.
### Table: Average water usage in control and DSR plots (cubic meter)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Control Plot</th>
<th>DSR Plot</th>
<th>Water saving</th>
<th>% water saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pusa Basmati 1121</td>
<td>126,031</td>
<td>83,046</td>
<td>42,984</td>
<td>34.1</td>
</tr>
<tr>
<td>Normal duration varieties</td>
<td>25,766</td>
<td>24,161</td>
<td>1,605</td>
<td>6.2</td>
</tr>
<tr>
<td>Pusa 44</td>
<td>80,787</td>
<td>57,829</td>
<td>22,958</td>
<td>28.4</td>
</tr>
<tr>
<td>Overall</td>
<td>232,584</td>
<td>165,037</td>
<td>67,547</td>
<td>29.0</td>
</tr>
</tbody>
</table>

“DSR technology has helped me save water for irrigation. There is a need to promote this technology for conservation of water resources in the State.”

Tarsem Singh, Farmer,
Village Kalarab, District Sangrur
Innovative insurance products can help in faster adoption of resource saving technologies and practices and hence can contribute effectively to the natural resource sustainability. Punjab Agricultural University, CIPT and Agricultural Insurance Company of India (AIC) partnered to develop an innovative insurance product for the promotion of tensiometers in Punjab. The insurance product was named as PAUTITIS.

A total of 937 farmers participated in the pilot on technology insurance (PAUTITIS). These farmers were classified into four size categories, namely marginal (≤ 2.5 acres), small (2.5 ≤ 5 acres), medium (5 ≤ 10 acres) and large (> 10 acres) farmers. While the insurance against yield loss due to tensiometer was provided to 500 farmers, around 437 farmers were selected as control group and these farmers were distributed almost similarly across the four farm size categories as was the case with insured farmers.

A comparative analysis of the socio-economic characteristics of the farmers involved in the PAUTITIS project revealed that relatively younger farmers were inclined to opt for the insurance scheme as the average age for insured farmers was 39 years as compared to 47 years for non-insured farmers. The average number of years of schooling was also higher for the insured farmers (11 years) when compared to the non-insured farmers (8.7 years). The farmers who opted for insurance product were having relatively larger proportion of area under paddy crop and also had relatively larger proportion of the land laser levelled.

The overall rate of adoption for the insured farmers was 70.2 per cent, while the adoption rate for non-insured farmers was 26.5 per cent. Figure 2 indicates the rate of adoption. It is visible that the rate of adoption was substantially higher for all the farm size categories of insured farmers as compared to the non-insured farmers.
There was no clear trend on the impact of technology insurance on the extent of water saving. On an average, the extent of water saving was 806,174 litre/acre for the insured farmers and 809,875 litre/acre for the non-insured farmers. The difference in the extent of water saving between insured and non-insured farmers was non-significant. Likewise, the extent of electricity saving was 142 Kwh/acre and 144 Kwh/acre for the insured and non-insured farmers, respectively.

In continuation to PAUTITIS 2014, the same experiment is being carried out during the Kharif season of 2015 in Punjab. A total of 1,000 farmers (500 adopters and 500 non-adopters) have been sampled, from the same districts chosen the previous year, to carry out the proposed experiment.

It is expected that insurance will play a key role in allaying the fears of farmers with respect to perception of yield losses arising out of adoption of a new technology such as tensiometers. By the means of risk-proofing the farmers from yield losses, insurance is expected to play an important role in boosting the adoption rates of any new technology which is supposed to benefit the farming community in conservation of natural resources.

“AIC, right from the conceptualisation of the idea, has constantly supported the Punjab Agricultural University Tensiometer Innovative Technology Insurance Scheme (PAUTITIS). It is a one-of-its-kind product piloted by CIPT with 500 farmers first time in 2014. The first year pilot test results revealed a significant increase in the adoption of technology due to insurance, indicating a role of insurance in technology adoption. AIC is committed to further the initiative and looking forward to scale up the coverage in the seasons to come.”

M. K. Poddar, General Manager
AIC of India
CIPT has endeavoured to reach large number of farmers in Punjab through Farmers’ Cooperatives. The engagement of cooperatives has ensured better access to small and marginal farmers, faster adoption and better impact of the interventions on water sustainability.

Cooperatives in Punjab are diversifying their activities and have successfully shown the viability of Agro Machinery Service Centers (AMSCs). CIPT is collaborating with Punjab Agricultural University and Department of Cooperation in Punjab to transform these cooperatives into information hubs for the farming sector. It also intends to include the Farmers’ Clubs being promoted by NABARD within its ambit.

CIPT has trained around 300 higher officials and secretaries of the Cooperative Societies on issues of groundwater depletion in Punjab and the use of tensiometers for water saving in agriculture.
A decision support system (DSS) consist of an administration of computer systems and applications which strengthens the decision making process of the end user. DSS can be efficiently used in planning, management and operations of the process in questions via information and communication technology (ICT).

In order to promote effective two-way communication between the research and development agents and the farmers, CIPT has developed an interactive web portal and mobile application for the farmers. The web portal provides easy access to the recent developments in crop production and weather and will promote farmers’ interaction with the experts through question and answer session. This will prove useful for the farmers having access to the internet. However, for those farmers having no internet connection, mobile applications have been developed which can be easily downloaded on the android phones.

The information contained in the DSS relate to important parameters of crop cultivation such as improved varieties, sowing and seed treatment, judicious use of fertilizers, main diseases of respective crops, which insecticide/pesticide to use and useful/harmful pests of respective crops.

The web portal can be accessed at - http://cipt.in/punjab/index.php#
CIPT believes in designing tools which can reach out to a large section of the population. Realizing that the web based decision support system portal can only be used by farmers with access to internet connection, CIPT has developed mobile applications which can be easily downloaded on android phones.

The mobile application contains the same set of information as is available in the web based portal. It contains information on the major crops of Punjab - Rice, Wheat, Maize, Cotton and Sugarcane.

Across the past few months the application has been downloaded by more than 300 farmers and is being regularly used by a majority of them.

CIPT is planning a comprehensive capacity building exercise focusing at the extension officers of Krishi Vigyan Kendras, Department of Agriculture and Department of Cooperation in the coming season so that farmers can make better use of the information contained in the mobile applications.

The mobile application can be downloaded from-
https://play.google.com/store/apps/developer?id=CIPT+(Parm+Chouhan)
Information through bulk messaging service: Faster and reliable mode of information

Faster messaging service (both text and voice) can help provide crucial inputs to the farmers at the right time. These include weather based information, crop specific inputs, information on advisory issued by the government departments, agricultural universities.

CIPT collaborated with Punjab Agricultural University to reach out to 10,000 farmers through text and voice messages since 2014. A total of 500,000 text messages and 2,000 voice messages have been sent to the farmers.

Timely and reliable information will come handy in improving agricultural practices amongst the farmers. CIPT proposes to carry out an impact assessment study of the bulk messaging service with the farmers across its intervention areas to ascertain the effectiveness of the messages, its timeliness and wholesomeness.
Based on our past experience and farmers’ feedback, the need to develop a low-cost and digital alternative for the tensiometer was felt. The farmers conveyed their preference for the tensiometer technology to be simplified.

In partnership with NECTAR, CIPT developed a low cost soil moisture meter and chlorophyll meter. The low cost sensors and chlorophyll meters were calibrated at the research fields in PAU and have been handed over to progressive farmers.

“Time has come for us to move towards digital technologies for accurate and fast estimation and developing response actions.”

Baljeet Singh, Secretary
Latala Cooperative Society, District Ludhiana
CIPT has partnered with Village Shop Private Limited to develop different variants of low-cost moisture sensors and weather stations. These low cost sensors and weather stations will be used to collect the real time data from the farmers’ fields and integration of data with the decision models can help in developing valuable crop advisories to the farmers. Localized data generated from the weather stations will be useful in integrating micro-level weather information in climate modeling.

This initiative aims to generate probabilistic information on important weather parameters such as rainfall, temperature and humidity (weakly, seasonal and annual). Providing such information to farmers at the right time through modern information dissemination tools will enable them make irrigation practices.

These new innovative technologies will also help in automating irrigation systems for various crops through precision technologies for improving water use efficiency.
Food, water, and energy are inextricably linked and there is deep interdependence. India is the largest groundwater user in the world and about 90 per cent of groundwater is used for food production. Energy is a vital input in agriculture for irrigation, harvesting, post harvesting, processing, value addition, storage, and transportation and agriculture accounts for 19 per cent of total electricity consumption and 12 per cent of total diesel consumption in India. Therefore, any rise in energy costs will result in higher cost of food production and therefore rise in food prices. Energy and water linkage is also critical as energy is needed for water extraction, transportation, distribution, and treatment and on the other hand water is required for energy generation from hydro and thermal power plants.

The study to understand the water-energy-agriculture nexus is an attempt to understand the inter-relationship between water, energy and agriculture sectors. The nexus concept establishes a need to develop a model for optimal utilization of resources and achieving water sustainability under changing climate within the region. The model mainly depends on the nexus approach which views the water, energy and agriculture sectors as not being separate but being a complex and inextricably entwined. Thus, the approach would promote climate change adaptation and water sustainability while improving the farmer’s livelihood and food security.

The major objective of the project is to develop a water-energy-agriculture nexus model. The model will represent an integrated assessment that improves understanding of changing climate and resource conditions that farmers within the regions will face. The assessment will inform the nexus related responses in terms of strategies, policy measures, planning and institutional set-up or interventions for policy makers and planners in the government.
Agriculture continues to remain the predominant sector of Indian economy in terms of workforce engaged in this profession for their livelihood. Across the past few years, there has been growing acceptance that climate is changing and will impact ecosystems, food production and livelihood of people. In recent years agriculture sector has changed rapidly from one of fragmented production and marketing relationships toward integrated market systems.

Driven by gains from economies of scale and globalization of the food chain, multinational agri-enterprises increasingly dominate the sector with more and more vertical and horizontal linkages or integration. The changes are also being driven by the marketplace and responsiveness to consumer interests, including stricter compliance, timeliness and quality standards. Agriculture, as with many other sectors, is now a global marketplace driven by competitiveness, which demands certain levels of efficiency and productivity. The future of farmers, traders and agribusinesses in the food or agro-industrial chain and therefore the quality of their loan or investment depends upon both their ability to compete in the marketplace and/or to adapt to markets trends and practices.

In the given background, CIPT has undertaken a study on value chain for crops, fruits and vegetables. The purpose of the study is to analyse infrastructure gap, local and national market effect on state agriculture, scenario of food processing industries, financing gaps in the sector and role of small stakeholders in the value chain. The study also attempts to assess the diversification program of the state and business environment for investment in agriculture value chain/food processing sector.
There have been efforts since the inception of the project to disseminate the intended purpose and objectives of the project to the various stakeholders in the State of Punjab. Programmes for outreach and engagement were planned for the entire project duration. In course of the later years attempts have been made to share the findings of the projects with decision makers and external audiences both within the state as well as to the national and international audiences.

**ENHANCING OUTREACH TO DELIVER IMPACT**

**Interacting with stakeholders, disseminating findings and advocating for policy change**

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**National programmes**
- Policy dialogues with the Financial Commissioner Development (FCD) of Punjab, Chandigarh
- Roundtable meeting: India Water Action Network - August 22, 2014, New Delhi
- Roundtable on Water Challenges at Indo-US Technology Summit - November 18-19, 2015, Greater Noida
- Demonstration of CIPTs work at Indo-US Technology Summit - November 18-19, 2014, Greater Noida
- Round table on water challenges in Punjab – January 30, 2015, Chandigarh
- Meeting with Additional Chief Secretary (Development), Government of Punjab – March 18, 2015

**International programmes**
- Conference on Rebuilding Punjab: Political Economy, Society and Values at University of California, March 29-30, 2013, Santa Cruz
- UNEP Capacity Building Workshop on National Planning for Food Security - September 18-20, 2013, Kampala, Uganda
- Presentation on ‘Water-energy-agriculture sustainability in India’ - May 20, 2014, Earth Institute, Columbia University, New York
The state of Punjab has played an important role in agricultural growth and development of India. However, in the recent times the agricultural sector is facing challenges of stagnation in production, over-exploitation of natural resources, rational use of inputs and increased uncertainties due to changing climate. One of the reasons for the decline in agricultural productivity is the disconnect between what is being practiced by the farmers on the fields and what is generally recommended by universities and agriculture department. To bridge this gap there is a need to engage with students and the youth.

To realize this objective, CIPT launched a programme titled ‘Agents of Change’ in the state of Punjab along with Khalsa College, Amritsar, a prestigious education institute. The main aim of the programme was to bridge the gap between the classroom and farmers field, between curriculum based learning and experimental learning and to transform students as leaders - promoting the cause of sustainability.

The programme was officially launched on July 23, 2015 at Khalsa College. The ceremony saw the participation of around 700 students from the Department of Agriculture, Khalsa College and faculty members. Dr. S. S.Johl, renowned agriculture economist and Chancellor, Central University of Punjab was the Chief Guest.

Speaking on the occasion Dr. S.S.Johl, Chancellor, Central University of Punjab said that the biggest gap facing the agriculture sector is disconnect between what is happening at the farmer fields and what is being taught at the academic level or discussed at policy level. This gap needs to be bridged by developing a thorough understanding of the real issues and challenges facing the sector. Agriculture needs to be integrated with the rural life and economy, remarked Dr. Johl and asked the students to live the life in the villages.
The programme involves the following steps:

- **Formation of groups:** The students will arrange themselves into groups of 10. The team will be guided by mentors comprising 2-4 teachers from the Department of Agriculture, Khalsa College.

- **Selection of villages and its adoption:** Once the groups are formed, each team will identify two villages where they will visit for the interaction with the farmers. Prior to visiting the village the students will make contact with the village leader and functionaries of the Cooperative Society. They will prepare a plan to organise 25-30 farmers in designated date for meeting. Students will also prepare an outline of the major issues facing the agriculture and probable solutions for ensuring sustainability in the village. These will form part of the discussion which will be conducted in the villages.

- **Activities in the village:** Upon reaching the village, the students will be guided towards the discussion with the farmers by their mentors and team members of CIPT. After a formal round of introduction, an interactive session will follow where students asks questions pertaining to the socio-economic condition of the village, enquire about current farming practices, discuss challenges facing the farming sector. The idea behind the interaction is to create forum where students become recipient of on-ground information. Based on their understanding and guided by their mentors, the students will discuss ways to find solutions of some of the problems outlined by the farmers.

- **Preparation of project report:** On completion of the field visit, the students will compile the information obtained from the farmers and will develop a project report that encompasses information relating to – village profile, demographic and socio-economic details, challenges faced by the farmers relating to natural resources use and agricultural production. They will also research and discuss amongst themselves key approaches which could provide solutions to the identified problems. The report would also outline the role of different stakeholders in finding solution to the problems. As part of the report preparation phase, the students will be trained on research methodologies and report writing.

Three best teams will be selected who will then develop their findings into viable projects with support from their teachers and CIPT team.

“It is important for students studying agriculture to be in touch with ground realities of the sector and engage with the farming community to develop a clear understanding of matters concerning the farmers. The Agents of Change programme would be a milestone initiative in bridging the gap between classroom and farmer fields.”

Dr. Mehal Singh, Principal Khalsa College, Amritsar
Partnerships for agricultural sustainability

CIPT aims to provide rigorous, research based knowledge as the foundation for various field based initiatives involving the local communities, government, non-government and private partners. It has built partnerships with various organizations to promote water-energy-agriculture and livelihood sustainability. The partnerships have been with academia including the State Agricultural Universities, government agencies, private sector and other non-profit entities in the research and development sector.

A snapshot of the major partnerships is given below:

- CIPT partnered with Punjab Agricultural University, Ludhiana to research and find sustainable solutions for groundwater and agricultural sustainability. The partnership has led to the identification of interventions such as tensiometers and direct seeding of rice for water saving; development of web portal and mobile applications displaying package of practices for major agricultural crops of the state and their promotion to more than 15,000 farmers across more than 250 villages in Central Punjab.

- CIPT in collaboration with the Punjab Agricultural University has partnered with the Agricultural Insurance Company (AIC) of India to develop innovative insurance products for technology adoption. While the AIC is developing the insurance products suited to the adoption of technologies in different parts of the country and is providing support in pilot testing of the products, the CIPT is structuring the experimental design for testing of the insurance product and is also providing support in supervision and monitoring of the technology usage and resulting losses, if any.

- CIPT has partnered with Field Fresh Foods Private Limited and academia to develop the framework for the development of business viable value chains in agriculture. The partnership will help in gathering inputs on the essentials of food processing, food safety, marketing and other research and development needs for such value chains. It will also help in pilot testing business viable models. Attempt is being made to develop market outlook for alternate commodities by exploring the regional, national and global markets and will devise strategies for scaling up of the business viable chains. The success of such partnership may lead to successful efforts for crop diversification in the country.

- CIPT partnered with World Wide Fund for Nature (WWF) India and Sir Ratan Tata Trust (SRTT) in developing a mobile app and DSS for Better Cotton Initiative (BCI). It is also planned to conduct training workshops of the scouts at village level with respect to the DSS.
CIPT is engaged in the development and dissemination of publications for sharing the results of its work. A summary of the major publications developed is included below:

**Discussion Paper: Natural resources management in Punjab agriculture: Challenges and way forward**  
*S.S. Johl, R.S. Sidhu, Kamal Vatta*

The state of Punjab, with around 4.2 million ha of net sown area and around one million operational land holdings, is a leading agricultural state of India. Rice and wheat are the dominant crops of Punjab covering almost 80 per of the total cropped area. The cropping intensity at 191 per cent, fertilizer use at 249 kg/ha and irrigated area to the tune of 98 per cent compare much higher than the national averages. Intensive agriculture in Punjab has led to the decline in crop diversity, depletion of natural resources, rising power use and power subsidy in agriculture and decline in profitability from farming. A multi-pronged strategy focusing on “technology driven agriculture” actions complimented by rational policy is necessary to address the challenges facing the agricultural sector in the State. It is time that measures are taken for ensuring the long-term sustainability of agriculture in the state. There is an urgent need to diversify the cropping pattern by moving to less water intensive crops. Improving water-use efficiency and better soil health management based on the actual requirement of nutrients needs to be advocated. These actions can help in improving farm incomes, encouraging more efficient use of inputs and natural resources, checking and enhancing productivity in the long run.

**Technical Paper: Farmers’ awareness, perceptions and knowledge gaps: Looking for innovations in agricultural extension**  
*Kamal Vatta, Garima Taneja*

Punjab has followed a path of intensive agriculture, leading to prevalence of rice-wheat mono-culture along with higher input–use. As a consequence, it resulted into serious threat of long term sustainability of agriculture within the state. The present study evaluates the major challenges being faced by Punjab farmers in their farming practices,
knowledge attainment and further assessing their perceptions about the future threats. The results of the study indicate that farmers are aware about the ill-effects of intensive agriculture and their causes, but they lack awareness on potential solutions for tackling them and access to more scientific and recommended set of practices for more effective operations. The paper generates a case for the innovations in the extension education system, where ICT can play an important role. Various options of web portals, mobile applications and bulk messaging services need to be explored to enhance the effectiveness of the traditional approaches of extension education. Furthermore it emphasize on the set of information, which can be routed more effectively through the innovative extension tools and can add value to the farmers’ decisions.

**Technical Paper: Strengthening value chains for fruits and vegetables in Punjab: Alternative for faster growth in agriculture**  
Shayequa Zeenat Ali, Dharvinder Singh, Sandeep Dixit, R.S. Sidhu

The paddy-wheat monoculture induced decelerating agricultural trend in Punjab which have been felt in the form of stagnation in output, declining productivity, environmental degradation, declining farm incomes and de-peasantization and suicides by farmers. Shifting away from rice and wheat which are the most water intensive crops of the state and devoting more area under fruits and vegetables will help in increasing farm incomes, overall agricultural output and conserving water resources. In spite of increasing area under cultivation, production and consumption of fruits and vegetables in Punjab, there are many challenges which hinder the shift away from rice-wheat monoculture towards high value crops. Fruits and vegetables being highly perishable in nature require cold storage, special processing, transportation and marketing infrastructure. These have a bearing on the volatility of supply and hence prices of end products affecting the various stakeholders involved in the value chain. In light of the discussion above an in-depth analysis of issues affecting value chains of fruits and vegetables in Punjab is required.

**Book Chapter: Assessment of agricultural water management in Punjab, India using Bayesian methods**  
Tess A. Russo, Naresh Devineni and Upmanu Lall

The success of the Green Revolution in Punjab, India, is threatened by a significant decline in water resources. Punjab, a major agricultural supplier for the rest of India, supports irrigation with a canal system and groundwater, which is vastly over-exploited. The detailed data required to estimate future impacts on water supplies or develop sustainable water management practices is not readily available for this region. The paper used Bayesian methods to estimate hydrologic properties and irrigation requirements for an under-constrained mass balance model. Using the known values of precipitation, total canal water delivery, crop yield, and water table elevation, the paper presents a method using a Markov chain Monte Carlo (MCMC) algorithm to solve for a distribution of values for each unknown parameter in a conceptual mass balance model. Model results are used to test three water management strategies, which show that replacement of rice with pulses may be sufficient to stop water table decline.

**Research Communication: Android application for identifying nitrogen deficiency in wheat crop**  
Surbhi Jain, Tess A. Russo, Kamal Vatta and Upmanu Lall

The research communication has been developed by the above authors and submitted to the Journal Current Science. The paper summarizes CIPT’s initial experience on the use of technology for estimating the demand for nitrogen in wheat and rice crops. The study explains the probability on the basis of the Bayesian classifier using likelihood evidence components for enhancing accuracy of images.

**Summary Report: PAU Tensiometer Innovative Technology Insurance Scheme (PAUTITIS)**  
Kamal Vatta, Dharvinder Singh and Ashish Bhardwaj

The summary report documents the findings of the PAUTITIS project initiated in the year 2014. A comparative analysis of the socio-economic characteristics of the farmers involved in the PAUTITIS project revealed that relatively younger farmers were inclined to opt for the insurance scheme as the average age for insured farmers was 39 years as compared to 47 years for non-insured farmers. The overall rate of adoption for the insured farmers was 70.2 per
cent, while the adoption rate for non-insured farmers was 26.5 per cent. There was no clear trend on the impact of technology insurance on the extent of water saving. On an average, the extent of water saving was 806,174 litre/acre for the insured farmers and 809,875 litre/acre for the non-insured farmers. The difference in the extent of water saving between and insured and non-insured farmers was non-significant. Likewise, the extent of electricity saving was 142 Kwh/acre and 144 Kwh/acre for the insured and non-insured farmers, respectively.

**Baseline Study Report: Water-Agriculture-Livelihood (WEALS) Security Program in India**

Kamal Vatta, Romit Sen, Sandeep Dixit, Dharvinder Singh and Nikunj Parekh

CIPT carried out a baseline study as part of the USAID supported Water-Agriculture-Livelihood (WEALS) Security Program in India. The objective of the study was to assess the current situation of water, energy and climate and their impact on farmers; understand the current practices adopted by the farmers; come out with strategies and approaches to ensure long-term sustainability of water, energy and agriculture.

The findings from the three states are classified under the following sections – socio-economic profile, agricultural profile, water and energy use, access to extension services and use of ICT.

**Research Paper: Sustainability of groundwater use in Punjab agriculture: Issues and options (Draft stage)**

Kamal Vatta, Upmanu Lall, R.S Sidhu and Charlotte MacAlister

The paper discusses the current situation of water demand and supply in Punjab. It highlights recent concerns on groundwater situation in Punjab and review of the literature on such concerns. It builds on how the demand-supply mismatch started worsening over time by outlining the trends in demand and supply. It further explores the major reasons for such mismatch such as the decline in rainfall, increased focus on foodgrain production, free power provision for agriculture and dominance of rice in the production system. The paper then builds on the implications of the depleting groundwater resources by highlighting the rise in investments on improved motors and deepening of borewells, implications for the marginal and small farmers, impact on energy use in agriculture and power subsidies and other implications for the environment and water quality.

In the next sections of the paper, the effort will be to document the past efforts towards the sustainability along with the reports of the expert committees such as Johl Committee and Alagh Committee. It will also highlight the reasons for the failure of those efforts and will also highlight some success stories. In the last sections, the paper will focus on the technological options such as tensiometers, direct seeding of rice, policy issues and the needs for research and development.
Capacity building and awareness programmes

CIPT has made constant efforts in undertaking capacity building and awareness programmes. These have been conducted with the objective of not only spreading information about the interventions but also to serve as a forum for sharing of knowledge, understanding the problems of the farmers and exchange of ideas.

Village level meetings have been a strong component of the programme. These meetings have helped to generate awareness on the rapid depletion of groundwater resources and helped build momentum for the spread of resource saving activities, promotion of tensiometers and collection of information on the use, constraints and impact.

Across the past six years, around 550 village level camps and follow up meetings have been conducted. While one camp was held in each village prior to the installation of tensiometers, another meeting in each village was held to identify adoption rates, constraints and future strategies of scale up. The farmers were also being made aware on the development of web-portals, development of sensors, mobile applications and other project activities during these follow up meetings.

The farmers and extension agents in the state have shown positive response to the development of ICT tools. These tools were viewed as being more interactive owing to its nature of being technology based and farmers were keen to learn about the application of Information Technology (IT) in sourcing the information relating to crop cultivation.
Water, Energy and Agriculture Sustainability in Punjab

Local actions for lasting impact