CUTS International

Compendium on

Sustainable Agricultural Practices

Insights from the Indus, Ganges & Brahmaputra Basins

Introduction and Rationale

South Asian agriculture heavily depends on monsoons and is highly susceptible to climate change. The advances attained in food grain production in the past decade has significantly contributed to the region's food security but has exhausted its natural resources. High variability in monsoons with respect to onset, amount, distribution and withdrawal have forced farmers into being part of a vicious cycle of drought and flood in most parts of the region. In view of the impact of climate change on agriculture and farm income, the adaptive capacity of small and marginal farmers in the region needs to be enhanced.

The river basins of Indus, Ganges and Brahmaputra are known for their cereal-based cropping system across the national borders of Bangladesh, Bhutan, India, Nepal and Pakistan. Rice-Wheat cropping systems in this belt has led to mining of nutrients and water from the soil. The Fifth Assessment Report of Inter-governmental Panel on Climate Change (IPCC) states "In the Indo-Gangetic plains, which produce 90 million tonnes of wheat a year (about 14–15 per cent of global production), projections indicate a substantial fall in yields unless there is a shift to different crop varieties and management practices".

Aggressive withdrawal of ground water for irrigation has also put serious pressure on water and energy resources. Soil degradation is another major constraint, which limits agricultural productivity in the Indian sub-continent. Indiscriminative use of fertilisers and pesticides, improper planning and management of irrigation systems, burning of crop residues and mono-cropping have led to series of land management issues like water logging, declining productivity, acidity and alkalinity. This calls for climate resilient management practices which include cultivation of stress tolerant varieties, crop diversification, efficient irrigation practices, crop residue management and conservation agriculture.

In this background, under the aegis of the regional programme for South Asia – Sustainable Development Investment Portfolio (SDIP) supported by Australian government, CUTS International has developed partnerships across the river basins of Indus, Ganges and Brahmaputra in Bangladesh, Bhutan India, Nepal and Pakistan. Through the interventions and network of its partners in India viz., Centre for Research in Rural and Industrial Development (CRRID), Punjab; Indian Grameen Services (IGS BASIX), Bihar; Nand Educational Foundation for Rural Development (NEFORD), Uttar Pradesh; and Rashtriya Gramin Vikas Nidhi (RGVN), Assam, we have identified a few climate smart sustainable agricultural practices which make efficient use of resources and can be replicated in similar agro-climatic conditions across South Asia.

Despite the initiatives taken by research faculties, government extension services, CSOs and the international donor community in developing climate smart agricultural practices; promoting resource-efficient agricultural practices; and building the resilience of farmers have not reaped intended benefits. This lacunae in knowledge dissemination calls for more focussed engagement with the farming community and also sharing information on successful sustainable agricultural practices with a wider beneficiary group.

This compendium is a compilation of those practices, which are promoted and advocated by CUTS partners in their locality and can be scaled up and disseminated to a wider group of farmer communities in South Asia, taking into account the commonalities in cropping systems and agro-climatic zones in the region. This will also demand necessary support from state and national government in terms of policies and deeper engagement with CSOs to facilitate knowledge sharing.

More specifically these practices aim to:

1. Imparting technical knowledge for better management of resources;
2. Building adaptive capacity and resilience of small farmers against climate change;
3. Enhancing productivity in marginal land and assure food security; and
4. Sharing successful models of institutional frame work for enhancing skills.

Additionally, this work will also look into the enabling policy frameworks required for scaling up of resource efficient agricultural practices.

1. Imparting Technical Knowledge for Better Management of Resources

Water is a key input in agriculture and in water-intensive cropping patterns involving rice, wheat and sugarcane in the Indo-Gangetic plain. Though the Indus basin has a well developed canal system for irrigation, poor management and maintenance has forced farmers to rely on ground water for irrigation. With the availability of subsidised power for agricultural purpose, states like Punjab and Haryana in India once known for canal irrigation started withdrawing ground water for irrigation; thereby increasing the depth of access to groundwater levels. Deeper ground water sources demanded submersible pumps with higher horsepower drawing more energy, thus leading to the exploitation of critical water and energy resources and mounting the input cost to farmers and subsidy bills to the state.

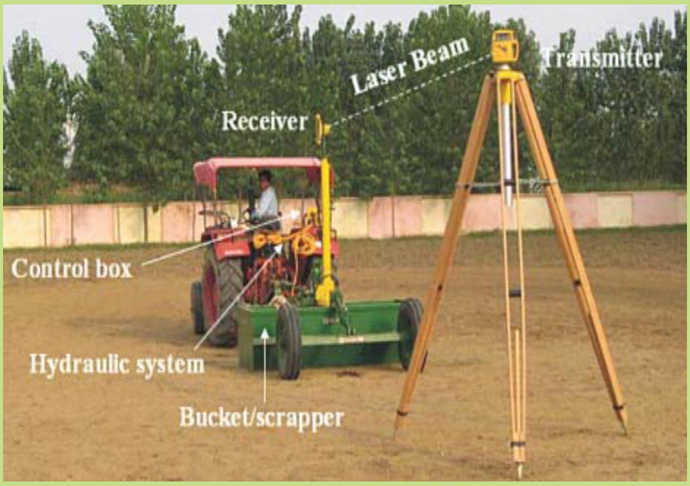
According to the Ministry of New and Renewable Energy Resources, approximately 500 Mt of crop residue of India, is generated in the country every year of which nearly 125 Mt is burned. Crop residue generation is found to be greatest in Uttar Pradesh (60 Mt) followed by Punjab (51 Mt) and Maharashtra (46 Mt).[1] Crops like sugar cane, rice and wheat generate the bulk of residue in the country.

Burning of crop residue is a common practice in parts of Indus and Ganges basin to clear the field after harvest. This has led to the wastage of nutrients in the residues which would have been recycled and also adversely affected the soil health of microbes and fauna. In this light, technological interventions, which would make use of the crop residues either as mulch or as compost, needs to be resorted to.

In this section, cases of laser leveling, zero tillage and System of Rice Intensification (SRI), have been highlighted. SRI and laser leveling make efficient use of water and energy whereas zero tillage reduces Green House Gas (GHG) emissions and makes use of the residue or stubble as mulch and helps moisture conservation and nutrient recycling.

Name of the Technology/Practice:	Laser Land Leveling
Resources Conserved:	Water, Energy, Nutrients and Labour

Description:
Laser land leveling is the leveling of a field within a certain degree of desired slope using a guided laser beam throughout the field. A laser land leveler connected to a farm tractor uses a laser equipped drag bucket to transmit laser beam readings to the control box located next to the operator. The operator can adjust the required settings according to land leveling requirement.



Mechanism of Land Leveling Using a Land leveler

Advantages:
- Saves 25-30 per cent of water
- Saves energy spent for irrigation
- Improves crop establishment and yield
- Improves uniformity of crop maturity
- Reduces weed problems
- Saves labour cost and time

Challenges:
- High initial cost of equipment
- Lack of awareness and
- Faulty irrigation practices

More details are available at: *http://www.cuts-citee.org/SDIP/pdf/Policy_Brief_on_Water-Remodelling_Water_Use_in_Indian_Punjab_for_Efficiency_and_Sustainability.pdf*
http://dswcpunjab.gov.in/contents/data_folder/laser_level.htm

Economics:
The laser leveler and tractor set costs about INR8-10 lakh. But re-leveling is not required for at least three years plus the added benefits of savings in water, energy and labour and increase in yield. Due to the high cost of the machinery, intervention from government agencies have shown successful adoption rates. However, scheduling and tertiary cost (operator, availability etc.) have caused a lapse in demand. Field interaction by CUTS suggests that farmer-led cooperative societies tend to function better due to the successful and localised rent-operate-transfer (ROT) model of business.

Change Agents: Government (through subsidies and demonstrations), farmer cooperatives/ producer organisations, CSO (awareness generation)

Supporting Partner: CRRID (Chandigarh)

Name of the Technology/Practice:	Zero Tillage (ZT) technique
Resources Conserved:	Water, Crop Residue, Cost

Description:
Zero tillage or no till farming is a cropping method in which the farm land and soil is not disturbed by tilling before crop sowing. This helps in retaining soil moisture content and reducing the cost of cultivation. In India, it is getting increasingly popular in the Indo-Gangetic Plain in sowing wheat after rice crop. The equipment uses a special drill and places wheat seeds at the right depth in the soil with minimum disturbance to soil. The paddy stubble remains intact, increasing moisture and organic content of the soil.

Zero Tillage Practice in Bihar

Advantages:
- Cost saving in land preparation
- Ensures timely sowing of wheat
- Efficient use of crop residue
- Conserves soil moisture and saves irrigation

Challenges:
- Lack of awareness/poor access to technology
- Non availability of equipment in season

Economics:
The cost of the equipment is around INR40000, but there is a resource saving effect in terms of diesel and tractor and thus the cost of cultivation.

Change Agents: Government (through subsidies and demonstrations), farmer cooperatives/ producer organisations, CSO (awareness generation)

Supporting Partner: CRRID (Chandigarh), IGS (BASIX) (Patna), NEFORD (Lucknow)

Name of the Technology/Practice:	System of Rice Intensification (SRI)
Resources Conserved:	Water and Nutrients

Description:
SRI refers to a set of practices and principles aimed to improve the productivity of irrigated rice. In this technique, 8-12 days old seedlings are transplanted in the main field with one seedling per hill with a spacing of 25-30cm. It follows the principle of intermittent irrigation or Alternate Wetting and Drying (AWD), which involves letting in a 1-2 cm layer of water and allowing it to dry until cracks become visible, at which another thin layer of water is introduced. During flowering, a thin layer of water is maintained, followed by alternate wetting and drying in the grain filling period, before draining the paddy 2-3 weeks before harvest. Early weeding using mechanical weeder (10th and 20th day after transplanting) reduces weed problems.

SRI Technique

SRI involves limited use of chemical fertilisers and promotes adequate application of organic manure.

Advantages:
- Less quantity of seed required (seed rate is 2 kg per acre)
- Savings on the cost of irrigation, seeds and fertilisers
- Early quick and healthy plant establishment
- Reduced plant density
- Improved soil fertility management
- Reduced and controlled water use for irrigation

Challenges:
- Suited to locations where good soil drainage and controlled irrigation facilities exist
- Timely weed management is a prerequisite for the success of SRI
- Demands close monitoring and good management skills of farmers

More details are available at: *http://www.cuts-citee.org/SDIP/pdf/Pamphlet_on_System_of_Rice_Intensification_(SRI).pdf*

Economics:
The yield from the crop is 2-3 times more than the traditional system. Under this system of rice cultivation a yield of 80-100 mounds (1 mound = 40 kgs) is achieved from one acre of land.

Change Agents: Agriculture and extension department of respective state governments, non-government organisations (NGOs)

Supporting Partner: RGVN (Guwahati, Assam), IGS (BASIX) (Patna, Bihar)

Case Study on Zero Tillage and SRI
Ranjit Mandal, 37 years old is a resident of Badhouna village (Haveli Kharagpur block) of Munger district. He owns around three acre of farmland in which he used to grow paddy and wheat by conventional methods with poor yields (paddy-1200 kg/acre; wheat-900 kg/acre). He was selected as a lead farmer of the area by IGS (BASIX) in the year 2012-13 and was given training on SRI, ZT and other improved agricultural practices and started following these techniques realising higher yields (paddy–SRI method–2000 kg/acre; wheat/zero tillage method–1500 kg/acre). The cost of cultivation is less in ZT compared to broadcasting method of wheat cultivation due to savings in labour cost and time for land preparation, irrigation and low seed rate compared to conventional method. The plants were also found resistant to lodging. More details are available at: *http://www.cuts-citee.org/SDIP/pdf/Case_study_on_zero_tillage_technique_in_Bihar.pdf*

2. Building Adaptive Capacity and Resilience of Small Farmers against Climate Change

Cropping season in South Asia coincides with monsoon. A delay in the onset of monsoon subsequently delays transplanting in the rice growing belts. Occasional flooding resulting from heavy rains or heat waves during summer months also affects crop production and productivity. In its field work, CUTS has found that there is an increasing demand for short duration and stress-tolerant varieties to adapt to the cropping pattern with change in climate variables, especially temperature and precipitation.

Early drought, flood, terminal heat and salinity are the most widely observed forms of stress in the Indo-Gangetic Plain. In Eastern Uttar Pradesh, NEFORD tested and screened a large number of candidate genotypes for resilience to different stresses using 'Mother' and 'Baby trials' and the promising varieties/genotypes were identified through 'Participatory Varietal Selection' (PVS) approach. The selected varieties have been promoted among farmers, as adaptation strategy to reduce vulnerability to climate change.

Given below are a few adaptation strategies suitable for various stress conditions affecting cereal systems in the Eastern Gangetic Plain promoted by CUTS' partners which can be replicated in other parts of this agro-climatic zone.

Name of the Technology/Practice:	Stress Tolerant Varieties
Kind of stress:	Drought, flood, salinity, heat

Stress tolerant varieties

- Drought tolerant rice variety (100days) - *Sahbhagi Dhan*
- Flood tolerant rice variety-*Swarna Sub1*
- Short duration heat tolerant wheat (100days) - *Halna*, NDW 1014
- High Salinity tolerant wheat variety: *KRL-19*

Cropping systems for different types of stress

- Salt affected area: *CSR-36* (rice)- *KRL 19* (wheat)
- Flood affected area: *Swarna Sub1* (Rice) - *Halna* (wheat)
- Drought-prone area: *Sahbhagi dhan/Shushk Samrat* (Rice)-NDW-1014

Economics:
The yield of *Swarna Sub 1* was 1.5t/ha higher than the parental variety *Swarna* and can withstand 15 days of submergence. Similarly, the *Shuska Samrat* and CSR 36 out yielded other popular stress tolerant varieties like *Moti* and *Sarju 52*, respectively.

In flood prone area, *Swarna Sub1* (Rice)- *Halna* (wheat) combination gave higher net returns and benefit cost ratio; *Halna* being short duration variety could complete its life cycle even when sown late whereas long duration varieties suffered due to increased temperature in the grain filling period.

Comparative Performance of Shushk Samrat vs Moti on Farmer's Field in Uttar Pradesh

Change Agents: Government agencies, CSOs, seed firms, cooperatives

Supporting Partner: NEFORD, Uttar Pradesh

Name of the Technology/Practice:	*Sanda/Kalam* method/double transplanting in rice
Adaptive condition:	Delayed onset of monsoon

Description:
The *sanda* or *kalam* method is an age old practice of double transplanting rice, which has been upgraded. For nursery, 4 kg of seed is sown in a 40 m^2 area which is sufficient for transplanting in one hectare. Seedlings are transplanted when 21-25 days old@8-10 seedlings per hill in close spacing of 5-8 cm in a small area (400 $m^{2)}$. The second transplanting is done 30-35 days after the first transplanting using normal spacing@one seedling per hill in the main field.

Double Transplanting in Rice in Uttar Pradesh

Advantages:
- Reduced seed cost
- Escapes early stage drought
- Easy to maintain nursery in a compact area with lifesaving irrigation, saving water, energy and man power

Challenges:
- Suited only for long duration varieties
- High cost of labour for two transplanting

More details are available at: *http://www.cuts-citee.org/SDIP/pdf/Pamphlet_on_Sanda_method_in_Uttar_Pradesh.pdf*

Economics: The net return in case of *Sanda* method was INR32610 compared to only INR15062 per hectare for the normally transplanted rice as the increased cost of labour is compensated by higher yields, less quantity of seeds and less number of lifesaving irrigations.

Change Agents: Agriculture and extension department of respective state governments, CSOs

Supporting Partner: NEFORD, Uttar Pradesh

3. Enhancing Productivity in Marginal Land and Assure Food Security

Increased pressure on land resources due to surge in population and urbanisation has put agricultural land at risk. Prime land is taken out of agriculture and increasingly degraded and marginalised lands are being brought under cultivation. Special management practices are required to make marginal lands productive. Given below are two examples where unproductive sandy soils and waterlogged areas can be utilised for growing vegetable crops, thereby contributing to nutritional security and farm income. These practices are relatively low cost, easy to adopt, demands little chemical inputs and are suitable for small and marginal farmers.

Name of the Technology/Practice:	Vegetable cultivation in sandy soils
Adaptive Condition:	Unproductive sandy soils

Description:
Sandy soil cultivation can be done in Char[2] areas either using pit method or gunny bag method depending on the depth of sandy layer. For sandy soils up to 1m depth, pit method can be adopted whereas in deeper soils above 1 m gunny bag method is most suited. In both the methods, a combination of cow dung and loamy soil in the ratio 1:1 is used to fill the pits/gunny bags.

These methods are suitable to grow vegetable crops like ridge gourd, bottle gourd, bitter gourd, watermelon etc. in sandy soils rendered unfit for cultivation after the floods recedes. It makes use of minimal chemical inputs like fertilisers and pesticides; pheromone traps are used to control fruit fly infestation.

Women Farmers Engaged in Vegetable Cultivation in Sandy Soils in Assam

Advantages:
- Suitable in marginal sandy soils found in Char areas in Ganges and Brahmaputra basins
- Increase in total cultivable area
- Supplements income of the local communities and helps in alleviation of poverty
- Ensures nutrition security
- Involves low capital and infrastructural requirements

Challenges:
- Assured supply of irrigation is necessary; pot[3] irrigation can be adopted if water source is far away
- Mulching is required to reduce loss of water by evaporation

More details are available at: *http://www.cuts-citee.org/SDIP/pdf/Pamphlet_on_Vegetable_Cultivation_in_Sandy_Bed.pdf*

Economics:
The cost of cultivation is similar to the regular cropping systems. Cost Benefit Analysis (CBA) for 100 pits of pumpkin shows a total production cost of INR30000, and a total income of INR85000 with a net profit of INR55000.

Change Agents: Agriculture and extension department of respective state governments

Supporting Partner: RGVN, Assam

Name of the Technology/Practice:	Vegetable cultivation in Floating Bed
Adaptive Condition:	Low-lying water logged area

Description:
Since water-logged and prolonged flood conditions are not favourable for crop cultivation, alternate methods have been adopted for vegetable farming. Using a floating mass of bio-land, floating bed agriculture has shown success in such situations. The floating bed is made up of invasive aquatic species like water hyacinth, algae, waterworts, coconut husk etc. After collecting the biomass bamboo poles are laid on it and then again water hyacinth is pulled together from both sides and compacted. This platform provides a base to raise crops on it.

For transplanting, seeds are placed in balls made of compost, manure and decomposed water hyacinth and watered regularly. After germination, they are placed on the fully decomposed floating beds (it takes 15-20 days for the bed to decompose fully).

All kinds of vegetables and paddy can be brown in these beds, however, leafy vegetables are grown most commonly. The plants grown on the floating bed get nutrition and food either from composted organics or from the water and can survive floods and water logging.

Advantages:

- Suitable in inundated coastal areas or in still water bodies where there is no tidal activity and abundant organic material like water hyacinth are present
- Increase in total cultivable area
- No additional chemical fertilisers and manure is required
- Supplements income of the local communities and helps in alleviation of poverty
- Minimal infrastructure and very less capital requirement as raw materials for the construction of floating beds are readily available from local waterways
- After cultivation, the biomass generated can be used as organic manure
- Clearing waterways is beneficial in maintaining high biodiversity

Vegetable Cultivation in Floating Beds in Assam

Challenges:

- Limited to wetlands where there is supply of fast growing aquatic weeds
- Increased incidence of pest infestation; only roguing and use of organic pesticides are advised.
- Beds should be fenced to protect against ducks and rodents
- Market accessibility is limited in waterlogged areas
- Need for awareness generation among local communities to adopt this practice

More details are available at: *http://www.cuts-citee.org/SDIP/pdf/Pamphlet_on_Floating_Vegetable_Bed_Cultivation.pdf*

Economics:
The cost of cultivation is less than the regular cropping systems since the raw materials are readily available from the water bodies. Cultivating vegetables in seven beds incurs a cost of INR750, generates an income of INR2940 and a profit of INR2190.

Change Agents: Agriculture and extension department of respective state governments

Supporting Partner: RGVN, Assam

4. Sharing Successful Models of Institutional Frameworks for Enhancing Skills

Weakened forward and backward linkages often limit the access of small farmers to inputs, credit and markets; adversely affecting agricultural production and farm incomes. Collaborative structures between farmers input providers, credit services, extension agencies and private sector would build the institutional capacities of farmers and enhance their marketing power enabling them to generate higher margins. Cooperative Societies, Farmer Producer Organisations/Companies, Farmer's club, Self Help Groups etc. are common forms of collaborative structures in South Asia. The success of these institutions depends on the entrepreneurial skills, market linkages and credit support which result in improved market intelligence, collective marketing strategies and farm management techniques.

Market Extension Exercises with LSPs in Assam*

In order to address the institutional gaps in the rural economy for service provision and technology dissemination, RGVN initiated an innovative approach benefitting 5000 marginal farm households in the flood prone plains of Brahmaputra, covering six districts. 108 progressive farmers were given intensive training on agricultural technologies through extension agencies and equipped as Local Service Providers (LSPs).

These LSPs receives bi-monthly skill updates from extension agencies. In a demand-led approach, a beneficiary household is consulted on which service provision and technical training sessions with the LSP they would like to enter. This is against a fee payable by the beneficiary household to the LSP in return for the services and training.

This improves the technical/management capacities of the target groups, as well as establishes linkages between extension agencies and LSP amongst the wider beneficiaries.

The LSP Association at district level has developed linkages with input dealers and these associations encourage production according to market demand through Market Extension Exercises and Match Making Workshops.

** Supporting Partner: RGVN, Assam*

Way Ahead

Promotion of efficient use of natural resources as well as building adaptive capacities of small and marginal farmers demands strengthening of research and extension services. Through its interactions with farm households in South Asia, CUTS has recorded that farmers mostly rely on progressive farmers, relatives and neighbours for information on new technologies except in Bhutan and Bangladesh where government led extension services were found to be effective.[4] This underpins the role of informal social networks in the adoption of technologies by farmers as in the case of laser level technology (Nathan, *et al*., 2013) and also necessitates capacity building of extension staff at the professional level. Diverse sources for providing extension services involving government, NGOs, private sector and universities offer greater choices to farmers and can cater to the specific needs at farm level.

There is also a need to identify good agricultural practices at the local level and scale up through standardisation of agronomic practices wherein research faculty in both public and private sectors can contribute. Development of stress-tolerant varieties and conservation of hardy indigenous varieties through participatory breeding programmes would popularise their use. Governments can support the cultivation of stress tolerant varieties through on farm demonstrations and developing a seed value chain. Cultivation practices suited to specific ecosystems like vegetable cultivation in floating beds and sandy soils need to be promoted in appropriate locations.

A prime concern of farmer regarding adoption of any new technology is its cost. It was observed by NEFORD that even when *Swarna Sub1* variety of rice could withstand submergence for 15 days, the long duration and labour shortage for rice cultivation prevented farmers from its adoption. Since it was of 150 days duration, farmers have to forego the *Rabi* crop in the following season. To overcome these problems, NEFORD advocated direct seeding of *Swarna Sub1* as a labour-saving device in *Kharif*, followed by zero till sowing of a short duration heat tolerant wheat variety, like *Halna* in *Rabi* which was readily accepted by the farmers. Likewise, cost effective technologies suited for different cropping pattern have to be designed to meet the requirements at local level.

Inclination of farmers towards indiscriminate use of nitrogenous fertilisers like urea is attributed to its subsidy. Though farmers are aware of benefits of Farm Yard Manure they are reluctant to its application because of non-availability in required quantity and cost. Removal of input subsidies might lead to judicious expenditure of money to purchase fertilisers and alternate sources of nutrients for improving soil fertility. Recycling of crop residues, crop rotation with pulses, composting and crop diversification would lead to better and efficient use of soil nutrients. Incentives in this direction would promote crop residue management and sustain soil productivity. Furthermore, market-oriented agriculture production would be an added incentive for crop and product diversification.

Similarly, heavily subsidised electricity for irrigation has resulted in depletion of ground water resources. Use of axial flow pumps in surface irrigation systems, energy efficient and solar pump sets can save energy. Capital subsidies to laser levelers, zero tills and solar pump sets to producer organisations and cooperatives can make these technologies accessible to small and marginal farmers. Adequate credit support through financial institutions will also play a crucial role in popularising technological interventions. Establishment of agro-service centres at the local level is vital for the use and promotion of new machineries and implements. Skill development of all players in the value chain is also essential in this regard.

Similar agro-ecological situations exist in the Eastern Gangetic Plain (comprising of Bangladesh, India and Nepal) and in the Indus basin of India and Pakistan with more or less similar food production systems. Agricultural technologies, practices and policies in one country can be embraced in analogous ecosystems existing across borders. Thus, there is great scope of knowledge sharing of climate resilient agricultural practices within South Asia; critical given that the region is becoming increasingly susceptible to climate change. Generating awareness among the farming community, strengthening research, credit and extension services, integrated and inclusive planning, reviewing agricultural policies and subsidies at national levels would facilitate infiltration and greater adoption of sustainable agricultural practices. Use of mass media and information technology, decentralising provision of extension services by engaging progressive farmers at the community level, organising farmers into producer groups and market-led innovations in agriculture would enable better dissemination of knowledge and delivery of services.

Endnotes

1 MNRE (Ministry of New and Renewable Energy Resources). (2009) Govt. of India, New Delhi. www.mnre.gov.in/biomassrsources.

2 Mid channel bars of the river Brahmaputra and its tributaries, are locally referred to as a char area

3 A pot with water is set over each pit. A pore is made under the pot to ensure the desired water flow for the plant. The pot needs to be filled up with water when it is empty.

4 'Rethinking Perceptions – Agriculture, Water and Energy Scenario in South Asia', CUTS International (Can be accessed at: *http://www.cuts-citee.org/SDIP/pdf/Rethinking_Perceptions_Agriculture_Water_and_Energy_Scenario_in_South_Asia.pdf*)

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