Socio-Technical Manual

for Training of Trainers

Manual on Participatory Planning, Technology, and Knowledge Transfer of Eco-Village Development in India, Nepal, Sri Lanka and Bangladesh

Socio-Technical Manual for Training of Trainers: Manual on Participatory Planning, Technology and Knowledge Transfer of Eco-Village Development in India, Nepal, Sri Lanka and Bangladesh

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1. Introduction to Manual on Training of Trainers (TOTs) on Eco-Village Development (EVD)

'Global Warming' and 'Climate Change' have been pivotal issues of concern for all of humanity for the past several decades. At the global level, various conventions, conferences and international agreements have centred around limiting and reversing the impact of rising global temperatures. There is now a widening consensus that rather than the previously agreed threshold of a 2 ^{O}C limit to temperature rises (over pre-industrial levels), we collectively need to try to not exceed a 1 to 1.5 ^{O}C increase if we are to prevent catastrophic impacts on smaller island nations and coastal areas. With its impacts stretching beyond the global commons, climate change is an international political issue with several levels of inter-governmental negotiations being held to seek a valid solution. Meanwhile, despite the great public awareness and global political momentum over climate change, its repercussions have already been felt by the most vulnerable people of the world, a large swathe of people living in developing countries, especially in the remote and far flung and hilly and mountainous regions, desert climates and coastal areas.

Instead of living with the "Wait and Watch Syndrome", allowing meaningful action to be orchestrated through a slow "Top-down Approach", the time is now ripe to "Think Globally and Act Locally", and by using "Bottom-up Approach". This can be done effectively and in a sustainable manner, through the promotion and implementation of many micro-levels, people-cantered actions at the grassroots level.

The most appropriate action, which can be replicated sustainably, is by working at the village level. By considering each village as the smallest unit of development, we can actively promote local people's participation in the planning, implementation and management of appropriate activities based on the analysis of their implementation capacity and their needs. By implementing sustainable technologies and methodologies, we can mitigate the negative impact of climate change, and increase the climate change adaptation as well.

In this publication we show that instead of using (1) a 'Purely Technical Approach' (PTA), the best approach to follow is (2) a 'Socio-Technical Approach' (STA) to implement development programs related to climate change challenges faced by us at present as well as in future.

The Purely Technical Approach (PTA) may be easier to implement and might take much less time, as it is based on high quality technical expertise and centralised action. The professional expertise that accompanies this approach is not normally available locally and is, instead, drawn from external sources using a top-down approach to implementation. However, without the participation of local people, in many cases the actual beneficiaries only remain spectators, without understanding anything technical. Therefore, the PTA can neither sustain itself nor can be replicated effectively.

From experience it has now been recognised that while technology is 'Size Neutral', it is neither 'Resource Neutral' nor 'Poor People Neutral' nor 'Gender Neutral'. Therefore, if a purely technical approach (PTA) is followed in any development program it only benefits the people with resources, who can buy these technology or technical solutions. Whereas, the resource-less people, poor, deprived, marginalised and women normally don't get the desired benefits, and are often bypassed. In fact, instead of getting empowered using the purely technological solutions, such group often get even more side-lined.

On the other hand, the Socio-Technical Approach (STA) of planning and implementation recognises that in a village setup, the major asset of the poor, deprived, marginalised and women are their labour, which needs to be effectively leveraged to create human capital to empower them.

Instead of exploiting such groups, the technology should become sub-servient to them, acting only as one of the important tools for their development and empowerment. For example, (a) participatory development of technology, namely Grameen Bandhu household biogas plants by INSEDA (India) with the grassroots support of WAFD (India); (b) development of appropriate financing and credit system for the promotion and implementation of Solar PV systems by Grameen Shakti (Bangladesh); (c) development of rural artisans backed by the back-up support of marketing of appropriate technology, namely promotion and implementation of Anagi improved cook stove by IDEA (Sri Lanka); and (d) upgrading of traditional technology for harnessing water energy, namely improvement of traditional water mills for income generation by local people by CRT/N (Nepal). In all these four examples from various geographical settings in South Asia, 'Social Engineering' was used by the four national NGOs as one of the key approaches for development, promotion and implementation of technology for the empowerment of the marginalised groups of rural people, by keeping the target group in the centre of the development (instead of the technology). Therefore, this approach for promotion of technology is called as the Socio-technical Approach (STA) to development.

The common thread in all the four above mentioned examples is the capacity building of local groups for the transfer of knowledge and skills upgradation. The external agencies following the STA as their development objective, also use external resources, for both establishing of training-and-demonstration units, as well as, for building the local human capital for promoting long term sustainability. In addition, time and expertise are also used for upgrading and strengthen the local people/community, to be able to perform a participatory analysis of the problems and to learn to find the local solutions based on their local and traditional knowledge, skills and their own expertise and technical capacity.

The empowered local people by following the STA approach, are also able to look at new solutions to solve their age old and new problems, based on new knowledge gained and skills acquired from the development oriented external experts, who have expertise and appropriate experience in transfer of 'Knowledge and Technical Skills' at the grass-roots level.

The gestation period required for noticeable concrete results and impacts in the case of STA might be comparatively long. However, this approach can lead to various co-benefits like income generation, the creation of regular livelihoods for the local villagers by using their own locally available or locally generated natural and other resources, sustainability and replicability potential.

Socio-Technical Approach (STA) Driven Eco-Village Development

This publication is focussing on using the Socio-Technical Approach (STA), at the village planning based on the solutions of the "Eco-Village Development" (EVD) Concept. Our experience shows that the EVD concept is one of the best approaches for the regeneration of natural sources with the participation of local people, implemented in a decentralised manner. This is based on the use of local solutions that employ low-carbon, pro-poor, green technologies that are environmentally benign and eco-friendly.

In EVD, the village is the major focus with implementation of appropriate and replicable technological solutions for climate mitigation and adaptation as well as development of people and poverty reduction. Solutions include e.g., improved smokeless cookstoves, household size biogas plants, solar energy technologies (such as solar drying units, solar cells for lighting), and improved water mills; adaptation technologies include improved, organic farming, roof-top rain water harvesting units/systems.

The emphasis is on solutions that can be easily implemented by local NGOs and other grassroots development agencies with appropriate modifications and capacity building of their functionaries based on their needs and environment. Befitting the context, these EVD solutions have comparatively lower costs than the centralized solutions which make them more affordable, they are more easily operated, cared for, maintained, repaired and managed by the local villagers.

The EVD concept includes adapting solutions to local needs and circumstances while including a bottom-up, multi-stakeholder approach, gender mainstreaming, and appropriate technology transfer.

South Asia is a region with a large rural population with a majority living in subsistence conditions. While the experience of NGOs, who have been promoting a single technology in rural areas, have been very encouraging, but they also recognise that to promote the sustainability of the entire village community, integrated solutions that address food, energy, water and livelihood security are essential.

In South Asia, about 1.5 billion people struggle for access to energy, sanitation, safe drinking water, nutrition, and health services. While improvements have been made for many over the years, climate change makes the situation worse in many places in the region. Heat stresses, floods, extreme storms, deforestation, rising sea levels at coastal areas etc., all resulting with decreased agriculture areas, decreasing crop productivity, and less fuel wood.

For instance, India is home to over 600,000 villages, some of which are in remote and far-flung areas of the country. These vulnerable areas are, where the Eco-village development (EVD) concept can play an even more important role, by decentralised action for the promotion and implementation of local solutions based on a socio-technical approach.

This publication describes and illustrates some of these EVD planning methods, and sustainable technologies, and their climate mitigation and adaptation roles, in the hope that it can be useful for the future village development planners, facilitating NGOs, CSOs, voluntary organisations, trainers, and training of trainers (TOTs) so that can be replicated more widely as a part of a sustainable strategy to build climate change resilience that would effectively contribute to climate mitigation and adaptation, as well as appropriate village and rural development.

2. Participatory Planning of Eco-Village Development (EVD)

Participatory planning meeting in Sri Lanka

Introduction

The Eco-village Development (EVD) is an integrated socio-economic development concept, in which existing villages are taken as the smallest unit for action normally by external agencies, like NGOs, (Non-Government Organisations) CSOs (Civil Society Organisations), VOs (Voluntary Organisations) and DOs (Development Organizations). Therefore, for the success of any EVD program, it is important to ensure participation of the target groups, especially the women of the community. The difference between the Eco Villages (EVs) in the developed countries and the EVD programs in developing and emerging economies, especially in regions like South Asia, is that in the former case, like-minded group of people already interested in the eco-village concept, come together and identify an appropriate place and then build communities from scratch. These are intentional communities. In the latter case, the eco villages are developed around existing village communities. These communities practice age old customs and follow more traditional practices.

External agencies, who wish to transform the existing villages into sustainable Eco-villages, should be using a participatory methodology as a part of their development strategy. This is done to help improve and upgrade locally available knowledge related to energy, livelihoods and food security, and tools based on traditional knowledge and skills of the target groups. Ideally, the external agencies follow participatory development methods, capacity building and technological improvements and upgradation in existing local technical solutions, to match the community needs. This is done in a way, so it can be managed by the community themselves using their own resources and newly acquired skills for the effective care, service, maintenance and repairs of technologies and their management on a sustainable basis.

To ensure success, the external agencies normally follow a socio-technical approach (STA) for developing and innovating the technological solutions, so that they fit within the socio-cultural milieu of the target villages. The training in operational, daily care and maintenance aspects are provided by the external agencies. This process continues into the future, as well with the implementing, providing on-going back-up support and hand-holding and refresher trainings, as well as training of trainers (TOTs) to of the target group till the local community can manage these resources themselves well on their own.

The best technique to follow for the participatory planning with rural people is the Participatory Rural Appraisal (PRA) approach, which can be appropriately modified based on the local situations.

Effective PRA exercises involve assembling a team that is cross-disciplinary and from different backgrounds to allow a wealth of diverse perspectives. The village participants should also have a mix in terms of gender, age, caste, economic status, livelihoods and so on. Knowledge should flow both ways between the planning and implementing agency and the target beneficiaries. In rural settings, in the developing countries, especially in South Asia, the women can be more reserved while sharing their opinions even though they are critical stakeholders in the development process. Humility, openness and patience would be the key for success. To sensitively address their shyness, cultural taboos and biases the women resource persons from the side of implementation agency would help in this regard.

The basic steps and process of Participatory Rural Appraisal (PRA) are briefly described in the sections below:

Objectives of PRA

There are four main objectives of the PRA concept: (a) putting the beneficiaries first to ensure a contextually appropriate set of solutions for them; (b) recognition of local knowledge as an important component to solution finding and the project of development; (c) effective project development and implementation; and (d) creating an effective model that is sustainable and resilient beyond the project period.

Principles of PRA

There are five key principles that form the basis of any PRA activity no matter what the objectives or situations are:

1. *Participation:* Local community participation is key in planning activities as well as knowledge sharing and transfers. This includes the transfer of knowledge related to local customs that can smoothen out the implementation process.

2. *Flexibility:* The amount of resources available in the project site, the skills and size of the implementing team and the time frame for the implementation all play a role in determining the flexibility available to respond to various challenges.

3. *Teamwork:* A strong team consists of a mix of locals with a sizeable proportion of women in the group, a mixed interdisciplinary team of socio-technical experts and people with knowledge of the local language and implementer's language to ensure better communication.

4. *Optimal Ignorance:* Efficiency also involves collecting only that information which is required to run the project effectively. No extraneous (unnecessary) knowledge needs to be collected as it is a waste of time, money and human resources.
5. *Systematic:* Alternative non-quantitative statistical methods have been developed to ensure the validity and reliability of PRA exercises. These include sampling methods that cover a cross section of people across castes, incomes, education and cross-checking through meetings with community members to check for inconsistencies.

Important Tools and Components of the PRA

There are a wide range of participatory tools and techniques available to conduct a PRA exercise and what is used depends upon the context. Some of them are described below:

Semi-Structured Interview

Semi-structured interviews are partially structured conversations that allow information gathering in a more flexible way. While the broad guidelines are put in place, new lines of questioning are allowed to naturally come up based on the information shared by the interviewee. This style is more relaxed and is more suited to topics that the villagers are more comfortable and interested in. These interviews should be conducted in pairs since they go off-script and so one person can take down all the notes. Questions are generally more open-ended, and the interviewer should be trained to pick on different cues for questioning.

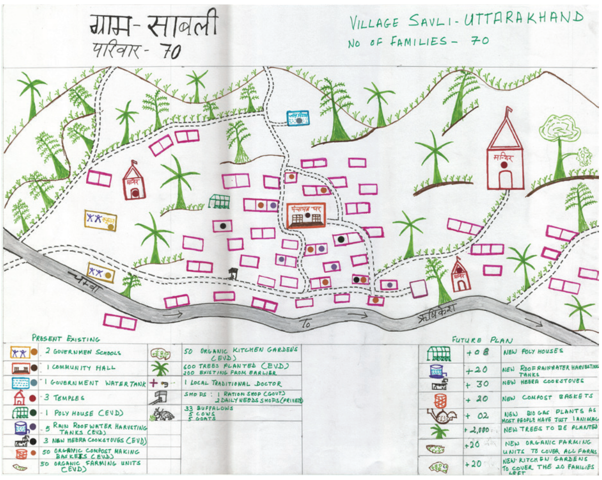
Procedures for a Semi-Structure Interview

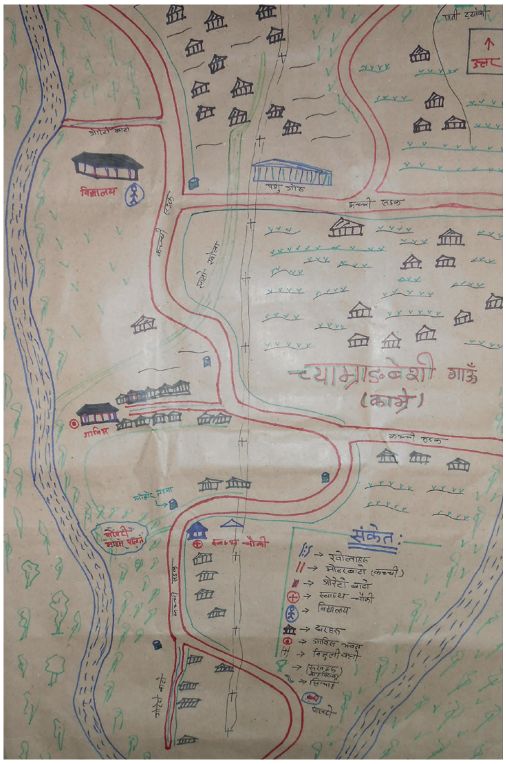
- A checklist of topics and questions should be prepared.
- A good cross-section of interviewees should be selected from various religious groups, interests, both genders and so on.
- Trained and well-prepared interviewees are a must. They should be patient and sensitive listeners, tuned to various nuances so that they can ask the right follow-up questions.
- Flexibility should be allowed but the broad questions and format should be also followed for easier organization and to ensure that the relevant points are covered.
- Open-ended questions are important, not just yes-no questions. This allows the interviewees to be more descriptive.
- Based on the interview, relevant themes can be added.
- Note taking or recording the interviews in some form is important. In some cases, a recording device might make the interviewee uncomfortable, so this must be borne in mind.

Maps

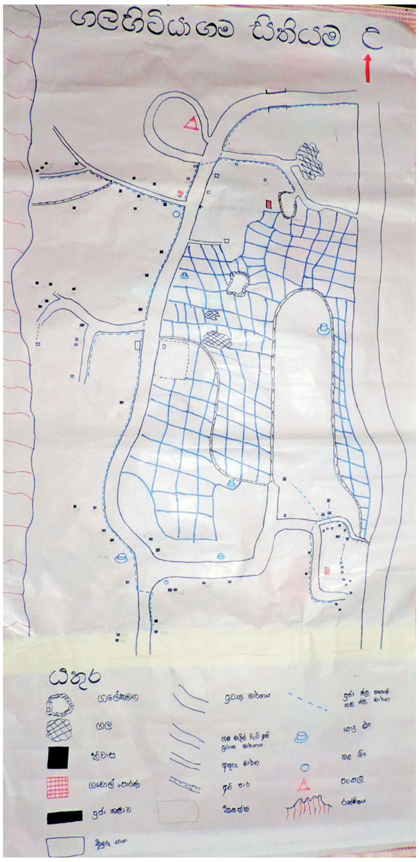
Participatory mapping is an important tool for gathering baseline information. However, even though these maps are not always accurate in scale, they do give a good idea of the resources, buildings and even perspective of the area shared by the participants.

- Participatory mapping shows the resources, buildings, trees, places of importance to the various groups in a community. These are mental representations of a village; therefore, it isn't unusual to see an emphasis on different assets and resources based on age, gender, class, employment etc.
- The maps should be verified with other village members and the observations of the PRA team as well. It is ideal to draw the maps from a high vantage point.





Participatory mapping of EVD villages by INSEDA in India (top left and bottom right) and village resource mapping in Nepal (top right) and Sri Lanka (bottom left).



Village Social Mapping

In constructing social maps, the participants draw out all the infrastructure, key buildings, installations and social facilities such as places of worship, schools, health centres, medium and small size biogas plants, wells, water reservoirs, libraries, roads and footpaths, doctors, shops, small industries, and so on. These maps should be made with separate groups to allow cross-checking. Men and women can be segregated into different groups since they perceive things differently. It must also be ensured that the participants understand the purpose of the mapping exercise and what is meant to be covered. These maps serve as quick visual depictions of the major facilities and layout of the village. They give a good idea of the social institutions and people living there, the number of households, the gaps in infrastructure and so on. They also help serve as a diagrammatic baseline study that can help with planning, implementation, monitoring and evaluation.

Some of the following aspects can be discussed and covered in the social mapping exercise:

- Number of households and whether there has been any change over a time frame and if so, why.
- Composition of the households and employment type, incomes (if available), education and even which households are led by women.
- Places of community significance or of significance to different groups. For instance, this can cover places where villagers or different groups assemble.
- Demographic details related to caste, ethnicity, and class and so on. This can help with targeting programmes and certain interventions.

More details regarding this process is in the next chapter, and in the case studies of India and Sri Lanka in the appendix.




From top left to bottom right: Villagers in EVD villages in India (INSEDA), Sri Lanka (IDEA), Bangladesh (Grameen Shakti) and Nepal (CRT/N) participating in village social and resource mapping.

Village Resource Mapping

The village resource map is a diagrammatic representation of the various resources in the village that includes land, water, and energy (e.g., fuel available for cooking and lighting) livestock and so on. The map should depict the various resources including those available in abundance and those that are scarce (for instance, land, fruit trees, potable water, resource plants e.g., bamboo). The exercise should also indicate whether everyone has access to land, income levels, resources that are most in need, division of labour, water sources and so on.

As with the social mapping exercise, the resource map should also be made by separate groups with men and women represented.

Transaction (or Transect Walks)

Transect walks allow the cataloguing of the location and distribution of various resources, land use, infrastructure and so on in the community. This is an observation-based method in which participants walk across a defined area or path and allows the selection of a site, the verification of data drawn through other exercises (triangulation).

The process involves marking out a route or path for the transect walk. The participants can be divided into several smaller groups. A facilitator, who is a trained local person, and can guide the walk, ask probing questions and take down notes, should accompany them. The groups should be briefed on the objectives of the walk beforehand and explained the methods they need to use to collect their observations. At the end of the walk, the groups share their observations with everyone in the form of an oral and visual depiction.

Timeline (Historical Mapping)

Historical mapping allows the villagers to document changes in natural resources, environment, land use, the village's growth and so on over a period. This exercise is especially useful when trying to trace gradual changes in the village ecosystem. This helps trace the origin of a problem and visualize the future progression as well. An example of timeline mapping is tracing environmental degradation, deforestation, soil erosion changing rain fall pattern, biodiversity, effecting micro and macro flora and fauna etc, destruction of man-made wild life habitat, leading to human and animal conflict, noticeable seasonal variation and climate change, fall in agricultural productivity, decreasing water resources over time.

Seasonal Calendar

A seasonal calendar helps analyses patterns in the village, giving information on time and labour allocation over the year for the community members. Some of the aspects that should be covered are the changes in incomes and expenses over the year, agricultural productivity, months with scarcity of food and fodder, rainfall patterns, when agricultural work is carried out by men or women, and availability of water. Is there a different season when men are active and when women are active, non-agricultural load on men and women, availability of fodder and fuel wood and so on?

Labour Schedules and Daily Schedules

Labour schedules allow for a candid discussion on the pattern of labour division and the gendered division of labour. It helps visualize the distribution and management of labour resources and labour intensiveness of various activities as in farming, livestock management, household management, selling/marketing of their on-farm and off-farm produce and so on.

Daily schedules identify routine activities and show how labour is allocated during various times of the day, peak labour hours, off-hours and so on. It also acts to illustrate the value and amount of work that women often end up doing.

Wealth Ranking

Wealth ranking shows the economic status of the various community members and can illustrate the link between social status and economic status. It also helps draw out whether there is very inequitable distribution in income and identifies the very poor as well.

Participatory Technology Development (PTD)

The Participatory Technology Development (PTD) is a method that involves open and detailed discussions with the intended beneficiaries to understand the technological interventions that are most suited for them. It is a collaborative approach that generates feedback regarding interventions allowing for the possibility to design socio-technical solutions that better meet the needs of the end users.

PTD also calls for ongoing feedback sessions so that iterative changes can be made especially while testing, developing and innovating newer technologies.

During the sessions, some of the tools are the Problem/Solution Matrices and Dream Village Mapping based on the Resource Maps. These help in visualisation and create common understanding. Read more in these tools in the next chapter and in the village case studies.

Village resource and "Dream Village" mapping in Nepal.

3. Planning and Organizing Implementation of EVD Program

Mapping excercise in Sri Lanka.

Introduction

For the successful implementation of the Eco-Village Development (EVD) or any development program, the participation and involvement of local people (target group) is essential from the beginning of the program, starting from the needs assessment to planning the implementation strategy. Development must be seen more as a positive change from the bottom up than from top down and the role of the external NGO staff and external experts should be that of facilitators and guides. Participatory planning is a process by which a community undertakes to reach a given socio-economic goal by consciously diagnosing its problems and charting a course of action to resolve those problems. Doing so allows the beneficiaries to feel more closely involved in the planning process and are more invested in the project's implementation and successful outcome. Plans prepared by outside experts, irrespective of their technical soundness, cannot inspire the people to participate in their implementation.

The following sections outline the broad steps involved in participatory planning and community involvement in the projects as a precursor to implementation.

Planning

Resources are scarce, but our needs are unlimited. Therefore, we must select and prioritize our needs to make the best use of such resources and to utilize and manage resources accordingly. At its simplest definition, the planning process is what helps make the ideal selection of priorities. Prior to acting to achieve an objective, a process of preparation is required.

Different Types of Planning

The relevance of planning runs from the macro level in the form of national planning, devolving all the way down to the village and individual level. However, the planning process is common to all projects large or small.

The first step in planning is drawing out the list of objectives which flow from the bottom up. In the case of EVD, these objectives can range from increasing access to clean energy for the village, to increasing knowledge about the impacts of climate change. The planning process flows like a cycle, hence, the name planning cycle. It includes a few interconnected steps which are illustrated in the image below.

Step 1 - Assessing the Current Situation
Planning is carried out to change the current situation and this requires collecting baseline data against which to measure the extent, magnitude and nature of change we hope to see.

Step 2 - Identifying the Problems
A problem is an unsatisfactory situation indicating a difference between the current situation and the expected situation. When this difference is viewed negatively, it is a problem. Viewed positively, it indicates potential and an opportunity for development.

Step 3 - Analysing the Problems
Problems that are identified. For example, the loss of income is a problem, and the various factors leading this problem need to be considered. In this case, it is possible that the loss of income is due to lower agricultural productivity because of lower rainfall and rising temperatures due to climate change. Therefore, all these roots contributing factors need to be addressed to draft a suitable solution.

Step 4 - Establishing Objectives
The situation that is expected after solving the current problematic situation is an objective.

Step 5 - Prioritising Identified Objectives
Resource scarcity necessitates the prioritization of key objectives. By employing a more scientific prioritisation we can select that would enable maximum benefits from the meagre resources available.

Step 6 - Identifying Strategies to Achieve Prioritised Objectives
In order to realise the objectives, the strategies identified have to be activated. This includes the activities to be carried out, the required resources, the time frames for implementation, the parties responsible for various activities, the process for reviews & evaluations will be carried out and so on.

Step 7 - Implementation
An institutional structure having qualified human resources with clearly delegated responsibilities, and coordinated working is required for implementation.

Step 8 - Evaluation
Evaluation needs to be continuous based on various milestones. During implementation, this is critical for course correction to find out whether the objectives are being reached. Post-implementation evaluation helps us determine whether the expected objectives have been achieved, to what extent and how well they have been achieved, reasons for successes and failures, and lessons to be learned are being found out through evaluation.

From top left to bottom right: Participatory planning meetings with village elders and women in EVD villages in India (INSEDA and WAFD), Sri Lanka (IDEA), Bangladesh (Grameen Shakti) and Nepal (CRT/N).

Collecting Basic Data Using Participatory Rural Appraisal (PRA)

- Once local contacts are established, the next step is to collect, with the people's help, basic data about the community, characteristics of the area, resources situation, socio-economic status and other relevant facts, using the broad principles and techniques of PRA.
- The aim is to get a factual baseline picture which will help in setting goals and measuring changes brought about by the EVD project at a later stage.
- It is helpful at this stage to associate with local officials and NGO and VO functionaries in collecting and verifying facts from different sources.
- To seek people's cooperation, it is important to respect their ideas and abilities. The focus should be on the community as a whole and seeking its commitment to make the project successful.

Participatory Rural Appraisal (PRA)

This is a practical tool for participatory data collection and analysis.

Participatory Rural Appraisal (PRA) as covered under chapter 2, involves active people's participation, by following a set of informal techniques used by development practitioners in rural areas to collect and analyse data. Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) were developed in the 1970s and 1980s in response to the perceived problems of outsiders missing or mis-communicating with local people in the context of development work. In PRA, data collection and analysis are undertaken by local people, with outsiders facilitating rather than controlling.

When to Use the PRA

PRA supports the direct participation of communities, with the target groups themselves becoming the main investigators and analysts. The community together with the facilitation of the NGO team sets the priorities; determines problems and needs; collects, documents, and analyse data; and plan and implements solutions based on their findings based on people's participation. The entire exercise should be so engaging that the target group starts enjoying the exercise and becomes more involved and committed to give out information and solutions based on their understanding of the local solutions.

Actions stemming from PRA tend to assist the external facilitator and the team to extract relevant information from the local communities, especially the women, marginalised, poor and deprived groups, as they get the chance of being heard, for the preparation of a realistic action plan with the active participation of the local community. Outsiders should recognise that they are there as facilitators and must not direct it. To conduct the PRA in an effective manner, it is desirable to have a multi-disciplinary team, consisting of individuals with background of social sciences, women development, and appropriate technology. The team leader/facilitator should have good overall expertise, as well as experience in managing such teams for under taking the PRA exercise. The PRA uses group animation and exercises to facilitate information sharing, analysis, and action among stakeholders.

PRA is an exercise in communication and transfer of knowledge. Regardless of whether it is carried out as part of project identification or appraisal or as part of country's economic and sector work, the learning-by-doing and teamwork spirit of PRA requires transparent procedures. For that reason, a series of open meetings (an initial open meeting, final meeting, and follow-up meeting) generally frame the sequence of PRA activities. A typical PRA activity involves a team of people working for about two weeks on workshop discussions, analyses, and fieldwork. The reason for the entire participatory planning exercise taking about two weeks is that the rural people, especially the women have many other work and household chores to do, so they could spend maximum of half day at a time.

How to Make and Use Participatory Mapping

- Create a wall, big poster or ground map with group participation. Members should do the marking, drawing and colouring with a minimum of interference and instruction by outsiders.
- Using pencils, pens or local materials (e.g. small rocks, different coloured sands or powders, plant material) group members should draw maps that depict/illustrate certain things. Each group member is then asked "to hold the stick" to explain the map or to criticize it or revise it.
- Create resource maps showing the location of houses, resources, infrastructure and terrain features-useful for analysing certain community-level problems.
- Create social maps, showing who is related to whom and where they live. This is useful in conducting PRA baseline surveys, etc.

Seasonal Calendars

These charts show monthly changes in climate (rainfall or temperature) or agricultural activities (agricultural hours worked, different activities undertaken, crop cycles). The calendars are useful in identifying planting and harvesting times, labour constraints and marketing opportunities.

Matrices

These are grid formats used to illustrate links between different activities or factors. They are useful in information gathering and analysis. An example is "problem-solving matrices", where a series of problems affecting a group are placed on the vertical axis and their possible causes placed on the horizontal axis as below:

For example, if there is a problem where the members of the *mahila mandal* (women's group) or self-help group do not come to the monthly meetings we can try to find the cause jointly by making the following matrix.

Problems	**Possible causes**		
	Other work	No profit	Distrust of leader
Low member attendence			
Low saving			
Lack of unity			

The matrix technique is useful for identifying and prioritizing problems, in spotting inter-relationships, etc., Some examples for problems listed could be: bad harvest, lack of water, or fuel wood, and using a lot of time to get these; darkness in the evening. LPG is available, but expensive, difficult to carry, and food does not taste the same, and therefore using inefficient stoves without chimney. Smoke in the kitchen causing eye infections, lung diseases etc.

The problems listed also helps in identifying the solutions needed to solve the problems or part of them. Read more in the case studies in the appendix and in the different technology chapters following this.

4. Cooking Solutions and Improved Cook Stoves (ICS)

Introduction

At present, close to half of the world's population (approximately 3 billion people) use solid fuels for their domestic energy cooking needs. Among those who use indoor cooking stoves, the poorest communities living in rural areas, up to 90% of households, continue to rely, and most frequently use solid fuels, such as coal, wood, charcoal, animal dung and crop residues. Over the years, the individuals and the rural communities developed and innovated various types of traditional cook stoves for cooking food based on their local needs and type of food eaten by them.

Solid fuel burning in simple stoves in poorly ventilated kitchens is a significant source of indoor air pollution. Solid fuel smoke contains thousands of substances, many of which are hazardous to human health. However, most of the well-understood substances are carbon monoxide (CO); small particulate matter; nitrous oxide; sulphur oxides; a range of volatile organic compounds, including formaldehyde, benzene and 1,3-butadiene; and polycyclic aromatic compounds, such as benzoic-a-pyrene, which are thought to have both short and long-term health consequences.

It is estimated that 4% to 5% of the global mortality and disability-adjusted life-years are from respiratory illnesses, such as asthma, lung cancer, ischemic heart disease, and blindness. Many of which can be attributed to solid fuel combustion when cooking and from indoor pollutions from traditional cook stoves in South Asia and other developing countries.

Households in developing countries consume significantly less energy than those in developed countries; however, over 50% of their energy use is for cooking food. Many of them also spend considerable part of their income purchasing wood or charcoal for cooking.

The health problems from cooking over a traditional open fire or simple stove can include lung and eye ailments as well as many other illnesses, and even birth defects. The health problems associated with cooking using biomass in traditional stoves affect mostly women and children in rural areas, and especially the infants as they spend the maximum time with their mother near the domestic stoves. Replacing the traditional cook stove or fireplace with an improved cook stove with better combustion and often with release of the flue gases through a chimney or exhaust pipe out of the house can significantly improve a family's health.

Moreover, deforestation and soil erosion are often the results of harvesting wood in an unsustainable manner for cooking fuel.

In South Asia the largest number of poor people is living in rural areas, and about 75-80% of the rural population use, either traditional or improved cook stoves for cooking. Improved cook stoves are gaining in popularity, but even in Sri Lanka, where the success is probably the highest, still around half the families that cook with wood use simple stoves or fires.




From top left to bottom right: Use of Improved Cook Stoves (ICS) within the EVD project by four NGO partners: By CRT/N in Nepal, by INSEDA & WAFD in India, by Grameen Shakti in Bangladesh, and by IDEA in Sri Lanka.

Benefits of Improved Cook Stoves

To mitigate the problems of traditional cooking, improved cook stoves (ICS) are promoted in all the South Asian countries. These ICS are designed, developed and innovated by designers to reduce the fuel consumption per meal and to curb smoke emissions from open fire inside the dwellings in the developing countries, during cooking. The main goals of most improved cooking stoves are to reduce the negative health impacts associated with exposure to toxic smoke from traditional stoves and in parallel to reduce the pressure placed on local forests by reducing the amount of wood the stoves consume.

Climate Mitigation Aspects

Traditional stoves are also substantial contributors to climate change. One reason for this is that inefficient use of wood easily leads to deforestation, and wood use from deforestation is as bad for the climate as fossil fuels. Both types of fuel give CO_2 emissions, the most common driver of climate change; and another reason is that part of the smoke, the black carbon (elemental carbon), is in itself a driver of global warming. So even when the wood for traditional stoves is grown sustainably and no deforestation takes place, they contribute to climate change.

ICS usually save half the wood use and produce less black carbon smoke. Therefore, they are reducing the global warming. For each household, the reduction is typically about 4 tons of CO_2e per year with change to a good improved cook stove. This is a high reduction compared with the relatively low greenhouse gas emissions that rural families have in South Asia.

Climate Adaptation Aspects

The use of improved cook stoves reduces the rate of fuel wood use and thus contributes in arresting deforestation. In the long run, it indirectly assists in reducing soil erosion and landslides in hilly areas. Improved cook stove cuts indoor air pollution to significant levels which have a broad range of health benefits particularly for women and children. The gained time not spent in collecting fuel wood can be used in alternative activities such as education of children, which builds adaptive capacity. Additional features of cook stoves, such as water heating, can further reduce drudgery of women.

Improved Cook Stoves Technology

Improved cook stoves come in many designs with different prices, for different family sizes, and adapted to different cultures and to different climates. All ICS have a fire chamber, where the fire is surrounded with walls, usually of ceramic materials, to increase the flame temperature to ensure a better combustion than a traditional fire.

Many ICS are two-pot stoves, where one fire can heat two pots: one directly above the fire and one at the end of a short flue gas tube that leads the hot flue gas and part of the flames to the second pot.

Two-pot stoves are roughly twice more efficient than traditional fires. In the following pages are four types of two-pot stoves described in detail.

A number of ICS has chimneys that lead the flue gas outside. They are in India known as “smokeless chulhas”. While some promotes ICS with chimneys, others promote ICS without chimneys, where the ICS are to be installed in chimney hoods in the kitchens, to ventilate the smoke out of the building. Of the four types described in the following, three have chimneys while one doesn’t have.

Often ICS are built into the kitchen to provide a more stable base for cooking and to increase the lifetime of the ICS.

ICS can be made from mud, fired clay, concrete, and steel. If steel is used there is often a ceramic linger inside to increase temperature of combustion. In the following pages are described different types made of these different materials.

Several other ICS designs exist, and new designs are being developed to improve energy efficiency, ease of use, and lower emissions. One newer design is a “Rocket Stove” that uses small diameter wood fuel, which is burned in a simple high-temperature combustion chamber containing an insulated vertical chimney, which ensures complete combustion prior to the flames reaching the cooking surface. These stoves are based on rocket principle as described by Dr Larry Winiarski in *Design Principles for Wood Burning Cook Stoves*, published by Aprovecho Research Center, Shell Foundation, Partnership for Clean Indoor Air.

Some ICS types are combining cooking with other functions, becoming hybrid ICS. One type is described below, which combines a two-pot stove with chimney with a water heating tank and solar electric light for the kitchen.

Description of Models

The four NGOs, which are, Grameen Shakti (GS) from Bangladesh, INSEDA from India, CRT/N from Nepal and IDEA from Sri Lanka, who are partners in the Eco-Village Development (EVD) Project since 2015, have developed and innovated different Improved Cook Stoves for meeting the cooking needs of their own countries. These ICSs have been also promoted and integrated within their EVD programs. Because the needs and eating habits differ, the ICS designs also differ. Therefore, each one of them is briefly described in the subsequent paragraphs.

"HEERA" - Multipurpose Hybrid Improved Cook Stove Promoted by INSEDA in India

The HEERA stove is different from other ICS, as it is a Hybrid Improved Cook Stove innovated and further developed by Engr. Raymond Myles, Secretary General and Chief Executive, INSEDA in response to the need of the local people living in and around the Eco-Village Development (EVD) program area of INSEDA and WAFD.

HEERA Hybrid Improved Cookstove by INSEDA.

The program area was in the Tehri Garhwal district of the Uttarakhand state in India, where the villages are situated at a height of minimum of 5000 feet (1500 m) to a maximum of 6500 feet (2000 m) above the sea level. Before developing this stove, intensive Interaction was done with the women in groups from the joint EVD program of INSEDA and WAFD, and the following needs were emerged:

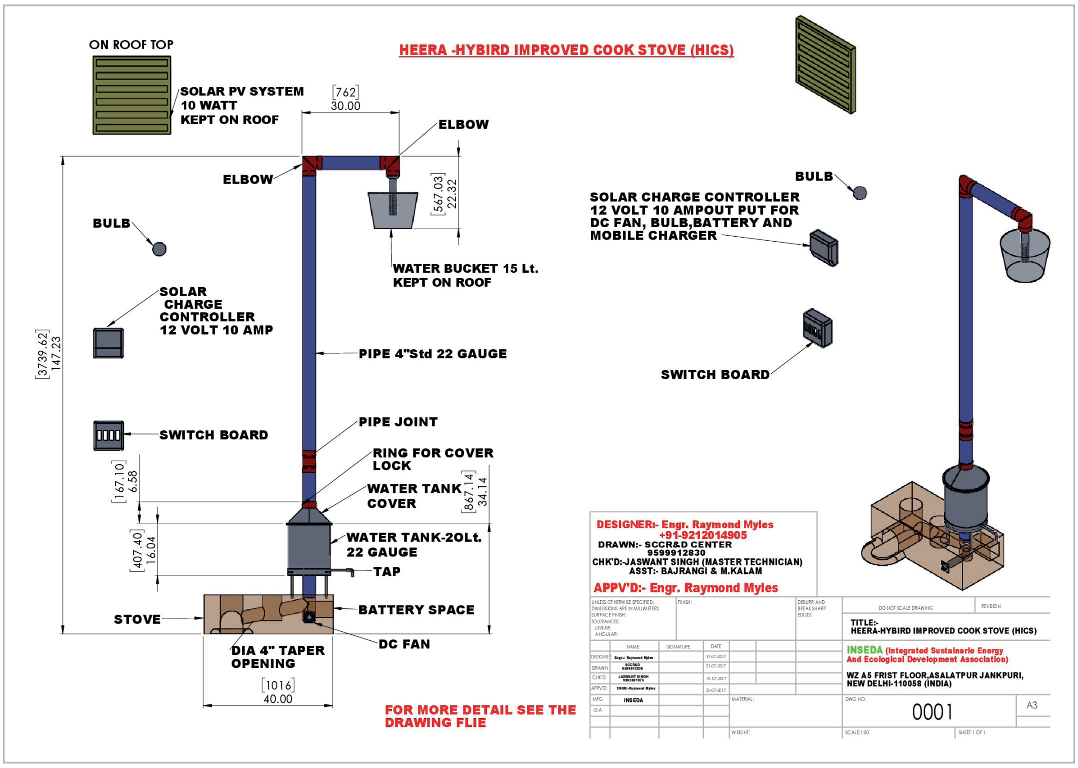
- The traditional cook stoves were inefficient and using too much firewood, which was causing drudgery of women as they had to travel down the hills to collect dried wood and bring back on head loads.
- The women wanted saving in time of cooking so that the time saved could be utilized for other economic activities and would also be able to take rest in between the cooking of two major meals.
- The women mentioned that the pollution inside their house due to smoke was creating health problem for them like eyes and lung related diseases.
- In the hills and sub-mountainous and mountainous region of Uttarakhand state, local people use warm water throughout the year, which required them to use the traditional stove more often, thus, consuming more wood and creating more indoor pollution due to smoke.
- Most of the houses designed had low roof, especially kitchens, because of which it was dark inside even during the day, and at present they were doing their cooking either in dim light, or in nearly dark kitchen.
- During winter time they had to light fire to keep warm because it became very cold for 3-4 winter months, especially in the nights.

During the process it was also realized that:

- Due to black carbon from the smoke, and the carbon being released from hundreds and thousands of traditional cook stoves in the region, the combined affects were leading to global warming in the area and the Himalayan glaciers were being melted; and each year, things became worse.
- In order to provide an improved cook stove that meets all the requirements, it will be costly, so it was desirable that its average working life should be at least 6-7 years.
- The design of stove should be such that the major part of the building material (60-70%) should be using locally available material and local skills after appropriate training, to ensure sustainability

Keeping all this in mind, a hybrid ICS was designed and developed and tested by the innovator at the campus on INSEDA for over 1 year and based on testing appropriate modifications were incorporated in the design so that it would meet all the needs of the local people as well as, if properly used, cared and maintained, it can almost eliminate indoor air pollution and also reduce the outdoor pollution from the smoke up to 30-40%.

These main building materials of this model are: bricks, sand and cement. It has provisions to have two cooking pots. Next to the second pot is an opening for placing the chimney, which is made of galvanised iron sheet and is integrated with a 15-20 litre water tank so that when the mixture of hot flue gases and smoke escape from the 'smoke outlet pipe' outside the kitchen, they continuously warm the water to be used for domestic purposes. The 'smoke outlet pipe' is divided into 3-5 sections (depending up on the total length of the pipe, which again is based on the height of the roof) so that the upper portion(s) of the exhaust pipe can be easily detached, and a woman (owner of the hybrid ICS) can clean it from inside using a brush when too much soot accumulates inside the pipe.



The exhaust (smoke outlet) pipe, once it goes outside, on the roof, is bent into an L shape. This pipe is attached to another L shaped pipe, below which a bucket/container of about 15-20 litres is placed. The end of the pipe, which goes inside the bucket, is perforated so that the flue gases mixed with smoke are released inside the bucket through these perforations. Thus, the particulate matter of the smoke as well as some smoke settles into the water bucket, and the comparatively cleaner smoke is released into the atmosphere. This way, at least atmospheric pollution is lowered to some extent.

For providing enough pressure for the smoke to get channelled and released into the water container, INSEDA has incorporated a small fan, which is operated by a 12-Volt battery placed in a cemented opening on the side of the stove, to keep it protected from the flames and the heat of the stove. This battery is charged by a 10-12-Watt solar photovoltaic unit, which is placed on top of the roof of the kitchen.

The same battery that runs the fan, is also connected with a 3-5 Watts LED light which provides light in the dark kitchen, as well has a USB socket to charge the mobile phone from the solar battery.

Top: The outer part of HEERA cookstove.
Bottom: Solar powered LED light inside the kitchen.

Thus, this stove is a Hybrid Improved Cook Stove, and the developer and innovator of this design has named it HEERA, which means 'Diamond'. This is also a gender-neutral name, as in India, both women and men can be named Heera.

Based on the demonstration, combined with field testing and implementation of a few of this within the EVD program, INSEDA has received a large number of requests from villagers, who are willing to contribute 10-15% of the cost of this stove.

Improved Concrete Cook Stove Promoted by Grameen Shakti in Bangladesh

About 85% families of Bangladesh use traditional stoves for cooking and other heating purposes. It has been found that only 5-15% heat is being utilized and the rest 85-95% is wasted away.The annual biomass consumption for cooking purpose in Bangladesh is about 40 million tonnes, which causes deforestation and pollutes the environment.

To mitigate the problems, ICS have been developed and are disseminated by Grameen Shakti since 2006. All the ICS are made of concrete and thus highly durable.

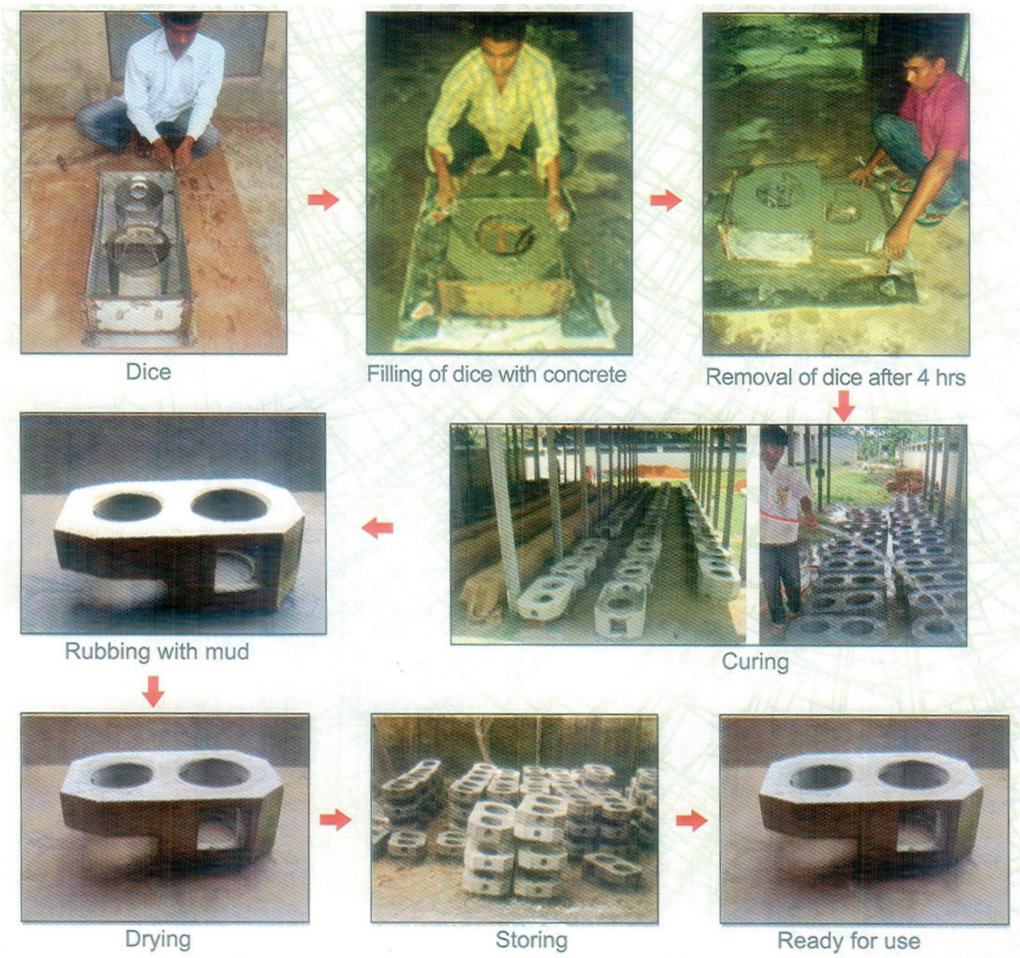
Improved Concrete Cookstove by Grameen Shakti

Advantages: (a) Reduce indoor air pollution and thereby reduces health hazards of the users; (b) Save 50-60% of the traditional fuel used; (c) Reduce CO_2 emission in the atmosphere and thereby reduce the greenhouse gas effect; (d) Maintain proper nutritive values of the cooked food; (d) Cause less blackening of utensils; (e) Reduce cooking time compared with the traditional cook stoves; (f) Cause less fire hazards; and (g) Conserve the forest resources of the country.

There are two types of ICS: (a) stoves for domestic cooking purposes; and (b) stoves for large scale cooking and semi industrial purposes.

Components are: (a) Structure; (b) Chimney Holder; (c) Grate; (d) Chimney; and (e) Cap.

When using the stove, it is advised that (a) due to limited space on grate, excess biomass fuels are not allowed to insert in to the stove at a time; (b) when the cooked food comes to boiling state, minimum amount of biomass fuel needs to be inserted only to keep the food boiling; (c) If the fire stops inside the stove during cooking, the air is allowed to flow /(or the air is blown) through the mouth of the ash-exit instead of the mouth of inserting biomass fuel.



Improved Mud and Metal Cook Stoves Promoted by CRT/N in Nepal

Improved Mud Cook Stoves


Improved Mud Cookstove by CRT/N.

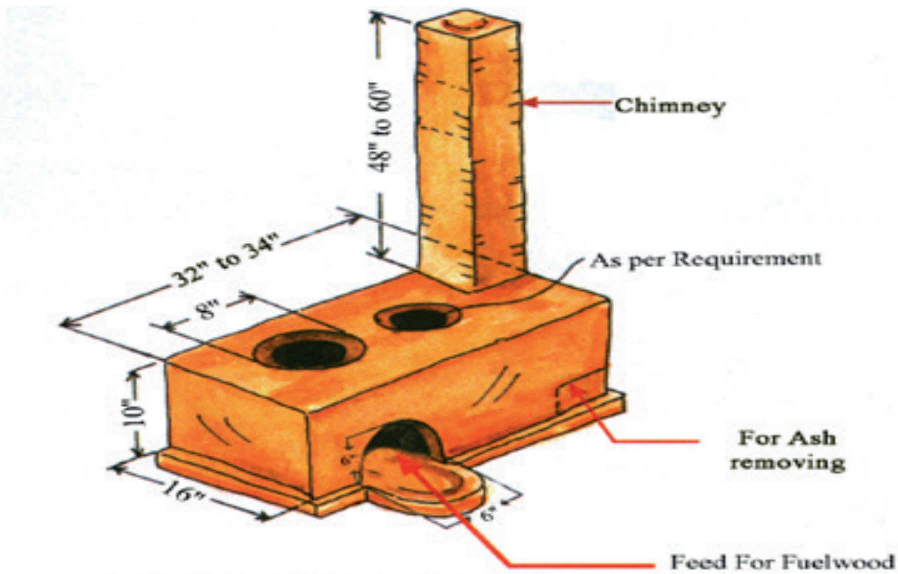
It is a modified version of the traditional cook stoves, designed to overcome problems that are inherent with the traditional stoves. These ICS are made of local materials so that the villagers themselves can easily construct them.

The stoves are made of 3 parts mud/earth, 2 parts straw/husk and 1-part animal dung and sand. The whole structure is plastered smooth with the same mud mortar. The iron plates are fitted on the potholes for pots. The technology has developed to the optimum level, so its design and installation are popular with the users. This ICS can be made in different sizes and capacities to suit the family size and pot size. It can have one or more openings for pots/pans.

These stoves are cheap and easy to operate. There is no need to blow the fire regularly.

The household model has been further modified to Institutional ICS, for use in hospitals, hostels, barracks, teashops and restaurants. All traditional institutional cook stove can be turned into an institutional ICS as they are made of the local and cheap materials and can be easily installed by masons or trained village males/females. These have been designed to save firewood and improve the sanitation and health conditions at work places.

The various components of the ICS are (a) fuel inlet for feeding the fuel (fire-hole); (b) double pot holders; according to the number of potholders, the ICS is named as single pot, double pot or triple pot ICS. The potholes are round funnel in shape; the pot bottom fits tight on them; (c) inbuilt baffle which allows the flame towards the second pot with optimizing the heat use; (d) chimney, for exit for smoke; and (e) an opening to remove the soot to keep the chimney channel clear for smoke to exit easily.



Operating Procedure: Fuel wood is burnt beneath the first opening. The fire and heat travel from the first opening to the second with the help of an in-built baffle located just below the second opening. This heats up the pots on them. The hot air and smoke produced inside the ICS exits through the chimney.

Improved Metal Cook Stoves

It is a modified version of the traditional cook stove. Certain features on the internal and external dimensions have been modified to make them more efficient in fuel wood consumption, convenient for cooking and much safer for the operator. In this type of stove, all components are constructed by metal. In the rural areas, especially in the high hill areas where the temperature is very low in the winter and sometime during the summer also, people need heat. An improved metal cook stove can be used not only for cooking purposes, but also for space heating.

The metal stove is more expensive than the mud stove and cannot be made by the villagers. It was used in Nepal after the earthquake in 2015 to provide safe and easy cooking in a difficult situation.

Improved Metal Cookstove by CRT/N.

Advantages: (a) The metal stove can be used to heat the room in the cold places; (b) It is possible to use big/ small pots for the cooking purpose by using different size rings; (c) Less time is required to cook the food; (d) The kitchen is smokeless, (e) Being portable one can shift the stove anywhere they like; (f) No need to keep on blowing after proper combustion; (g) Cooking pots/ pans are less darkened with soot deposits; (h) Much less risk of household fire or of children getting caught in accidents.

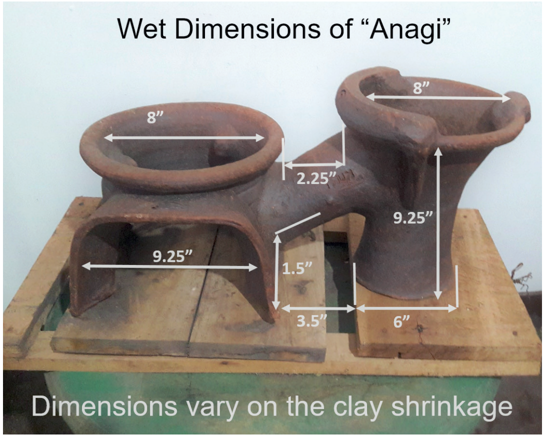
Technical Features: (a) Fuel wood is burnt beneath the first opening. The fire and heat travel from the first opening to the second/third, which heats up the pots as well as top metallic plate; (b) The smoke produced inside the ICS exits through the chimney; and (c) Due to higher thermal conductivity (0.12 Cal/cm/°C/sec) of the mild steel than the mud, it radiates heat around and warms the room.

”Anagi” - Improved Biomass Stove Promoted by IDEA in Sri Lanka

The most popular ICS in Sri Lanka is marketed under the trade name Anagi. The word “Anagi” in Sinhala language means precious or excellent. So Anagi stove is very useful as it saves fire wood and cooking time. Lab tests carried out on the stove indicate a technical efficiency of 21 % and numerous field cooking tests indicate average firewood savings over 30%.

Anagi was first introduced in Sri Lanka in 1986 by the Ceylon Electricity Board in collaboration with the Intermediate Technology Development Group (ITDG) under the Urban Stoves Program. Its success prompted the stove to be selected for commercialization in the rural areas with the participation of the Integrated Development Association (IDEA) and the ITDG. Later the Asian Cook Stove Programme (ARECOP) supported the program to be extended to remote areas where access to commercial networks is absent. About 300.000 stoves are produced annually and sold in the Sri Lankan market.

Anagi is two pots single-piece clay stove designed to meet the cooking needs of a six people family. It can accommodate medium-size hard or soft wood and other loose



biomass residues such as coconut shells, fronds and leaves. The stove design has been carefully developed to suit the cooking habits and the types of food cooked in Sri Lanka. The stove can be used directly, which is preferable for short cooking as done in urban houses. For cooking over a long period of time as in many rural houses, insulating the stove with a mud mixture improves the firewood saving capacity.

The stoves are made by skilled potters with the assistance of unskilled workers for assembling the various components of the stove. In general, a skilled potter and 3 assistants could produce about 1000 stoves a month. The potter needs to be skilled in traditional pottery making technology for selection to be trained in stove making.

The stove has three main components as follows:

- Fire box; 2nd pot hole; and Tunnel (which connects the firebox and the 2nd pot seat)

The secondary components are:

- Pot rests; buttresses; baffle; flame shield; and the door

These are made separately using moulds. The three main components are thrown on the pottery wheel by a skilled potter.

Stove construction process consists of: (a) proper selection and preparation of clay, (b) throwing the main components on a pottery wheel, (c) moulding the secondary components, (d) assembling all the components, (d) finishing, (e) air drying, (f) packing inside the kiln, and firing.

Although the Anagi stove is made of clay, just like a traditional household pottery item, its features and its construction methods differ as number of components must be made and assembled unlike in the traditional pottery-making technology. Thus stove-making needs a special training to avoid excessive breakages in the construction and standardised the stove dimensions. Improperly made Anagi can be worse than an open fire hearth.

The Anagi stove is typically placed under the chimney hood in the kitchen reducing the smoke in the kitchen.

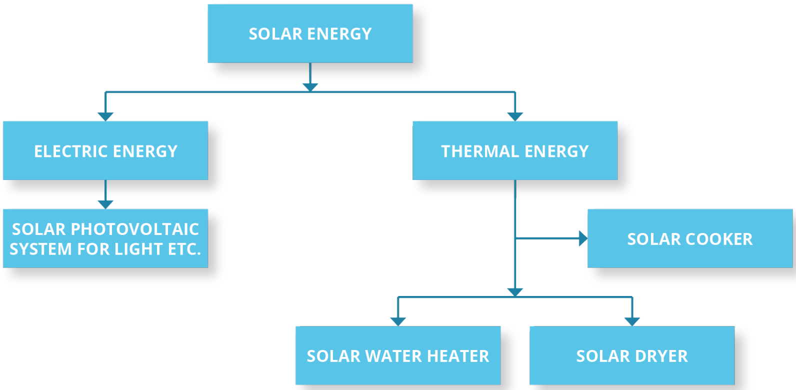
The guidelines for this special training is given in a training manual titled “How to make Sri Lanka‘s Anagi Stove”. This training manual is the work of ITDG and IDEA. A video prepared by ARECOP in collaboration with IDEA also provides the steps of making the Anagi Stove.

The average useful working life of the stove is about 3 years if it is used with insulation. Normally insulation consist of clay/mud.

5. Off-grid Solar Power and Lighting Solutions

Introduction

The electricity generated from the sunlight is called solar electricity. The process of converting solar energy into electricity is known as photovoltaic (PV) process. Solar energy can be divided into following categories:



Solar PV cells became a very popular technology after the price fall during the last decade. There are millions of households struggling to have reliable electricity access in South Asia, where solar cells is an obvious solution. From planning point of view, solar cells are useful when the electricity is not available or unreliable (such as only available a few hours a day). When planning, the main issues are the needed size/capacity, placement, financial scheme and maintenance service. To overcome the financial challenges micro credits schemes are available in many countries. One of the most successful schemes is in Bangladesh, where Grameen Shakti has provided micro credit and maintenance service to more than one million households since its small start in 1998.

Solar PV cells are also used for powering community facilities like street light, and water pumping, schools, health care centres. Street lighting and water pumping were some of the identified needs in the eco-village development in Bangladesh. In the following, the technology of a Solar Home System is explained.

Solar Home System (SHS)

Solar Home System is a complete package of some specific components by which the solar energy is converted to electricity and stored in storage system for operating the electronic appliances during day as well as night. People can use a SHS for:

- Lighting the house, shop, office, school-college, religious places etc
- Operating TV, cassette, radio, VCP (video record player)
- Operating DC (Direct Current) soldering iron, small fan and microphone
- Operating computer and cellular phone
- Operating any DC motor driven equipment like fan, drill machine etc.

Benefit of the Solar PV Technology

- End User is the owner of his/her solar home power generating system
- No bill is required
- Generates electricity for more than 20 years without any fuel
- No load shading
- No fuel cost is involved
- Solar system cannot be damaged easily
- Suitable for any part of the country
- No noise pollution
- Environment friendly

Climate Mitigation Aspects

If solar power gives power for light that would otherwise come from kerosene lamps, they reduce the use of kerosene, which is a fossil fuel that gives CO_2 emissions when burned. When they reduce CO_2 emissions, they reduce climate change.

If the local power replaces electricity from the grid, it reduces the CO_2 emissions from electricity production and thereby reduce climate change. In Bangladesh, India, and Sri Lanka, a large part of the electricity is made with fossil fuels (coal, gas) and the production has high CO_2 emissions.

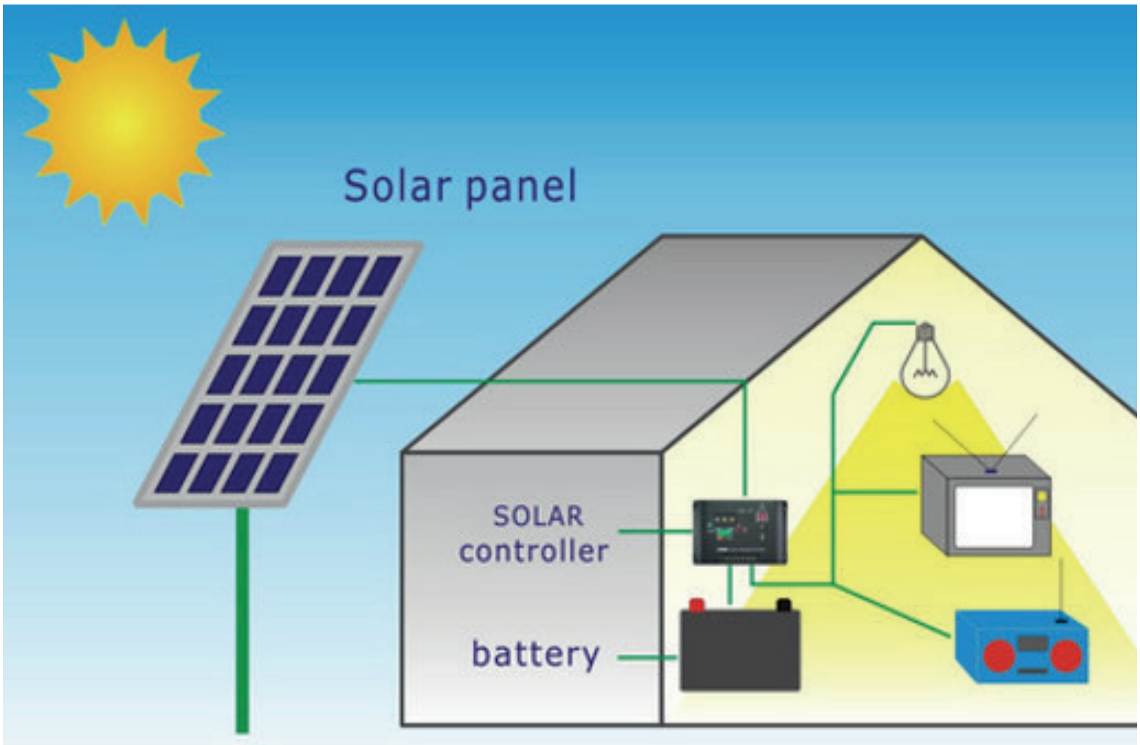
For a family, the reduction with change to solar or hydro power is in the range of 300 – 800 kg CO_2/year.

Technical Description of Technology

A SHS consists of following equipment:

- Solar PV panel
- Charge Controller
- Battery
- Load (LED lamp)
- Other accessories (cables, switch, structure)

From left to right: Solar panel, lead-acid battery, charge controller and LED lights.



Owner (End User) can use 12 V DC TV, radio, mobile charger by their own cost. The system can be used for 4-5 hours/day. Moreover, the system has a back-up period of 2 days, especially in the rainy/cloudy days.

How to Install a Solar Home System

The following aspects should be kept in mind to install a SHS:

1. Selection of a Suitable Place:

The following 4 issues should be considered while selecting suitable place for installing a panel:

A) *Abundance of Light:* Solar PV panel should be installed in such a place where profuse sunlight falls on it.

B) *Angle of placement of the panel:* Solar PV panel is installed facing south at 23^o alignment with ground in Bangladesh. It is also mentionable that this alignment depends upon different geographical location of different countries. In Bangladesh the sunlight falls directly in summer and it falls transversely in winter. So, it is desirable to place the panel at 45^o slanting in summer and 15-20^o in winter to get the best result. But it is troublesome to put the panel at different angles with the change of seasons. Therefore, the experts arrived at a decision to place the panel at certain angle taking average angle of the sunlight throughout the year that is from January to December to avoid placement of panel at different angles at different time to get more electricity. This angle is 23^o degrees in Bangladesh.

C) *The effect of shade/light on panel:* Care should be taken so that shade does not fall on the panel. Shade or barriers of sunlight cause less efficiency of the panel. That is the capacity of producing electricity is reduced and effects adversely on the electricity production.

D) *The distance between the panel and the battery:* The distance between the panel and the battery should be kept as close as possible. Under no circumstances it should exceed 40 ft. It is be better to keep the distance between 20-25 ft. Because the capacity of the electricity is low, and quantity is also less i.e., the higher the distance between the panel and the battery the more is the resistance and the voltage loss. If the loss of electricity is more then it results in the decrease of efficiency of the entire system.

2. Installation of the Charge Controller

The charge controller is the heart of a solar system and it is an automatic device. It protects the battery from over charging and over discharging and increases the efficiency of the battery. So, the controller should be installed in a place, which is as close as possible to the battery. Above all it should be installed in a place from where the performance can be constantly observed without any difficulty. The controller should be the first to be installed in the solar PV system.

3. Installation of Battery

The battery should be installed at a safe place near about the controller where there should be enough air flow. The following aspects should be taken care at the time of installing the battery:

A) *Always keep the battery horizontally*

B) *Insulated instruments should be used while working with battery*

C) *Battery must be kept in an airy and dry place*

D) *Installation of LED Light*

The light should be placed in such a way so that all areas of the room are lighted equally to present a beautiful look. The distance between the controller and the switch of the lamp should not exceed 20-25 ft. Always keep the switch and the lamp beyond the reach of the children.

5. Wiring

The efficiency of the system depends upon its wiring. So special care should be taken in wiring. The wiring should be simple and as per specifications outlined in the electrical diagram. All wire connection should be done correctly. It should be kept in mind that a perfect wiring increases the beauty of a room as well as increases the efficiency and life of the system. Wrong wiring can severely damage the solar PV system.

Solar panel placed on the roof.

Maintenance of SHS

1. Solar panel has to be cleaned every 15-20 days with a wet cloth.
2. Care should be taken that there is no shadow on the solar panel.
3. In case of dust, a clean (dry) cloth can be used to wipe out.
4. During the cyclone/heavy storm, the solar panel must be taken off from the roof and kept inside the house safely.
5. The charge controller needs to be cleaned regularly.
6. The level of electrolyte of the battery should be checked every 30 days.
7. Battery must be kept on wooden plate.
8. Battery cannot be discharged/overcharged for long time.
9. No flammable item is allowed close to battery.
10. Light must be kept clean and dry.

6. Rooftop Rain Water Harvesting System

Introduction

Rain water from roofs has been harvested for more than 4000 years. The aim is to use the harvested and stored rain water in the dry periods. With the increased periods of heavy rainfall and longer dry periods because of climate change, rainwater harvesting has several advantages. Rainwater can be used for washing, irrigation, bathing, and cooking.

Benefits of Rain Water Harvesting System

Among the benefits are: supplementing water needs especially during summer and drought period; reducing soil erosion; flooding of roads; reducing cost of pumping water; providing high quality water, soft and low in minerals; and the systems are relatively easy to install, operate, care and maintain.

Climate Adaptation Aspects

The impacts of climate change include rising water stress, decline in ground water table and drought conditions affecting the availability and access to water for agriculture as well as for domestic use and sanitation. Rooftop rain water harvesting solution could be one of the major sources of water for various purposes during dry season. The technology is crucial to provide crop saving irrigation and a safe source of potable water during prolonged water stress situation. The solution is helpful to check evapo-transpiration caused due to rise in average temperature. It provides an alternative source of drinking water in the case of contaminated ground water. Innovative use of rain water harvesting could help in recharging ground water contributing to adaptation to climate impacts.

Description and Planning

A rainwater harvesting has 4 parts: the collection area, which is usually the roof of the house, the channelling gutters or pipes, a filter, and a storage tank.

How much water can be collected can be estimated by multiplying the roof area (m^2) with the average monsoon rainfall (m). The actual volume (m^3) is reduced by 20% calculating with 80% collection efficiency. For example, if you have a roof of 10 m^2, and average 0.2-0.3 m monsoon rainfall than the maximal useful size of the tank is about 2000-liter (10 m^2 x 0.25 m = 2.5 m^3 x 0.8 =2 m^3).

The materials of the storage tank are typically plastic, reinforced concrete, fibre glass, galvanized steel, and stainless steel. These materials have advantages and disadvantages. Steel is expensive, and can have corrosion problems, reinforced concrete is heavy, relatively expensive, and if the iron rods are corroding it will crack. Plastic (polyethylene) tanks do not corrode, they are strong, lightweight, and relatively easy to install but they are also relatively expensive. These “poly tanks” has been used in India by NGOs and other development organisations; as well as in Nepal by CRT/N, where external funding was raised for covering the costs.

Rooftop Rain Water Harvesting System Built by CRT/N in Nepal

The amount of rainfall in the monsoon has decreased over the past few years in Nepal. This is causing water resource to dry up in many parts of the country. Moreover, devastating earthquake of 2015 disrupted water supply system in many of the affected villages of Nepal. In the places where water is scarce, rainwater harvesting is considered to be a safe and reliable alternative source for domestic water. It can be easily used in both rural and urban areas: it collects water from the pipes installed on building's roof and stores rainwater directly in tanks. The harvesting system consists of a catchment roof, plastic pipes, and a plastic storage tank.

Rain water harvesting set up in the roof of Ms. Rupa's house and a plastic tank to collect water, Chalal Ganesthan VDC.

Rooftop Rain Water Harvesting System Built by IDEA in Sri Lanka

There are several rain water harvesting technologies and solutions which could be adopted at village level to match the income levels and other conditions. In Sri Lanka, concrete cylinders are being utilized to build tanks to collect rainwater. This method too has several benefits such as being very cost effective and ease of maintenance. The unit entails only a few parts and the assembling process does not take more than one day once the concrete cylinders and the covering lid is made. So, this process cuts down the involvement of skilled labour and artisans for long hours, minimizing labour costs.


Rooftop rain water tank built from two concrete cylinders in Sri Lanka by IDEA.

Rooftop Rain Water Harvesting System Reinforced with Bamboo Innovated and Built by INSEDA in India

A sustainable and cheaper solution for harvesting of roof top rain water is a bamboo reinforced cement mortar tank, several of these have been built by INSEDA in India, as explained below. If bamboo is available locally, it becomes much cheaper. As bamboo weaving is a typical woman work it can also be an income generating activity for women.

Bamboo reinforced rain water tank in India built by INSEDA.

This rooftop rain water harvesting system has been innovated in-house by the Secretary General and Chief Executive, INSEDA using participatory development (PD) approach, sitting with local people within the EVD villages (especially the women) and getting their inputs and feedback, so that local women can also get employment at the time of building it.

There are water storage tank designs of five different capacity as 1000-liter, 2000-liter, 3000-liter, 4000-liter and 5000-liter as a part of the rooftop rain water harvesting system. Higher capacity tanks can also be designed up to 10,000-liter capacity, but it is suggested that if there is demand for 10,000-liter capacity, then it is better to build two 5000-liter capacity tanks as women will find it easier to weave the bamboo structures of up to 5000-liter capacity.

Local women participate in the weaving of the cylindrical bamboo structure which is then taken to the site where the unit is to be installed. Using this bamboo structure, the trained master masons build the bamboo reinforced cement mortar (BRCM) tank at the site.

Bamboo reinforcement for rain water tank weaved by these women in India.

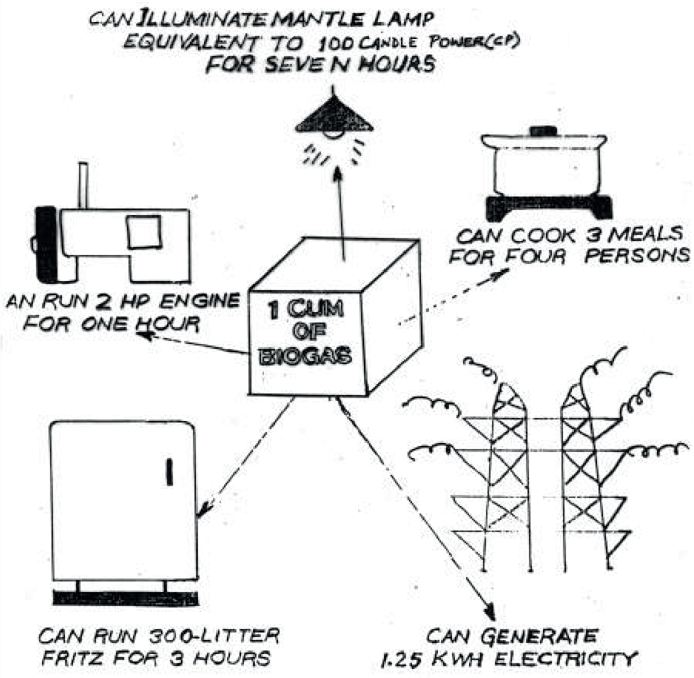
See appendix for a step-by-step instruction to construction of a 3000-liter bamboo reinforced cement mortar water storage tank.

7. Household Biogas Plants

Introduction

Household Biogas plant in India.

Biogas is a source of renewable fuel that can be used for cooking, lighting and power generation, while also providing organic manure in the form of biogas digested slurry. Household biogas plants are very popular in the South Asian region for household cooking and lighting. Typically, three or four bovines (cattle and buffalo) are needed to operate a household-sized biogas plant, which produces about 2 m^3 of gas daily. For a smallest viable 1 m^3 plant, two cattle are enough to feed the plant. Recently even smaller biogas plants have become available for families without cattle, that can feed the biogas plants with vegetable waste and/or waste from small animals, but these small plants cannot produce enough biogas for meeting the entire cooking needs of one family.



Role and Benefits of the Biogas Technology

Biogas technology has a very significant role to play in any integrated agricultural operations, as household sized biogas plants are providing gas for cooking and manure, and improving the rural sanitation, as well as in the treatment of effluent from large-scale dairy production, sewage treatment, organic wastewater treatment and agro-industrial wastes. It can even supply energy to small-scale village industries, using renewable organic resources in the form of biodegradable waste, which is normally available in plenty in rural areas. Furthermore, household biogas plants can generate massive employment in rural areas during construction by village women and village masons. From the biogas plant both the products (biogas and organic manure) are obtained from the same raw materials (bovine manure and another biomass waste).

Benefits of Simple Rural Household Biogas Plant

The simple rural household biogas plant is most ideal for integrating with other low carbon green technologies with in an Eco-village Development (EVD) program. The main benefits of a biogas plant are given below:

- The biogas plants digest, treats and converts biomass or any other biodegradable materials into two useful end products, (a) inflammable gas as fuel and (b) enriched organic manure as bio-fertiliser.
- Biogas provides a smokeless, high efficiency fuel for domestic purpose (cooking and lighting), as well as heating and power generation at the village level.
- The bio-manure in the form of digested slurry, obtained from bovine dung by recycling/processing through household biogas plant has a higher fertilizer value as compared to that of conventional farm yard manure (FYM) produced from the same quantity of animal dung.
- Biogas is a clean fuel and keeps, kitchen, household and the surroundings clean.
- Biogas production technology is an environmentally sound and eco-friendly technology and a carbon neutral system. Whatever carbon is produced while burning biogas for energy purpose, at least the same amount (quantity) if not more is offset, directly or indirectly. For example, indirectly by carbon offset due to reduction in deforestation (by replacement of firewood) thus reducing the release of greenhouse gases to the atmosphere as well as directly through use of biogas digested slurry (bio-manure) for biomass production, where the plants absorb carbon from the atmosphere.
- Controls environmental pollution and promotes public health through preventing flies and mosquitoes which breed in the fresh dung heaps, staked near the rural house and streets, especially during rainy seasons and reduces foul odours due to stopping of decomposition in open areas.
- Digested slurry, if applied directly along with the irrigation water to the crops and tree plantation, then less nutrient will be lost from the slurry; as compared to allowing the slurry to get dried in the digested slurry pits, as it will be exposed to the atmosphere for a longer period, and the useful nitrogen (in the form of ammonia) will be release to the atmosphere, as well as other beneficial nutrients and micro nutrients will be lost due to exposure to sun.
- Digested slurry is good for backyard horticulture and kitchen garden/home garden, undertaken for supply of nutrition from fresh fruits and vegetables to the rural families as well as, would give additional income to them from the sale of surplus slurry in dried or composted form.
- Biogas plants save time in cooking, cleaning utensils and removing drudgery to women and girl child in the Indian villages.
- Biogas is a very safe fuel in village home as it cannot explode easily due to 35-40% CO_2 (Carbon dioxide) in the biogas mixture.
- Prevents, eye and lung disease of women, adolescent girls, children and infants who are normally in the kitchen when food is cooked on firewood and dung cake in traditional stoves.

- Manure prepared from digested biogas slurry has good humus, apart from all the nutrients and trace elements that enrich, builds and regenerates the soil thus contributing to sustainable crop production.
- Application of manure from biogas plant also increases the water holding capacity of the soil, which makes it easily available to plants.
- The application of biogas manure changes texture and structure of the soil and makes it porous for better aeration, thus contributing to better crop yields.
- Biogas slurry (effluent) can be used for seed treatment, which is found to give better seed germination.
- Biogas slurry can be used in the intensive composite pisciculture to give better returns to the farmers

Climate Mitigation Aspects

The advantage of biogas is that when used for cooking it replaces the traditional cook stoves thus reducing the negative effect of climate change. The biogas plant reduces the CO_2 emissions from cook stoves and it also eliminates the black (elemental) carbon in the smoke as there is hardly any smoke when burning biogas. Also, when biogas is used to replace fossil fuel, it reduces the negative impact of climate change because of reduced total CO_2 emissions.

If biogas leaks from plants or piping or from partial combustion, it will increase the methane emissions, thus in such situation biogas would become a potential contributor to climate change. Because the main component of biogas is methane that is a strong driver of climate change, when leaked to the air, therefore it is important to keep leaks of biogas to an absolute minimum.

For one family, the change to biogas cooking with a good biogas plants with minimal leaks, the reductions are around 5 tons CO_2e/year. This is higher than the change to improved cook stoves.

Climate Adaptation Aspects

The adaptation of biogas reduces the rate of fuel wood use and cuts indoor air pollution to significant levels, which has a broad range of health benefits particularly for women and children. The opportunity cost of time spent in collecting fuel wood is invested in alternative work such as education of children and building adaptive capacity.

The bio fertilisers produced from biogas digesters helps in improved soil fertility and water retention capacity, which contributes to adaptation during drought conditions. The soil nutrients such as nitrogen, phosphorous and potassium aids in nutrient circulation in soil thus contributing to agro-ecology.

Biogas Production System – the Technology

The biogas is produced/generated under both, natural and artificial conditions. However, for techno-economically-viable production of biogas for wider application, the artificial system is the only viable method. The production of biogas is a biological process, which takes place in the absence of air (oxygen), through which the organic material is converted in to, biogas, which is essentially a mixture of methane (CH_4) and carbon dioxide (CO_2) and in the process gives excellent organic fertiliser and humus as the second by-product. Thus, biogas plant being low carbon, green technology can be very well integrated within the EVD program, as it provides two major benefits, clean, convenient and renewable energy (domestic fuel) for cooking, as well as nutrition rich bio-manure for organic agriculture, from digestion of recycled biodegradable (waste biomass).

Stages of constructing a household biogas plant.

Biogas and its Composition

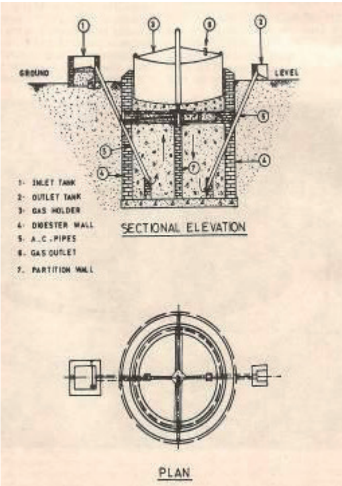
Biogas is a mixture of a few gases which are formed because of anaerobic digestion of bio-degradable (organic) materials. Biogas is a colourless, inflammable gas, produced by organic waste and biomass decomposition, sometimes with an odour of Hydrogen Sulphide. Biogas can be produced from animal, human and plant (crop) wastes, weeds, grasses, vines, leaves, aquatic plants and crop residues etc. The composition of different gases in biogas is as follows: Methane (CH_4) - 55-70%; Carbon Dioxide (CO_2)-30-45%; Hydrogen Sulphide (H_2S) 0-1%; Nitrogen (N_2)-0-1%; Hydrogen (H_2)-0-1%; and traces of Carbon Monooxide (CO) and Oxygen (O_2).

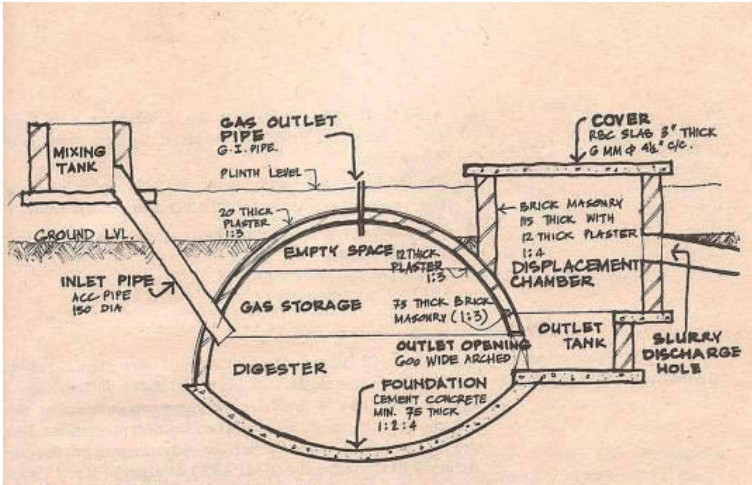
Biogas burns with a blue flame. It has a heat value of 500-700 BTU/ft^3 (4,500-5,500 kcal/ m^3) when its methane content is in the typical range of 55-70%. A 1-m^3 biogas plant will generate 4,500-5,500 kcal/m^2 of heat energy, and when burned in specifically designed burners having 60% efficiency, will give out effective heat of 2,700-3,200 kcal/m^2. The flue gases in biogas consist of only CO_2 and water vapour with small, normally harmless amounts of SO_2.

Biogas has lower heat value than fossil gases (natural gas and LPG) and for cooking with biogas is needed another gas stove than a stove for a fossil gas, or replacement of nozzles (that must have larger openings for biogas).

Biogas Plant

The Biogas plant is an airtight container that facilitates fermentation of material under anaerobic condition. The other names given to this device are ‘Biogas Digester’, ‘Biogas Reactor’, ‘Methane Generator’ and ‘Methane Reactor’. The recycling and treatment of organic wastes (biodegradable material) through anaerobic digestion (fermentation) technology not only provides biogas as a clean and convenient fuel but also an excellent and enriched bio-manure. Thus, the biogas plan also acts as a miniature Bio-fertiliser factory hence some people prefer to refer it as ‘Biogas fertiliser plant’ or ‘Bio-manure plant’. The fresh organic material (generally in a homogenous slurry form) is fed into the digester of the plant from one end, known as inlet pipe or inlet tank. The decomposition (fermentation) takes place inside the digester due to bacterial (microbial) action, which produces biogas and organic fertiliser (manure) rich in humus & other nutrients. There is a provision for storing biogas on the upper portion of the plant. There are some designs that have floating gas-holder and others have fixed gas storage chamber. On the other end of the digester outlet pipe or outlet tank is provided for the automatic discharge of the liquid digested manure.





Classification of Simple Rural Household Biogas Plants

Simple rural household biogas plants can be described as an underground masonry, cylindrical well-shaped fermentation tank (digester) connected with inlet and outlet pipe or tanks and covered by an inverted floating or fixed gas storage tank/chamber. The simple rural household biogas plant can be classified under the following broad categories- (i) biogas plant with floating gas holder, (ii) biogas plant with fixed roof, (iii) biogas plant with separate gas holder and (iv) biogas plant with flexible bag biogas plants. The ggeneral characteristics of four categories of household biogas plants are:

- ***Biogas plant with floating gas holder:*** This comes under the category of semi-continuous-fed plant. It has a cylindrical shaped floating biogas holder on top of the well-shaped digester. As the biogas is produced in the digester, it rises vertically and gets accumulated and stored in the biogas holder at a constant pressure of 8-10 cm of water column. The biogas holder is usually designed to store 50% of the daily gas production.
- ***Fixed dome biogas plant:*** The plants based on fixed dome concept were developed in some of the South Asian countries in the middle of 1970. Most of the fixed dome designs developed in South Asian countries are based on the principle of ‘Semi continuous-fed Digester’. The fixed dome household biogas plant designs developed in South Asia have fixed biogas storage capacity, which is normally of either 33% or 50% of the rated gas production per day. Most of the South Asian fixed dome plant designs use the principle of displacement of slurry in the digester for the storage of biogas in the fixed gas storage chamber. Therefore, in all the South Asian fixed dome design it is essential to keep the combined volume of inlet and outlet displacement chamber(s) equal to the volume of the fixed gas storage chamber, otherwise the desired quantity of biogas will not be stored in the plant.

The discharge opening is located on the outer wall surface of the outlet displacement chamber and automatically controls the maximum pressure in the Indian fixed dome design. One of the fixed dome biogas models is designed in-house by INSEDA, by making improvement in the designs of the earlier popular South Asian fixed dome models and replacing brick and cement concrete, with bamboo reinforced cement mortar. It was named "Grameen Bandhu" by the designer, meaning "friend of the villager". The Grameen Bandhu plant also generates biogas from the dung (manure) of domestic farm animals. The plant uses environmental-friendly bamboo as the main construction material for building this bamboo reinforced cement mortar biogas plant. One of the main advantages of the plant is that it utilises skills of rural people (rural master masons and rural women) after appropriated skills transfer in building this model, on the farmers site. Thus, also creating employment and self-employment opportunities within the rural ecosystems–and creating an environment that fosters rural entrepreneurship. The Grameen Bandhu plant is most appropriate for integrating within the EVD program.

- ***Biogas plant with separate gasholder:*** The digester of this plant is closed and sealed from the top. A gas outlet pipe is provided on top, at the centre of the digester to connect one end of the pipeline. The other end of the pipeline is connected to a floating biogas holder, located at some distance to the digester. Thus, unlike the fixed dome plant there is no pressure exerted on the digester and the chances of leakage in the main unit of the plant are not there or is minimized to a very great extent. The advantage of this system is that several batteries of digesters, which only function as digestion (fermentation) chambers (units), can be connected with only one large size gas holder, built at one place close to the point of utilization. However, as this system is expensive therefore, it is not so popular in South Asian countries.
- ***Flexible bag biogas plant:*** The entire main unit of the plant, including the digester, is fabricated out of rubber, high strength plastic or neoprene. The inlet and outlet are made of heavy-duty PVC tubing. A small pipe of the same PVC tubing is fixed on top of the plant as gas outlet pipe. The flexible bag biogas plant is portable and can be easily erected. Being flexible, it needs to be provided support from outside, up to the slurry level, to maintain the shape as per its design configuration, which is done by placing the bag inside a pit dug at the proposed site. The depth of the pit should be as per the height of the digester (fermentation chamber) so that the mark of the initial slurry level is in line with the ground level. The outlet pipe is fixed in such a way that its outlet opening is also in line with the ground level. Some weight must be added on the top of the bag to build the desired pressure to convey the generated gas to the point of utilisation. The advantage of this plant is that the fabrication can be centralised for mass production, at the district or even at the block level. Individuals or agencies having land and some basic infrastructure facilities can take up fabrication of this biogas plant with small investment, after some training. However, the cost of good quality plastic and rubber is high which increases the comparative cost of fabricating it. Moreover, the useful working life of this plant is much less, compared to other simple South Asian household biogas plants, therefore, the flexible bag plant has not been taken up seriously for promotion by the field agencies.

Rural Household Biogas Plants

The name household digester/ biogas unit is commonly used in India and other South Asian countries for a simple and low-cost family size biogas plant operating under ambient temperature. The capacity of the plants is defined as the quantity of biogas produced from it in a (one) day (24 hours) and measured in terms of cubic meter (cum or m^3) or litres (lt.) or cubic feet (cuft or ft^3). Thus, in India and other South Asian countries a 1 m^3 biogas plant refers to the 'Rated Capacity' of that particular unit which has been designed to produce (generate) 1-m^3 (or 1,000-lt. or 35 ft^3) per day (24 hours) under optimum conditions. This daily biogas generation is the average quantity of biogas, worked out based on annual gas production data for a given temperature zone and corresponding hydraulic retention time (HRT), and does not relates to either the maximum or minimum biogas production on any season or a given day.

Similarly, 2, 3, 4 and 6-m^3 (cum), and so on, imply that these biogas units have the rated (designed) capacity to generate an average daily production of 2m^3 (2,000lt. or 70 ft^3), 3 m^3 (3,000lt. or 105 ft^3), 4 m^3 (4,000lt. or 140 ft^3) and 6m^3 (6,000lt. or 210 ft^3) biogas per day etc., respectively, under optimum conditions. This is the easiest and simple way to refer to any simple low-cost family size (or household) biogas units. This is, by and large, accepted by those involved in the development, promotion, extension and financing of such units including the users of biogas plants, the rural people in Indian and other South Asian countries.

As the rural areas in most of the South Asian countries have very large potential of installing such units due to the availability of raw materials (feed stock or substrates) with majority of farm families with over 60% being rural peasants, therefore, these models are commonly known as rural household biogas plants.

For selection of correct size of rural biogas plants the table given below can be referred.

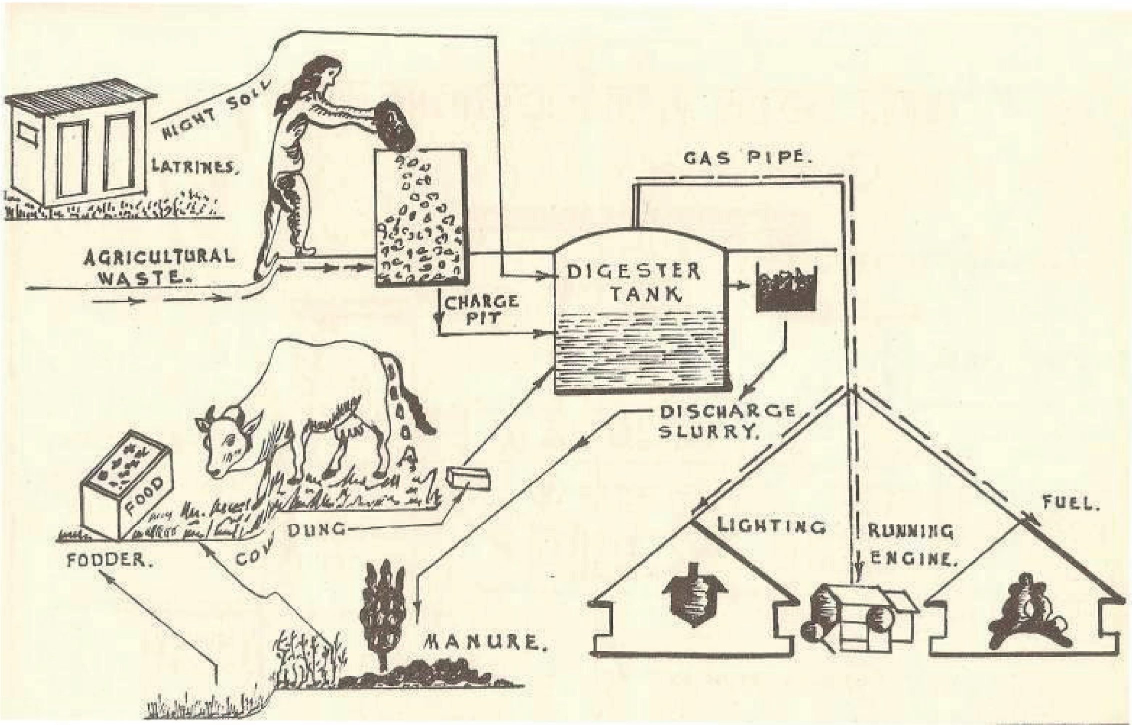
SL. No	Plant capacity		Average daily fresh bovine dung and slurry (ratio of 1 kg. dung:1 lt water) requirement		Approximate number of average size cattle	No. of family members (cooking and lighting requirement)
			Fresh dung	Fresh slurry		
	(m^3)	(ft^3)	(kg)	(lt.)	(nos.)	(nos.)
(a)	(b)	(c)	(d)	(e)	(f)	(g)
1	1	35	25	50	2-3	3-4
2	2	70	50	100	4-6	6-8
3	3	105	75	150	6-9	9-12
4	4	140	100	200	8-12	12-16
5	6	210	150	300	12-18	18-24

Plant capacity, daily requirements of cattle dung and slurry, biogas produced and number of households that can be served.

Different rural household biogas plant models in India built by INSEDA. From top left to bottom right: Fixed dome household biogas plant, Grameen Bandhu Model, Deenbandhu Model, KVIC Model.

Functioning of a Simple Household Biogas Plant

The fresh organic material (generally in a homogenous slurry form) is fed into the digester of the plant from one end, known as Inlet. Fixed quantity of fresh material fed each day (normally in one lot at a predetermine time) goes down at the bottom of the digester and forms the 'bottom-most active layer', being heavier than the previous day and the older material inside the digester. The decomposition (fermentation) takes place inside the digester due to bacterial (microbial) action, which produces biogas and digested or semi-digested organic material. As the organic material ferments, biogas is formed which rises to the top and gets accumulated (collected) in the gas-holder (in case of floating gas-holder biogas plant) or gas storage chamber (in case of fixed dome biogas plant). A gas outlet pipe is provided on the top most portion of the gas-holder or gas storage chamber of the plant. Alternatively, the biogas produced can be taken to another place through pipe connected on top of the gas outlet pipe and stored separately. The slurry (semi-digested and digested) occupies the major portion of the digester and the sludge (almost fully digested) occupies the bottom most portion of the digester. The digested slurry (also known as effluent) is automatically discharged from the other opening, known as outlet, is an excellent bio-fertiliser, rich in humus. This digested slurry can either be taken directly to the farmer's field along with irrigation water or stored in the biogas digested slurry pits for drying or directed to the compost pit for making compost along with other waste biomass. The slurry and the sludge contain a higher percentage of nitrogen and phosphorous than the same quantity of raw organic material fed inside the digester of the biogas plant. Therefore, a household biogas plant of 1, 2 & 3-m^3 capacity would be most ideal to be integrated within an EVD program, ensuring use of the digested slurry as fertiliser.



Components of a Simple Rural Household Biogas Plant

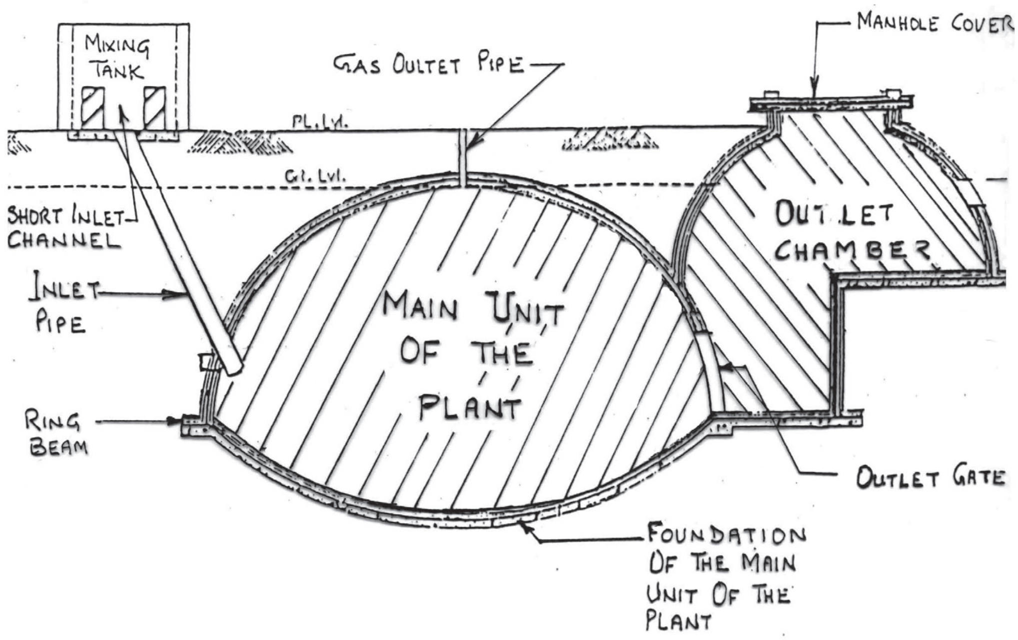
The major components of a simple rural household biogas plant are: (i) Digester, (ii) Gas-holder or Gas storage chamber, (iii) Inlet, (iv) Outlet, (v) Mixing tank and (vi) Gas outlet pipe.

- *Digester:* It is either an underground cylindrical-shaped or ellipsoidal (elliptical) shaped structure where the digestion (fermentation) of substrate takes place. The digester is also known as 'fermentation tank or chamber'. In a simple South Asian rural household biogas plant, working under ambient temperature, the digester is designed to hold slurry equivalent to of 55, 40 or 30 days of daily feeding. This is known as hydraulic retention time (HRT) of the biogas plant. The designed HRT of 55, 40 and 30 days is determined by the different temperature zones in the country. The digester can be constructed of brick masonry, cement concrete or reinforced cement concrete or stone masonry or pre-fabricated cement concrete blocks or Ferro-cement (ferro-concrete) or steel or rubber or bamboo reinforced cement mortar. In the case of smaller capacity 'Floating Gasholder' plants, e.g., the KVIC model biogas plant of 2 & 3 m^3 no partition wall is provided inside the digester; whereas the plants of 4-m^3 capacity and above, have been provided with partition wall in the middle. This is provided for preventing short-circuiting of slurry and promoting better efficiency. This means the partition wall also divides the entire volume of the digester into two halves. However, no partition wall is provided inside the digester of the 'Fixed Dome' designs. The reason for this is that the diameter of the digesters in all the 'Fixed Dome' models are comparatively much bigger than it is at the floating drum biogas plants, which takes care of the short-circuiting problems to a satisfactory level, without adding to additional cost of providing a partition wall.
- *Gas holder or Gas Storage Chamber:* In the case of floating gas holder biogas plant, the gas holder is a drum like structure, fabricated either of mild steel sheets or ferro-cement (ferro-concrete) or high-density plastic or fibre glass reinforced plastic. It fits like a cap on the mouth of digester where it is submerged in the

slurry and rests on the ledge, constructed inside the digester for this purpose. The drum collects gas, which is produced from the slurry inside the digester, as it gets decomposed, and it rises upwards, being lighter than air. To ensure that there is enough pressure on the stored gas so that it flows on its own to the point of utilisation through pipeline when the gate valve is open, the gas is stored inside the gas holder at a constant pressure of 8-10-cm of water column. This pressure is achieved by making the weight of biogas holder as 80-100-kg/cm^2. In it's up and down movement, the drum is guided by a central guide pipe. The gas formed is otherwise sealed from all sides except at the bottom. The scum or the semi-dried mat formed on the surface of the slurry is broken (disturbed) by rotating the biogas holder, which has scum-breaking arrangement inside it. The gas storage capacity of a family size (household) floating biogas holder plant is kept as 50% of the rated capacity (daily gas production in 24 hours). This storage capacity comes to approximately 12 hours of biogas produced per day. However, in the case of all the fixed dome designs the biogas holder is commonly known as gas storage chamber. The gas storage chamber is the integral and fixed part of the main unit of the plant of the fixed dome plant. The gas storage chamber is made of the same building material as that of the main unit of the plant. The gas storage capacity of all the 3-common family-size (household), fixed dome biogas plant is kept as 33% of the rated capacity (daily gas production in 24 hours). This storage capacity comes to approx. 8 hours of biogas produced during night when biogas is not in use.

- *Inlet:* In the case of floating biogas holder pipe the Inlet is made of cement concrete pipe. The inlet pipe reaches the bottom of the cylindrical digester-well on one side of the partition wall. The top end of this pipe is connected to the mixing tank. In the case of the very first approved Indian fixed dome models (Janata model) the inlet is like a chamber or tank-which is a bell mouth shaped brick masonry construction and its outer wall is sloppy. The top end of the outer wall of the inlet chamber has an opening connecting the mixing tank, whereas the bottom portion joins the inlet gate. The top (mouth) of the inlet chamber is kept covered with heavy slab. Whereas the Inlet of the other two fixed dome models (Deenbandhu and Grameen Bandhu) is made from cement pipes of 4 or 6-inch diameters.
- *Outlet:* In the case of floating gasholder pipe the outlet is made of cement concrete pipe standing at an angle, which reaches the bottom of the digester on the opposite side of the partition wall. In smaller plants (2 & 3-m^3 capacity), which have no partition walls, the outlet is made of small (approximately 2-ft. length) cement concrete pipe inserted on top most portion of the digester, submerged in the slurry. In the two fixed dome (Janata and Deenbandhu models) plants, the outlet is made in the form of rectangular tank. However, in the case of the third fixed dome (Grameen Bandhu model) plant the upper portion of the outlet (known as outlet displacement chamber) is made as hemi-spherical in shape, designed to save in the material and labour cost. In all the three- fixed dome models (Janata, Deenbandhu and Grameen Bandhu models, the bottom end of the outlet tank is connected to the outlet gate. There is a small opening provided on the outer wall of the outlet chamber for the automatic discharge of the digested slurry outside the biogas plant, equal to 80-90% of the daily feed. The top mouth of the outlet chamber is kept covered with heavy slab.
- *Mixing tank:* This is a cylindrical tank used for making homogenous slurry by mixing the manure from domestic farm animals with appropriate quantity of water. Thoroughly mixing of slurry before releasing it inside the digester, through the inlet, helps in increasing the efficiency of digestion. Normally a feeder fan is fixed inside the mixing tank for facilitating easy and faster mixing of animal dung (manure) with water for making homogenous slurry.

- *Gas outlet pipe:* The gas outlet pipe is made of GI (galvanised iron) pipe and fixed on top of the drum at the centre in case of floating biogas holder and on the crown of the fixed dome biogas plant. From this pipe the connection to gas pipeline is made for conveying the gas to the point of utilisation. A gate valve is fixed on the gas outlet pipe to close and check the flow of biogas from plant to the pipeline.



Sketch of the Grameen Bandhu model fixed dome household biogas plant.

8. Organic Composting

Introduction

At the simplest level, the process of composting requires making a heap of wet organic matter known as “Green Waste” (leaves, food waste) and waiting for the materials to break down into humus after a period of weeks or months. Modern, methodical composting is a multi-step, closely monitored process with measured inputs of water, air, and carbon- and nitrogen-rich materials. Shredding the plant matter, adding water and ensuring proper aeration by regularly turning the mixture aid the decomposition process. Worms and fungi further break up the material. Bacteria requiring oxygen to function (aerobic bacteria) and fungi manage the chemical process by converting the inputs into heat, carbon dioxide and ammonia. The ammonium (NH^+_4) is the form of nitrogen used by plants. When available ammonium is not used by plants it is further converted by bacteria into nitrates (NO_3) through the process of nitrification.

Composting of waste is an aerobic (in the presence of air) method of decomposing solid wastes. The process involves decomposition of organic waste into humus known as compost which is a good fertilizer for plants. However, the term "composting" is used worldwide with differing meanings. Some composting textbooks narrowly define composting as being an aerobic form of decomposition, primarily by aerobic or facultative microbes. An alternative form of organic decomposition to composting is "anaerobic digestion".

Organic manure from composting at bamboo compost basket in India.

Benefits of Composting

Benefits of composting is that it reduces cash expenses on chemical fertilizer, improves soil fertility, increases crop yield, it supports organic crop production and reduces dependency on outside inputs. The use of compost reduces the need for mineral fertilizer thus reducing production costs and outside dependence. Compost is rich in nutrients. It is used in garden, landscaping, horticulture, agriculture, and kitchen garden. The compost itself is beneficial for the land in many ways, including as a soil conditioner, a fertilizer, addition of vital humus or humic acids, and as a natural pesticide for soil. In eco-systems, compost is useful for erosion control, land and stream reclamation, wetland construction, and as landfill cover. Organic (bio-degradable) ingredients used in making compost can alternatively be used for generating biogas through anaerobic digestion/fermentation.

Climate Adaptation Aspects

Composting is a useful technology for retention of soil fertility in farming and kitchen gardening through the treatment of leaves, food waste and other organic products. The bio fertilisers thus produced replace synthetic fertilisers reducing input costs. It makes farming affordable for small holder farmers and improves their adaptive capacity to crop losses due to climate variability and change. Compost is useful for erosion control, water retention and reclamation of land and stream. Thus, compost would assist in adapting to erratic rainfall, heat wave and drought conditions by providing survival moisture to crop. Access to market provides an alternative livelihood option for small holder farmers which increase their adaptive capacity.

Requirement for Good Quality Compost

Composting organisms require four equally important ingredients to work effectively:

- *Carbon* - required for energy: the microbial oxidation of carbon produces the heat, if included at suggested levels. High carbon materials tend to be brown and dry.
- *Nitrogen* - required growing and reproducing more organisms to oxidize the carbon. High nitrogen materials tend to be green (or colourful, such as fruits and vegetables) and wet.
- *Oxygen* - required for oxidizing the carbon, the decomposition process.
- *Water* - required in the right amounts to maintain activity without causing anaerobic conditions.

Certain ratios of these materials will provide beneficial bacteria with the nutrients to work at a rate that will heat up the pile. In that process much water will be released as vapour (steam), and the oxygen will be quickly depleted, explaining the need to actively manage the pile. The hotter the pile gets, the more often added air and water is necessary; the air/water balance is critical to maintaining high temperatures (50°- 70° Celsius) until the materials are broken down. At the same time, too much air or water may also slow the process, as too much carbon or too little nitrogen does. Hot container composting focuses on retaining the heat to increase decomposition rate and produce compost more quickly.

Most efficient composting occurs with an optimal carbon to nitrogen ratio (C/N) of about 10:1 to 20:1. Rapid composting is favoured by having a C/N ratio of 30 or less. It is confirmed by field tests that above 30 the substrate is nitrogen starved; below 15 it is likely to outgas a portion of nitrogen as ammonia.

Nearly all plant and animal materials have both carbon and nitrogen, but amounts vary widely, with characteristics noted above (dry/wet, brown/green). Fresh grass clippings have an average ratio of about 15:1 and dry autumn leaves about 50:1 depending on species. Mixing equal parts by volume approximates the ideal C/N range.

The composting process is dependent on micro-organisms to break down organic matter into compost. There are many types of microorganisms found in active compost.

In addition, earthworms not only ingest partly composted material, but also continually re-create aeration and drainage tunnels as they move through the compost.

A lack of a healthy micro-organism community is the main reason why composting processes are slow in landfills with environmental factors such as lack of oxygen, nutrients or water being the cause of the depleted biological community.

Types of Compost Units

There are many types for compost making methods. Four types are briefly described below.

NADEP Compost, Developed and Built in India

The NADEP method of organic composting was developed by a man called Narayan Deotao Pandharipande (NADEP) from Maharashtra, India. In NADEP method, the compost can be prepared from a wide range of organic waste (biodegradable) materials including dead plant material such as crop residues, weeds, forest litter and kitchen waste. Compost making is an efficient way of converting all kinds biomass into high value fertilizer that serves as a good alternative to farmyard manure, especially for crop-growing.

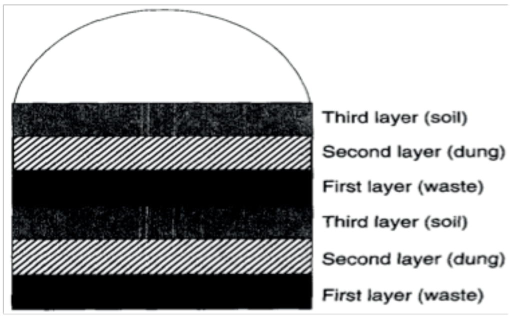
This method of making compost involves the construction of a simple, rectangular brick tank with enough spaces maintained between the bricks for necessary aeration. The recommended size of the tank is 10 ft (length) x 5 ft (width) x 3 ft (height). All the four walls of NADEP tank are provided with opening (vents) by removing every alternate brick after the height of 1ft. from the bottom for aeration. The tank can be constructed using either mud mortar or cement mortar.

Raw materials required for filling NADEP tank are: Agricultural waste (dry and green) – 1400 kg., bovine (Cattle or/and Buffalo) dung or biogas digested slurry – 100 kg and fine sieved soil – 1600 kg water – 1400 litres.

The important technique in the building of NADEP compost is that the entire tank should be filled with the composting materials in one go, within 24 hours and should not go beyond 48 hours, as this would affect the quality of the compost.

Before filling, the NADEP tank is plastered by dilute bovine slurry (cattle and/or buffalo dung) to facilitate bacterial activity from all four sides. It is also filled in definite layers each layer consisting of the following sub layers.

- *Sub-layer 1:* Consists of 4 to 6-inch-thick layer of fine sticks, stems (to facilitate aeration) followed by layer of 4 to 6 inch of dry and green biomass.
- *Sub-layer 2:* About 4 kg of bovine (cattle and/or buffalo) dung is mixed with 100 litre of water and sprinkled thoroughly on the agricultural waste to facilitate microbial activity.



- *Sub-layer 3:* About 60 kg of fine dry soil is spread uniformly over the soaked biomass for moisture retention, which also acts as a buffer during biodegradation.

The proportion of organic materials for each layer would be 100 kg organic (biodegradable) biomass: Thus, each group of three layers would be 4 kg bovine (cattle and/or buffalo) dung + 100 litre water + 60 kg soil. In this way, approximately 10 -12 groups of 3 layers would be filled for each NADEP tank. After filling the tank, biomass is covered with 3-inch-thick layer of soil and sealed with Bovine (Cattle and/or Buffalo) dung + mud plaster.

15-30 days after filling the organic biomass in the tank, it gets automatically pressed down to 2 ft. The tank is refilled by giving 2-3 layers over it and is resealed. After this filling the tank is not disturbed for 3 months except that it is moistened at intervals of every 6-15 days. The entire tank is covered with a thatched roof to prevent excessive evaporation of moisture. Under no circumstances should any cracks be allowed to develop. If they do, they should be promptly filled up with slurry.

From each NADEP tank of prescribed size approx., 2.5 tons of compost is prepared within 90-120 days.

The compost prepared using NADEP method will be ideal for organic agriculture/farming on farmers crop or horticulture field.

Composting for Organic Agriculture and Kitchen/Home Garden within EVD in South Asia

The composting for organic agriculture and kitchen/home garden practiced within the EVD program by the three South Asian NGO partners, namely, INSEDA (India), IDEA (Sri Lanka) and CRT/N (Nepal) are described in the subsequent paragraphs.

Bamboo Compost basket

Bamboo Compost Basket Developed and Promoted by INSEDA in India

Simple low-cost bamboo basket is innovated and being promoted by INSEDA in such a way that each basket can make enough organic manure for manuring about 1/20th of an acre, which would be between 220 and 250 sq. yard, which is referred as 1 Naalie in hills and mountains of Uttarakhand state of India.

The size of basket is 1-meter diameter x 1-meter height, which is most suitable to use by village women for filling with biomass and emptying the compost when it is fully made. This bamboo basket is very light and is convenient for carrying from one place to another on the hills and mountains.

Good quality manure using bio degradable waste available on the farm can take a maximum of 45-60 days using this bamboo compost basket. Thus, each basket can make manure 5-6 times in a year. This basket which is made from strips of bamboo can be made (woven) by local women after one day of appropriate training. If properly made, the compost basket can easily last for 3 years or more.

- *Materials required:* 2 bamboo measuring 10-ft long 2-inch diameter, and thick black plastic sheet of 3-meter length x 3-meter width.
- *Manpower required:* Two properly trained women are required to build.
- *Basic equipment and tools required:* sickle or any kind of chopper which can split the bamboo, measuring tape.

See appendix for instructions on day to day construction of this bamboo woven compost basket.

"Jeewa kotuwa"/compost basket.

Composting of Organic Agriculture and Kitchen Garden by IDEA in Sri Lanka

In Sri Lanka "Jeewa kotuwa" is widely being used as a solution for household level composting. This is regarded as a very economical composting practice which could be adopted by any household. This is made out of readily available raw material from the garden or locality. This method basically adopts biofencing in either closed circular or square shaping. In Sri Lanka biofencing is ususally carried out using "gliricidia", which is one of the most important multi-purpose legume trees in the region. Moreover, this tree is known to fix nitrogen in the soil. All the biodegradable kitchen waste and garden waste (except the heavy branches) could be disposed in this "jeewa kotuwa" and the compost could be taken from the bottom of the pile as needed.

Composting for Organic Agriculture and Kitchen Garden by CRT/N in Nepal

Growing your own food, which are organic is truly transformation in agriculture. There are plethora of benefits of organic agriculture and kitchen garden. The harvested crops of organic agriculture contain more nutrients and vitamins than other methods. Organic food produces healthy and safe, so the demand of organic farming is increasing day by day.

Organic manure in Nepal.

9. Organic Agriculture in General

Organic agriculture and kitchen garden promoted by INSEDA in India.
Organic farming unit in Tehri district of Uttarakhand state.

Brief Historical Perspective and Introduction

Agriculture had been in practice for thousands of years without the use of artificial chemicals or chemical fertilizers. The chemical fertilizer was first created during the mid-19th century. These were cheap, powerful, and easy to transport in bulk. Similar advances occurred in chemical pesticides in the 1940s, leading to the decade being referred to as the 'pesticide era'. These new agricultural techniques, while beneficial in the short term, had serious long-term side effects such as soil compaction, erosion, and declines in overall soil fertility, along with health concerns of human being due to toxic chemicals entering the body through the food supply chain. In the late 1800s and early 1900s, soil biology scientists began to seek ways to remedy these side effects while still maintaining higher production.

In 1921, Albert Howard and his wife Gabrielle Howard, two botanists from Britain, founded an Institute of Plant Industry in India, to improve traditional farming methods. They incorporated improved techniques and methods using their scientific training in to the local traditional methods, developed protocols for the rotation of crops, erosion prevention techniques, and the systematic use of composts and manures to promote organic farming in India.

In 1940 Howard published his book 'An Agricultural Testament', in which he adopted terminology of "organic farming. "Howard's work spread widely, and he became known as the "father of organic farming" for his work in applying scientific knowledge and principles to various traditional and natural methods. In the United States, J.I. Rodale founded both a working organic farm for trials and experimentation in the 1940s. The Rodale Institute started teaching, promoting and advocating organic methods to the wider public. These became important influences on the spread of organic agriculture.

While, the use of "organic" popularized by Howard and Rodale, refers more narrowly to the use and benefits of 'organic matter' from plant compost and animal manures to improve the 'Humus' content of soils, grounded in the work of early soil scientists who developed what was then called "humus farming". However, the modern understanding of "Organic agriculture" is a production system that sustains the health of soils, "Eco-systems" and people. It relies on 'ecological processes', 'biodiversity' and 'cycles' adapted to local conditions, rather than the use of inputs with adverse effects.

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Benefits of Organic Agriculture/Farming in General

In recent years, the increasing environmental awareness in the general population about the benefits of organic agriculture/farming has transformed the originally supply-driven organic movement to a demand-driven one. In the developing world, many producers farm according to traditional or natural methods (without the use of any chemical fertilizers and pesticides and herbicides) that are comparable to organic farming, but not certified, and that may not include the latest scientific advancements in organic agriculture, still they have started getting very good market prices due to awareness of general public about health and other benefits and better taste and longer shelf life.

Since 1990 the market for organic food and other products has grown rapidly, reaching over $60 billion worldwide in 2012.This demand has driven a similar increase in organically managed farmland that grew from 2001 to 2011 at a compounding rate of 8.9 % per animas of 2011, approximately 37,000,000 hectares (91,000,000 acres) worldwide were farmed organically, representing approximately 0.9 percent of total world farmland.

Climate Mitigation Aspects

Organic agriculture reduces the global warming caused by agriculture in two ways. The production of fertiliser with nitrogen has high greenhouse gas emissions, both with CO_2 from the fossil fuels used in the production and with N_2O (laughing gas) the bi-product in production process. As organic agriculture does not use such fertiliser, these greenhouse gas emissions are avoided. Good organic agriculture also increases the carbon in the soil with compost and other organic manure, as well as with less tilling. This soil carbon in normal agriculture is not utilised in the soil, it will instead go in the form of CO_2 in the atmosphere, where it will contribute to climate change.

Climate Adaptation Aspects

Organic farming acts as an alternative to industrial production inputs such as synthetic fertilisers and agrochemicals. It improves natural processes and revives ecosystem services by improving soil carbon, water retention capacity and soil fertility. Through better nutrient management capability, organic farming contributes to soil fertility which results in rise in crop yield, better drainage and drop in irrigation frequency. It contributes to adaptation by relying on food production locally and being independent of food import, volatility of agricultural inputs and food prices. Crop diversification and reliance on local varieties improves income sources and provides much needed flexibility to cope with adverse effects of climate variability and change. Organic farming is a low-risk farming strategy because of reduced input cost. Thus, it lowers risk from partial or total crop failure due to extreme weather events.

Organic farming assists in creating micro habitats for soil flora and fauna, restoring the natural pest management mechanisms and protects wild biodiversity. The restoration of ecosystem services act as a shield against extreme weather conditions such as water stress, heat wave, drought, erratic rainfall, water logging and flood conditions. In a nutshell, organic farming is an effective adaptation strategy to improve livelihoods of agriculture dependent population in developing countries.

Description of Organic Agriculture Model in Use

While the organic agriculture is fundamentally different from conventional agriculture because of the use of carbon-based fertilizers compared with highly soluble synthetic based fertilizers and 'biological pest control', instead of synthetic pesticides, organic farming and large-scale conventional farming are not entirely mutually exclusive. Many of the methods developed for organic agriculture have been borrowed by more conventional agriculture.

For sake of better clarity and understanding, the Chapter on "organic agriculture/farming in general" is divided in to two sub-sections Section 1: 'Organic agriculture/farming' and; Section 2: 'Organic kitchen garden' or 'Organic home garden'.

Section 1: Organic Agriculture/Farming

Organic farming is an alternative agricultural system, which originated early in the 20th century in reaction to rapidly changing farming practices. Organic farming continues to be developed by various organic agriculture organizations today. It relies on fertilizers of organic origin such as 'composted manure', 'green manure', and 'bio-fertilizer' etc., and places emphasis on techniques such as 'crop rotation' and 'companion planting', 'biological pest control', 'mixed cropping' and the 'fostering of insect predators' are encouraged.

Organic agricultural methods are internationally regulated and legally enforced by many nations, based on the standards set by the International Federation of Organic Agriculture Movement (IFOAM), an international umbrella organization for organic farming organizations established in 1972.

The organic agriculture can be defined as the combination of tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. Organic agriculture can be further defined as "an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones.

Section 2: Organic Kitchen Garden/Organic Home Gardens

Organic kitchen gardens/organic home gardens are the small farms normally developed at individual household or community level to cultivate fresh vegetables and herbs for household use as well as for market selling if extra production is achieved, and the owner desires to sell her/his produce as a means of income generation.

These organic kitchen gardens/organic home gardens are normally developed at the backyard of the house of the farmers/owners and have several benefits associated which are as follows:

- Availability of fresh vegetables throughout the year for household use thereby reducing the high expenditures on buying vegetables from the market.
- All the kitchen waste and other organic waste from home sweepings could be effectively converted into manure and can be utilized in the garden.
- The waste water from the household can also be utilized for irrigation purposes within the garden.
- Planting kitchen gardens at the backyard of house improve the surrounding environment thereby providing a fresh air to breathe.
- The edge plants being planted in the gardens provide a source of mulch, fodder, fuel wood, protection from pests, weeds and other predators.

Organic farming with drip irrigation promoted by CRT/N in Nepal.

Protection of organic kitchen gardens/organic home gardens:

The organic kitchen/home garden gardens need protection from the very start in the following manner:

- A permanent fence should be made to restrict the entry of livestock.
- Wood/bamboo can be used for the construction of fence.

- Thorny plants can be cut and used to make a fence, but
- The best method is to plant a living fence to protect the garden.

The crops within the garden also need protection from attack by many types of pests and diseases.

- Mixed cropping, crop rotations, use of liquid manure, etc, are the effective options for reducing the incidence of pest or disease attack.
- Bio pesticides could also be utilized effectively against the pest attack.
- Soil and water management is important in the organic kitchen gardens/organic home garden.
- Availability of enough moisture especially during the summer months for the organic kitchen gardens/organic home garden is very essential to avoid the crop damage.
- The seasonal trees or even fruit trees (suited for local climatic conditions) could be grown along the fence or within the gardens to provide:
    - Appropriate shade to the small plants grown in the garden particularly during hot seasons.
    - Further, mist collects on the leaves of these trees and drips onto the soil and small plants to provide extra moisture.
    - These trees can also provide other benefits, such as firewood, fodder or mulch material. These trees also act as windbreaks, thereby conserving the soil moisture within the garden.
- These methods will help conserve soil moisture thereby, reducing the need for excessive irrigation.
- Mulching also plays an important role in conserving the soil moisture. Irrigation of organic kitchen gardens/organic home garden. Mulching is putting a thick layer of biomass (fallen leaves etc) mixed with the compost over the soil in the kitchen garden especially after sowing of seeds, which shall improve the fertility of the soil along with conserving the moisture level of the soil.
- Collecting and using the waste water from the kitchen can be enough for the garden.
- Direct water from communal tap stands can be used for irrigating the kitchen gardens.
- Deep watering is better for deep rooting while shallow watering means roots will stay at the surface and will soon dry out.
- In the hot season, irrigation of the kitchen gardens should be done in the evening or at night, and not in the day time.

Improving the soil fertility of organic kitchen/home gardens vermi-composting:

- It is a process by which all the organic waste including kitchen waste, garden waste, house sweepings etc. could be converted into organic manure by the action of the earthworms (usually red wigglers or white worms can be used.
- This manure can be effectively used for improving the soil fertility.
- The material for construction of a vermi composting pit within the garden can be provided to all the self-helping group members and they are trained on the following aspects:

- Various materials/components required for construction of a vermi composting unit and the complete step by step process of construction
- Species of earthworms (seed stock) that are available and can be effectively used for converting organic waste into manure and quantity to be used.
- Detailed biological functioning of a Vermi composting unit along with its advantages over chemical fertilizers.
- Appropriate use of vermi composting for enhancing the soil fertility and for sale purposes
- Usage & dosage of vermi composting for major crops, e.g., Use of vermi wash as an effective growth regulator

• Typical design of a kitchen garden: In a kitchen garden the seeds and seedlings should be planted densely, i.e., very close to each other so that no space is being unnecessarily wasted in the garden.
• Further, a single type of vegetable should not be planted, but variety of vegetables should be planted together in different rows, i.e. mixed cropping should preferably be done. Crop rotation can also be practiced wherein legumes including pulses could be sown in a small portion of the garden one season to enhance the nitrogen levels in the soil.
• Mixed cropping will result in the development of different layers of roots in the soil. As small duration vegetables are harvested for food, this makes space for the long-lasting vegetables and while in between new seedlings can be planted.
• Further, another important aspect is ”edge planting” means growing of support crops.

Growing organic vegetables in Nepal.

10. Solar Drying of Agricultural and Horticultural Crops, Spices and Herbs

Introduction

Sundried vegetables from solar dryer.

The South Asian and other developing countries suffer heavy losses of food in the post-harvest period during which the harvested crop passes through a series of processes before it is stored. Out of this, drying is one of the most important steps of post-harvest handling of crops. The traditional methods of drying employed in South Asian countries are 'open air sun drying' or 'natural drying' in the shade. As there is not much control over the drying rate of crops, fruits, vegetable and spices in these methods, the dried product is very often under-dried or over-dried. If under-dried, it will lead to deterioration of agricultural and horticultural produce due to fungi or bacteria. If over-dried, it could make it hard, resulting in to bursting and spoilage of the produce. On the other hand, under controlled temperature conditions, the agricultural and horticultural produce would dry reasonably fast to a safe moisture level. Such conditions ensure superior quality, better nutritional value and germination percentage in dried produce.

In case of grain, the product quality would improve storage quality, reduce space and time requirements for drying. If the crop is harvested on time to clear the field due to facilities of post-harvest drying it will facilitate faster preparation of fields for sowing, planting or transplanting of the next crop. Moreover, the wet season harvesting, and storage improve drying hygiene thus improving product quality.

In case of fruits, vegetables, spices and fish etc. the controlled temperature conditions reduce the drying time, thus providing more time to sell by improving the marketing control of farmers. The drying will also reduce spoilage, improve product transportability, and improve drying hygiene and storage capability, thus protecting nutritional value.

The drying is usually accomplished only in commercial crop driers which drive heat from conventional fuels viz. electricity, oil, gas etc. Introduction of conventional fuel operated driers is difficult in rural areas of the developing countries because of the limited availability of these fuels (oil, electricity and gas).

On the other hand, the solar dryer is a technology where sun's heat is used for drying the food by extracting the moisture from the food placed inside the dryer. The sunrays are passed inside the dryer through glass or poly sheet and trapped inside the dryer. The bottom surface of the dryer is black painted or covered with black poly sheet, which helps in absorption of the sunrays that generates heat. The heat generated inside the dryer will warm the food placed inside the dryer. If the humidity inside the dryer is high, the food will not be dried. As such, the hot air and moisture evaporated due to warming effect is continuously taken out from outlet vent of the dryer with constant inflow of cool air from inlet vent. The dryer is placed in such a position that the hot air, due to its lightness, constantly goes out and cool air comes in. To control the inside temperature as well as the airflow, the inlet as well as outlet vents could also be regulated. In due course of time, the food gets dried.

Benefits of Solar Drying

When a dryer for crop, fruit, vegetable and spices etc. is used, it will reduce losses of agricultural and horticultural produce during the in-season harvesting periods. A solar dryer reduces drying time with protection from external disturbances such as rain and strong wind and other vagaries of nature. A solar-dried produce is hygienic and preserves nutritional value.

Some of the other benefits of solar drying of agricultural and horticultural crops, spices and herbs and medicinal plants are given below:

- Huge quantity of food goes waste during peak production while there is no food available during lean period. Farmers can get some cash value for the dried products when sold during lean period.
- Drying food items (raw or cooked) in the solar dryer is fast comapred to open sun drying.
- Solar dried food items are hygeinic as they are covered with glass or polythenesheet, the food items are not contaminated with dust insects or bird droppings.
- Drying process does not require external source of energy.
- Problem of bird fetching is eliminated.
- It requires very low repair and maintenance.
- Household solar dryers are portable so can be carried to different places when required.
- Solar dryers can be used for various income generating activities like making spices, pickels.

Climate Mitigation Aspects

Solar drying can also reduce climate change. If solar drying replaces commercial drying with gas, electricity, or coal, the CO_2 emissions of fossil fuel burning are avoided as most electricity in South Asia is made with coal burning at power plants, which gives substantial CO_2 emissions.

Climate Adaptation Aspects

Climate change can have negative impact on food quality, physical availability and economic access to food. In other words, it affects nutrition and food security of vulnerable people. In this context, food dehydration technologies assist in preserving nutrition quality and improving shelf life of fruits and vegetables of surplus food. The technologies assist in food security and nutrition security by improving physical and economical access to food. The technology contributes in income generation by improved storage and minimising food wastage. The food thus preserved could be used during drought and flood conditions. It also helps adapt to volatile food prices during climate induced disasters and become a reliable source of nutritious food.

The Solar Drying Can Be Broadly Divided in to Two Groups: a) Direct and b) Indirect

a) *Direct solar dryers* expose the substance to be dehydrated to direct sunlight. Historically, food and clothing was dried in the sun by using lines, or laying the items on rocks or on top of tents. In South Asian and other developing countries, the agricultural and horticultural produce are normally dried in the sun by laying the items on floors or on top of the roofs. This approach of sun drying is assisted by the movement of the air (wind) that removes the more saturated air away from the food items being dried. However, direct sun drying can chemically alter some food if left in exposed for a long time, thus changing the natural color and the taste. In these systems the solar drying is assisted by the movement of the air (wind) that removes the more saturated air away from the items being dried.

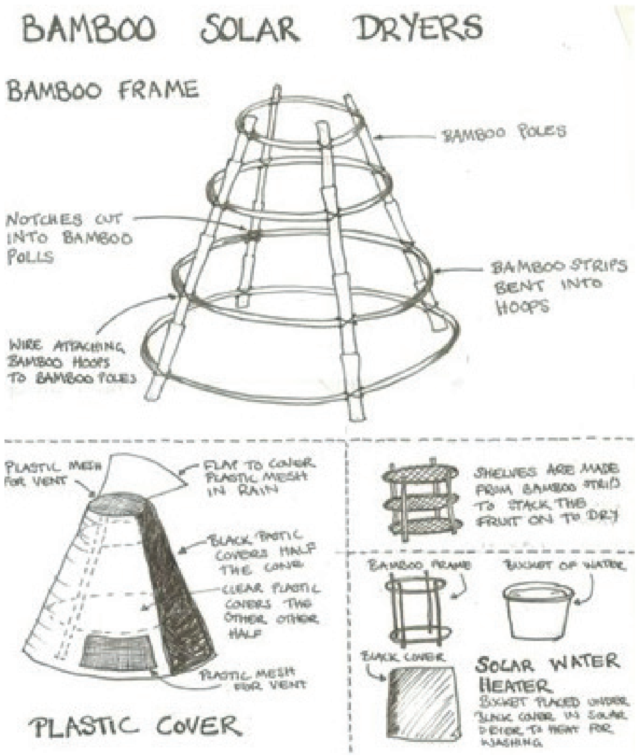
b) At *indirect solar dryers* the black surface heats incoming air, rather than directly heating the substance to be dried. The heated air is then passed over the agricultural and horticultural produce to be dried and then exits upwards often through a chimney, taking the moisture released from the substance with it or a pyramid shaped dryer with opening on the top for taking out the saturated air, which takes moisture released from the substance with it. They can be very simple, as most of the solar dryers used in India and South Asia. One of the advantages of the indirect system is that it is easier to protect the food, or other substance, from contamination whether wind-blown or by birds, insects, or animals. In case of the modern solar dryers, even though they use the direct but filtered sun light and, in some cases, also the black absorbing surface, the food items to be dried is placed directly on this surface. These driers may have enclosures, glass covers or good quality UV stabilized polyethylene sheet cover and/or vents to increase efficiency. In a more efficient solar dryer, 1 or 2 small PV operated DC exhaust fans are also be provided to remove the moisture laden hot air outside the dryer faster. Due to this the air circulation is faster and the efficiency of solar dryer is improved further.

There are many types of solar dryers, made from wood, metal and bamboo, covered by glass or transparent polyethylene (poly) sheet. Three types of solar dryers are described in the subsequent paragraphs. Two are made from bamboo and polyethylene sheet, developed and innovated by INSEDA in India, and one box dryer solar dryer is made from wood and glass by CRT/N and used in Nepal. The models from India were designed and developed in-house by INSEDA for use in its EVD program as their construction costs are significant low as they are built using locally available bamboo.

Pyramid Solar Dryer

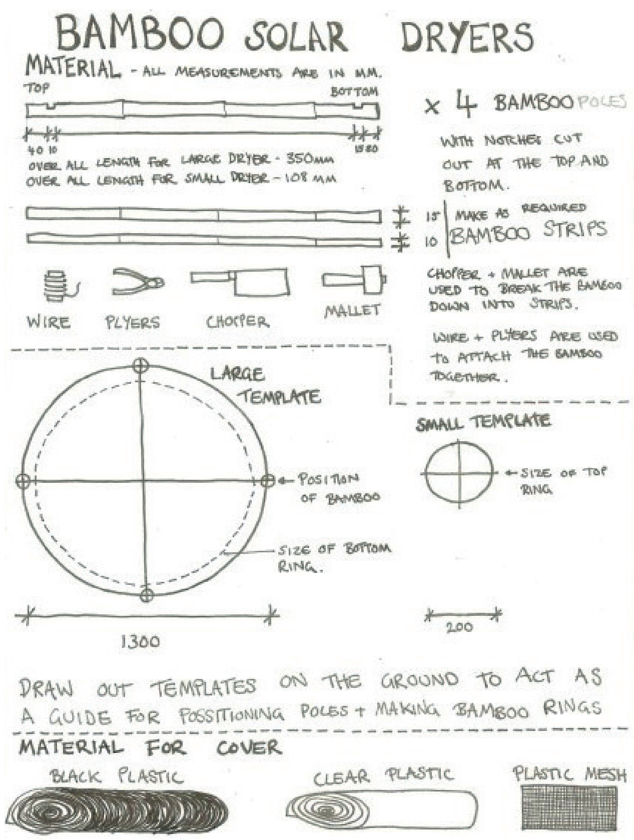
The pyramid solar dryer is easily portable low-cost household solar dryer, made from bamboo and polyethylene sheet for harnessing energy from sun to dry vegetables, fruits, spices and herbs in a clean hygienic way, retaining natural colour and taste of the final product, thus can be stored for longer time, as the shelf life is increased.

This simple low-cost solar dryer has been developed in-house by INSEDA keeping in view the small space in front of the houses in hilly and sub-mountainous region of Uttarakhand state of India, where houses are made on steps after cutting the sloppy hills in to terraces. It is covered with UV stabilized transparent sheet in front and black sheet at the back. The sunrays entering from the transparent sheet in the front, and the infrared rays from sun convert is absorbed by the black sheet in the back and heats the air inside the solar dyer. This solar dryer is designed so that it can be easily shifted or taken from one location to another in hilly terrains by woman of the household. This PSD ne-



eds no other traditional sources of energy to operate, and saves time compared to traditional method of sun drying in the open.

The pyramid solar dryer is easy to build by local women, as per the dimensional sketches using bamboo poles, and by easily stitching and placing the transparent and black poly sheets on the bamboo structure. The half sheet placed in the front is a transparent UV stabilised poly sheet and the balance of half portion for the back is of black colour poly sheet. After appropriate training the local women can easily make this dryer using the tools and dimensional drawing given below, and requires less care, maintenance etc. An opening of 24-inch length x 6-inch width is cut on the transparent UV stabilised poly sheet in such a way that the cut portion of the poly sheet acts as a flap of the same size (24-inch length x 6-inch width) for opening and closing this opening. The lower end of the opening is 2-inch above the bottom most portion of the solar dryer. Further, this opening is stitched with same size (24-inch length x 6-inch width) white net, to allow for free flow of air inside the PSD from the bottom portion. This plastic netting can be opened by rolling up the flap (24-inch length x 6-inch width) of the poly sheet, if more warm air is required, and closed by rolling down the same flap, if no or lesser warm air is required inside the solar dryer.



In the normal operation of the installation, the warm air enters from the bottom of the solar dryer through the netting and rises through the three bamboo meshed trays. The trays are, normally covered with white muslin or gauge cloth, to allow for free flow of warm air through the three bamboo meshed trays to dry the agricultural and horticultural products. Furthermore, they also remove the moisture from the agricultural and horticultural produce before warm air gets automatically released through opening located at the crown of the pyramid, in to the atmosphere. A flap is provided at the crown of the pyramid to close it when it rains or during the night, so that no dew or moisture come down from the top opening.

The solar heated warm air enters the pyramid solar dryer from the bottom opening covered with plastic netting, and through the UV stabilised transparent poly sheet. Both ways are warming up the air inside the solar dryer. Moreover, the black poly sheet at the back of the dryer retains the solar heat in two ways; (1) through the transparent poly sheet in the front, which faces the sun all the time; and 2) also from the warm air entering through the bottom netting stitched on the front transparent poly sheet. Thus, the black sheet at the back gets warmer and retains the heat for a longer time and slowly releases inside of the PSD to warm the air and dry the product kept on the cotton cloth spread on all the three, meshed bamboo trays, and improves the efficiency of the drying.

Constructing a pyramid solar dryer.

Bamboo Solar Poly Tunnel Dryer Innovated and Promoted by INSEDA in India

A solar poly tunnel dryer can be either made for individual household or as a sub-community solar dryer or for semi-commercial purpose: This portable and affordable small tunnel dryer, can be used either by individual or a group of rural people or a sub-community. The dryer is made from bamboo and UV stabilized transparent polyethylene (poly) sheets for harnessing energy from the sun for drying fruits, vegetables, spices and herbs in a clean hygienic way, retaining the natural colour and taste of these items, which can be stored for longer time, as the shelf life is increased.

This solar poly tunnel dryer has been designed and developed by the Secretary General and Chief Executive, INSEDA, for both hilly and plain areas of the country. Its size is 1.60-meter length x 1.00-meter width x 1.00-meter height (or 5 feet Length x 3-feet width, 3-feet height). The size can be increased based on the requirement and quantity of fruits and vegetables etc., for drying. To improve its efficiency, this solar dryer has been provided with two small exhaust fans which are operated by a 10-watt solar panel during the day.

The tunnel dryer was found to be twice efficient than the pyramid shaped solar dryer, as the dryer has provision to keep three layers of trays by the local rural women using meshed bamboo and can dry up to 3-5 times the capacity of pyramid solar dryer.

Solar poly tunnel dryer; drying vegetables; and construction of the top part from bamboo.

Materials required for building of solar poly tunnel dryer are:

- 2-inch diameter x 10-feet long, 8 number bamboo poles
- one 10-watt solar PV (photo-voltaic) panel
- two 12-volt heavy-duty DC fans
- 2-meter length standard electrical wire
- one appropriate size board (plastic or wooden) mounted with 2 good quality 'On' and 'Off' switches
- very good quality UV stabilized transparent polyethylene sheet of 4-meter length x3-meter width
- a thick black poly sheet 2-meterlength x 1.5-meter width
- cotton cloth of 15-metet length x 2-inch width (strips cut from a 3-meter length x 1-meter width cloth).

Manpower and days required to build a solar poly tunnel dryer

1 technician or Technical supervisor and one labour can build this solar dryer in 4 days. 2 women will require 1 day to make the three meshed trays from bamboo strips.

Rack/Box Solar Dryer
Promoted by CRT/N in Nepal

The rack/box solar dryer is such a technology where heat energy from sun is used to dry the food by extracting the moisture from the food placed inside the dryer. The rack/box solar dryer is made up of wood or metal where four verticle stands are used to keep the dryer above the ground. Inside the box there are racks or trays to place the food items to be dried. The trays can be made of wood, metal, bamboo, plastic or wire-mesh. A solar collector of the dryer is slanted from top to bottom to an approximate angle 25 degree to catch maximum sunlight.

The slanting side is made of plain glass sheet or transparent or translucent white UV polyethylene sheet through which the solar radiation penetrates and gets trapped inside the dryer. The bottom plate of the dryer is black painted which so as to absorb maximum solar radiation that generates heat. The heat generated inside the dryer will warm the food placed inside the dryer. The dryer is also provided with a door at the top so that food items can be placed or taken out from the dryer.

Rack/box solar dryer by CRT/N in Nepal.

11. Solar Greenhouse

Introduction

Agriculture is the backbone of the South Asian countries. The economic activities and experiences, during the last 50 years, have demonstrated strong correlation between agricultural growth and economic prosperity. However, in order to increase the agricultural production to meet the present and future population growth, new and effective technologies are needed, which can improve continuously the productivity, profitability, sustainability of our major farming systems. One such technology is the solar greenhouse technology. Although it is centuries old, it is new to India, Nepal and the other South Asian countries.

Solar Greenhouse Technology

About 95% of plants, either food crops or cash crops are grown in open field, under natural environmental conditions. In some of the temperate regions where the climatic conditions are extremely adverse, and no crops can be grown, human beings have developed methods of growing some high value crops continuously by providing protection from the excessive cold, which is called as Greenhouse Technology. The Greenhouse Technology is the technique of providing favourable environment condition to the plants. It is rather used to protect the plants from the adverse climatic conditions such as wind, cold, precipitation, excessive radiation, extreme temperature, insects and diseases. The technology is also of vital importance to create an ideal micro climate around the plants. This is possible by erecting a greenhouse or glass house, where the environmental conditions are so modified that one can grow any plant in any place at any time and any season by providing suitable environmental conditions with minimum labour.

Benefits of Solar Greenhouse Technologies

- The yield may be several times higher than that of outdoor cultivation depending upon the type of greenhouse, type of crop, environmental control facilities.
- Reliability of crop increases under greenhouse cultivation.
- Ideally suited for vegetables, flowers and horticultural crops.
- Year-round production of floricultural crops.
- Off-season production of vegetable and fruit crops.
- Disease-free and quality seedlings and saplings for transplanting in the agricultural land can be produced continuously.
- Efficient utilisation of organic fertilizer and bio-pesticides to control pest and diseases.
- Water requirement of crops is very limited and easy to control.
- Expensive agricultural, horticultural crops can produce and easily monitored for quality control.
- High value herbs, spices and medicinal plant, free of blemishes can be produced.

- Most useful in monitoring and controlling the instability of various ecological system.
- Perennial production of green vegetables is possible.
- The solar poly greenhouse can also serve the purpose of a nursery.
- In rural areas, solar poly greenhouse can be constructed using locally available materials, except the good quality UV stabilised poly sheets have to be bought from the market.
- This technology is very useful for growing off-season vegetable due to its ability to trap heat during the cold ambient climate.
- Other warm season crops may be grown throughout the year inside the green house, after making installing low cost simple drip or sprinkler irrigation.

Climate Adaptation Aspects

The technology enables farmers diversify cropping by altering the immediate crop environment. It provides an alternative income source by which farming could be productive, profitable and sustainable. Coupled with composting and organic farming technology, solar poly greenhouse technology could enhance profitability contributing adaptive capacity of farmers.

Solar Poly Greenhouse

The greenhouse traps the solar energy for growing the plant by making the design in such a way that it controls the micro-environment that high value plants can be grown during off-season to get better market price. Unlike western and industrialised countries, where green houses are made using glass, in India and other South Asian countries, a large number of greenhouses are made from very strong, UV stabilised polyethylene (poly) sheets is being used. In Nepal, the greenhouses are often referred to “Poly Solar Tunnel”, as they often have a tunnel shape. The two of types greenhouses are described underneath.

Simple and Affordable Bamboo Solar Poly Greenhouse by INSEDA in India

A solar poly greenhouse model has been designed and developed in-house by INSEDA based on discussions with our EVD project beneficiaries, especially the women in the villages in and around Ranichauri Centre, (Tehri district), Uttarakhand state of India.

It is a simple technology made mainly from bamboo and very good quality UV stabilized poly sheet and poly net. This technology can be made using local skills (after appropriate training), right at the farmer’s site. If made in hilly region where large flat lands are not available, the size of the greenhouse is kept as 5-meter length, 3-meter width and 2.75-meter height in the middle and 2-meter on the two sides. In hilly and sub-mountainous Himalayan regions of India, say at a height of 750 to 2500 meter (2500-8000 feet) above the sea level, where the temperature goes down sub-zero level (below 0 to -5.0 degrees Celsius) during 3-4 months of winter season, INSEDA normally builds comparatively simple design of the solar poly greenhouse, which does not require external power for operating a pump with sprinkler system or other device to cool down the inside of the greenhouse built in the planes of India and other South Asian countries, especially during the hot months in summer season.

Main material required for the greenhouse: Bamboo, UV stabilized very good quality plastic sheet and plastic net, bricks, cement, sand and pebbles.

Constructing a bamboo reinforced solar poly greenhouse and growing vegetables in it within the EVD program of INSEDA in India.

The solar poly greenhouse described here would also be suitable for hilly regions located at a minimum height of 600 meter (1500 feet) to a maximum of 3000 meter (10000 feet) above the sea level, where the 3-5 months of winter seasons are very cold.

For the lower part of hilly regions (say below 600-meter height above the see level), as well as plain regions of India, the temperature in the 3-4 months summer season goes up high to very high (say 35-48°C), INSEDA make special provision in the design to cool down the inside of the greenhouse during summer season, if the owner proposes to grow any crops or plant saplings during summer.

In plains the size of household the greenhouse unit can be increased to 6-8-meter length, 3-meter width, and 3-3.5-meter height in the centre and 2.5-meter on the two sides. In addition, in plains one exhaust fan would be provided for removing the hot air from inside the greenhouse. In addition, a perforated High-Density Polyethylene pipe is placed lengthwise (laid from front to back) inside the highest point of the ceiling, for regular spraying of water on the green netting; as well as a pipe for either drip or sprinkler irrigation to the crop and saplings. This will ensure that the green house remains cool and comfortable from inside for the crops in the plains, especially during the summer season.

For powering the overhead cooling shower and micro irrigation system for crops inside the greenhouse an appropriate size solar photo voltaic system must be installed, which will comprise of a solar panel, solar battery and a charge controller. This is to easily operate, a DC exhaust fan, a pump to operate the shower and a pump to operate a drip irrigation or sprinkler system. One can design a system such that only a single DC pump operated by the solar battery can operate both the shower and the drip (or sprinkler) system. By providing a solar battery the entire unit can operate during night or when the solar panel is not working at its full capacity e.g. during rainy season or when there are several foggy days during winter in northern plains of India.

INSEDA has developed and innovated this size of household solar poly greenhouse (6-8-meter length, 3-meter width, and 3-3.5-meter height in the centre and 2.5-meter on the two sides), especially for small, marginal and sub-marginal farmers on the plains of India and South Asia. The users of the greenhouse are typically interested in growing high value vegetable crops during off-season to meet their needs as well as earn additional income for selling of surplus produce.

This model is designed as small modular unit, so that any small, marginal and sub-marginal farmers can adopt them very well within the EVD program in a sustainable manner. However, if any of the farmers have more land and find more demand and much better market for such off-season crops grown by them, and want to expand, then they can build another unit of the same size. The second unit could be built along the length side of the first unit, in such a manner that they both have one common side, thus saving in cost of building the second unit. Similarly, if the demand for that crop/crops increase(s) and they are likely to get good market prices (and if more land is also available), then each year 1 or 2 modular greenhouse unit(s) can be added, by using the profit and investing the additional amount from their own resources. This way the same farmers (subject to availability of the land with them) can extend more area under the green house, within their own EVD villages. This approach is far better than taking risk of making a single large size commercial green house (either using own resources or borrowing money from lending institutions) without practical experience of operating one earlier.

Plastic Greenhouse or Tunnel Innovated and Promoted by CRT/N in Nepal

The plastic greenhouse looks like a small hut or tunnel. Bamboo poles are used for the frame, which is covered by plastic. The plastic greenhouse can be constructed according to the size we desire. The size depends upon the quantiry of plants we want to grow. The plastic sheet placed over the bamboo frame traps the heat during the daytime and keeps it warm for longer time. During the sunny day, the plastic house heats up because incoming visible solar radiation is absorbed by plants, soil andfloor, which become warmer and re-emit the energy as longer-wavelength infrared radiation, which cannot escape the greenhouse. Air warmed by the heat from hot interior surfaces is retained in the structure. As the greenhouse accumulates heat, the temperature inside the greenhouse goes up to 10-15 degree celcius more than the ambient temperature. Plant inside the greenhouse are also protected by harsh weather condition like extreme rainfall, fog, cold etc.


Building and use of plastic greenhouse within the EVD program of CRT/N in Nepal.

Limitations and Precautions of Solar Plastic Greenhouse

The many benefits of solar poly (plastic) greenhouse have been mentioned earlier in this chapter, but there are also some limitations of such greenhouses, which are given below along with some precautions to be taken to ensure long life and improved efficiency:

- To have a good flow of air during the daytime, the plastic (poly sheet) at the side of the frame is opened. During the night, the plastic is covered to protect the saplings from the cold.
- Plastic can be damaged by the hailstones.
- Plastic are prone to damage due to rain and sun, (especially if low quality poly sheets are used for making the poly greenhouse); therefore, it must be replaced when torn or damaged beyond repair after use for some time. This period will vary depending on the quality of plastic sheets.
- The layout should be such that the length of the solar plastic greenhouse should be along the east west direction.
- To ensure that wind does not blow the plastic away, the ends of the plastic at the base of the solar plastic greenhouse should be nailed to the ground with pieces of wood.
- At places where the temperature is too low, the plastic greenhouse could be covered with hay.

12. Improved Water Mill (IWM)

Introduction

Water mills are used traditionally in hilly areas for centuries. The water mills use the energy of falling water, kinetic energy, and converts it to mechanical energy. The improved water mills further convert this mechanical energy to electrical energy, which can be used at households as well as at micro-enterprises. It is a good solution in the off-grid mountainous areas with plenty of water resources like Nepal.

The improved water mill technology is a modified version of the traditional water mills designed on the principals of impulse turbine. Traditional water mill consists of runner made up of wooden blades, which needs to be replaced every year while improved watermill consists of metallic runner, which are designed in a way to optimise the efficiency of the runner as well as to gain maximum power from the available hydro- power.

Benefits of IWM Technology

Compared to the traditional water mills, the improved water mills have increased operational efficiency as well as it is more useful with additional machines. After the improvement, the water mills have increased capacity by more than 100 %, which can operate not only mechanical appliances such as cereal (maize, wheat, millet etc.) grinder, paddy huller, and oil expeller, saw mill etc. but also to produce electricity up to 1-3 kW by coupling it with electric generator. The efficiency of improved water mill in processing cereal is as follows: grinding of cereals (20-50 kg/h.); paddy hulling (50-70 kg/h), oil expelling (10-15 kg/h).

In summary the benefits are:

- It needs low water flow.
- It can be used for reducing household drudgery
- Saves substantial time of local community members
- Discourages the encroachment of diesel mills.
- It is more enterprise oriented than the traditional one and helps to increase the income level of the entrepreneurs.

Climate Mitigation Aspects

Power produced by water mills/micro hydro, that replace use of diesel for motors, pumps and elsewhere, reduce the emissions of CO_2 from diesel burning, and thereby reduces climate change.

If the local solutions replace electricity from the grid, they reduce the CO_2 emissions from electricity production and thereby reduce climate change. In Bangladesh, India, and Sri Lanka, a large part of the electricity is made with fossil fuels (coal, gas) and the production has substantial CO_2 emissions.

If the small hydro power gives power for light that would otherwise come from kerosene lamps, they reduce the use of kerosene, which is a fossil fuel that gives CO_2 emissions when burned. When they reduce CO_2 emissions, they reduce climate change.

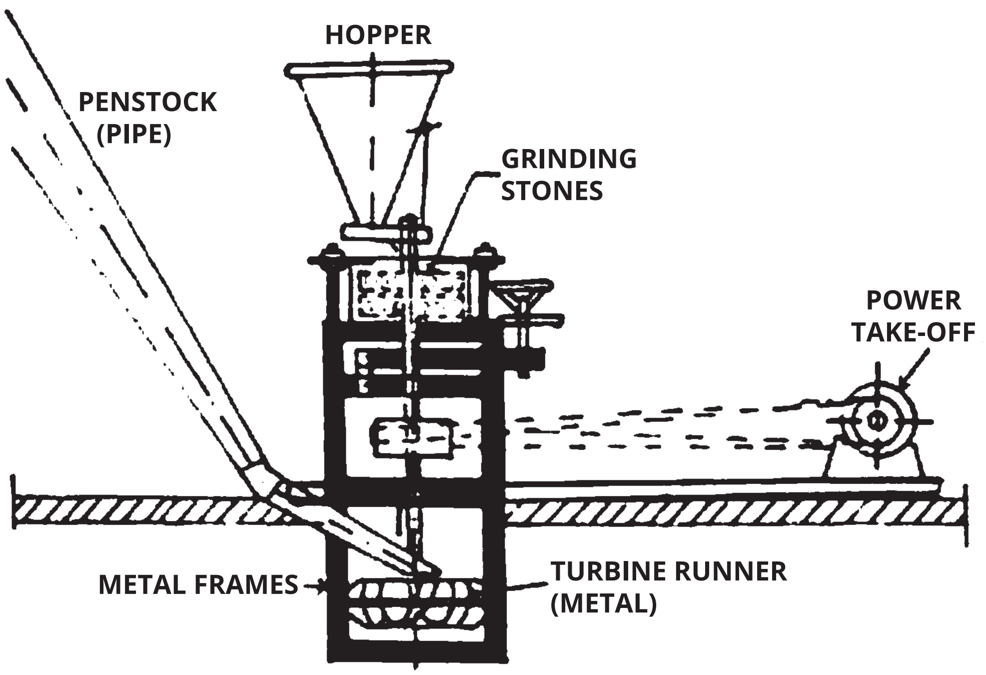
For a family, the reduction with change to hydro power is in the range of 300 – 800 kg CO_2/year.

Technical Description of IWM Technology

Operating Procedure:

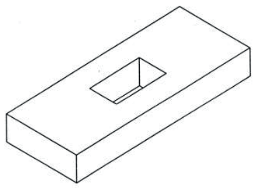
- Fill the hopper with grinding materials.
- Allow water to enter the penstock pipe, which is tilted at 300 with the horizontal.
- In case of additional end use connect it to the shaft coupled a pulley using flat belts

The water hits the runner blades and the shaft coupled with the runner begins to rotate. When the runner rotates, the upper grinding stone also rotates at the same speed. The feed to the grinding stone should be controlled from the hopper itself.



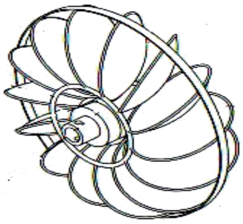
The various components of an improved water mill are:

Phali: Metallic structure placed in the groove at the lower surface of the upper grinding stone and the key of the shaft. It helps transmit mechanical power in the system.

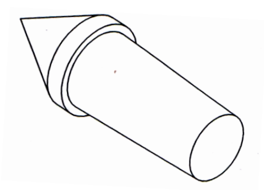


Shaft: It is placed on the Chakati (Base Plate) with Takker (Pivot) as a bearing and holds the runner. It transmits mechanical power from the runner to the upper grinder through the Phali.

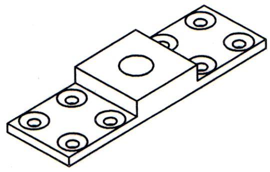
Runner: It consists of Fourteen numbers of buckets joined with runner hub by arc welding and to give it a circular shape with the help of runner strip and guide ring. It is attached with the shaft by nut-bolts. It converts the kinetic energy of waterfall into mechanical energy.



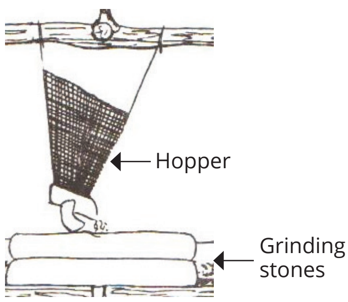
Takkar (Pivot): It is placed in the lower hole of the shaft and the Chakati (Base Plate). The Takkar and Chakati jointly work as a bearing for shaft. The water works as a coolant for the Takkar and Chakati.



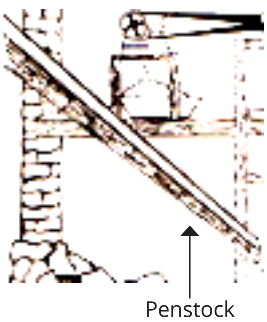
Chakati (Base Plate): It is a base plate for the Takkar and shaft. It is joined to the wooden column at the ground surface with a screw.



Hopper: The hopper is normally made of wood or tin and used for feeding the agro products into the grinding stones for processing.



Penstock: Penstocks convey water from the source from a required height on to the runner to rotate it and produce mechanical energy. The penstock can be made of wood or plastic pipes.



13. Biomass Waste for Rural Brick Production

Moulding bricks.

Introduction

Introducing the use of biomass waste for rural brick producing livelihoods enhances the productivity and sustainability, while reducing firewood consumption and environmental pollution.

IDEA had been involved in the training, dissemination and commercialization of improved cook stoves since 1991. In this field, it has covered 11 out of 22 districts in Sri Lanka including the tea estate sector. With the technical assistance of the Intermediate Technology Development Group (ITDG), IDEA implemented a pilot project in the Kandy district in 1998, which experimented on mixing paddy husk and saw dust with clay to manufacture bricks and improve the traditional kilns to reduce the use of firewood. The success of this project led the technology to be propagated in other districts of Sri Lanka such as Matara, Galle and Anuradhapura which became highly successful.

Biomass use across South Asia is more significant than any form of energy source both at household and industrial level, especially in the rural sector. In Sri Lanka, over 50% of Sri Lanka's energy needs are covered by fuel wood, which contributes to over 75% of the household energy. Industrial energy demand for biomass is over 70% of total energy demand. The brick industry is a biomass intensive activity which consumes significant amount of firewood which contributes to tree felling and deforestation. The traditional brick production processes encompassed low productivity and high biomass consumption which led to economic insecurity among brick makers and serious impacts to the environment. Introduction to paddy husk and improved kiln practices in brick production process could be identified as one of the key interventions to ensure sustainability of the industry.

Description of Technology

In conventional brick production, the brick mixture consists of mostly clay. Firing and stacking of bricks inside the kiln is done with passed-on traditional knowledge without any comprehensive modifications. These conventional procedures have experienced issues with the production process as well as with the produce. Based on the experiences by brick makers, the quality and strength of the bricks are uncertain with conventional brick making and firing practices. Issues such as cracking of bricks and wastage from the kiln, are common problems. With small and medium scale brick makers, brick production is carried out seasonally, especially during the off-agricultural seasons, urging them to use temporary kilns to fulfil their requirement. As oppose to permanent kilns which are heat efficient, temporary kilns made according to traditional systems are inefficient and consume large quantities of firewood which are cut from forests. Given the inefficiency of the production procedures, the economic and environmental impacts are adversely felt by the producers as well as the society directly or indirectly.

The introduction of technologies of mixing paddy husk and sawdust to clay in brick making to reduce the use of clay, has been proven widely beneficial through previous pilot projects. Initially, the clay samples are collected from the areas where the producers obtain their clay for brick making. Then these samples are tested in the laboratory to determine the suitable mixture of clay, saw dust or paddy husk. After the determination of the suitable clay mixtures for each area, the technology is transferred in the field to the brick makers. The quality and strength of bricks produced for different mixtures is been lab tested and proven before the transfer of technology. Both small and medium scale brick producers were targeted for this intervention. Quality of bricks produced has improved immensely because of this innovation. Moreover, technologies introduced to improve seasonal brick kilns and firing methods to reduce the firewood consumption and improved bricks quality has been very successful.

Advantages of the Technology

Overall Impacts and Sustainability

The intervention has helped to improve the environment as well as the economy of the beneficiaries. The bricks produced by biomass-clay mixture and improved kiln practices have helped to improve the quality of product, cost effectively while lowering the impacts on the environment. The brick kilns improvements have substantially reduced the consumption of firewood lowering cost of production while reducing tree felling for firewood which has led to significant reductions of carbon emissions.

Utilization of bio-waste in brick making has significantly reduced indiscriminate dumping and/or burning of rice husk and saw dust which had caused pollution of waterways and atmosphere. Consequently, a demand and value for rice husk and saw dust has also been created regionally. Moreover, it was evident that the upgradation of brick making, and the kiln impacted in improving the whole brick production process which was very relieving in terms of labour and time for the brick makers.

Advantages for the Brick Maker

- Preparation, mixing of the clay mixture and de-moulding the mixture is easier. This is comforting for the worker and helps in ease the hassle over labour shortage.
- The cracking of bricks while drying is completely avoided with the use of the upgraded mixture. In the brick manufacturing process, the bricks are usually dried in the shade before inserting in the kilns. With the old mixture, there were instances where bricks have been cracked and wasted.
- With the upgraded kiln improvements, efficient heat circulation, the time inside the kiln is substantially reduced. The use of sawdust in the clay mixture has also helped to reduce this time.
- With the upgraded kiln improvements, the consumption of firewood has substantially reduced.

Moreover, because of this project, many other regional brick makers, who were not involved in the project, have adopted the clay and rice husk mixture in their brick making through interactions with local producers involved. Hence, this has also accentuated the value of rice husk and saw dust.

Left: Bricks stacked on top of each other for drying. Right: Bricks left to dry in the sunlight covered with coconut branches to make the drying efficiently and uniformly.

Technology Transfer and Upgrades

Introducing a Clay-Rice Husk Mixture

The constituency of the brick mixture is one of the major determinants of the quality and strength of a finished brick. In finding the suitable mixture, analysis of the type and texture of clay used for brick making in the region is important. The role of the technician is to collect clay samples from the types of clay frequently used by the brick maker for testing. These clay samples are used to make different mixtures of clay, saw dust or paddy husk and tested in the lab for strength and water absorption to determine suitable mixtures for production. Once the appropriate mixtures are determined, the technology is transferred in the field to the brick maker. However, before transferring the appropriate mixture, the brick maker is asked to process a few samples of bricks in the field using different mixtures of clay and rice husk to get a feel on how different mixtures behave at processing and drying phases (For instance, mix of 10% ,15%, 20% of rice husk to clay by volume).

Temporary Kiln Upgraded to a Permanent Kiln with Awareness on Systematic Brick Stacking

Due to the seasonality of brick production activities, majority of producers tend to use temporary kilns for each brick firing turn. Most of the regional producers are used to the same practice. However, poor heat circulation and inefficiency are the drawbacks of temporary kilns, which these producers do not take in to account. As a result, there is high consumption of firewood and brick wastage (from under-fired or over-fired bricks).

The technology transfer involves the introduction to permanent kilns with practices to use both firewood and rice husk to be used as firing fuel. Basically, the structure consists of permanent walls at three sides, a roof and three firewood openings. By building a permanent structure, there is a significant improvement in heat retention with minimum heat losses. In brick firing, not only firewood is being used but rice husk as well to improve the consistency of brick burning process (while reducing the consumption of firewood). Below shown is an example of a permanent brick kiln facility. The dimensions of his upgraded permanent kiln facility are 24 feet X 15 feet X 9 feet (length X width X height). Around 12500 max bricks could be produced per one kiln turn under this facility.

With the construction of the permanent kiln, the beneficiaries are educated and trained on efficient kiln practices. For instance, they are given insights on how bricks inside the kiln are stacked systematically with interlayer gaps to be filled with paddy husk to improve the heat circulation and get the maximum heat-benefit.

From top left to bottom right: A replica of a temporary kiln facility. A permanent brick kiln facility. Over-fired and under-fired bricks dumped as wastage from a temporary kiln. Interlayer gaps between bricks to be filled with biomass to increase heat circulation and burning inside.

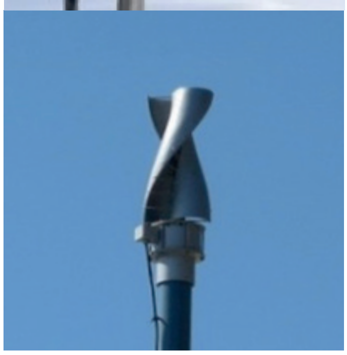
14. Other Low-Carbon Appropriate Green Technologies

A) Wind Turbine

Small windmills can be an option in hilly or coastal off-grid areas with high wind speed. Wind energy, in these areas, have been used for pumping water and grinding grains for centuries. Modern small windmills can generate electricity and charge a battery, as well as pump water. When choosing a wind mill there is need of estimation of the wind speed, and choosing the right site, and height and the type of wind mill, which meets the demand.

The small wind mills' size ranges from 50 W to 10 kW with a rotor diameter of 0.6 m to 3.5 m. Some are designed to work at low wind speeds, but in general, they require minimum 4 meter/sec wind speed. The turbines are typically placed on the top of a tower, but small wind turbines can also be placed on the top of a roof. It has to be made sure that the roof is strong enough to support he windmill that can give vibrations.

Technically, there are 2 types of wind turbines:



1. *Horizontal axis turbines*, which is the most common type. A mechanism or tail finish turning the rotor into the wind. Typically, the turbine has three blades or large number of blades. The multi-blade model is used for water pumping.

2. *Vertical axis turbine*, which is less common, has an advantage that it can harness the wind from any direction without the need to turn the rotor axis and hub when the wind direction changes.

There are many types of small windmills from different manufacturers on the market. The Nordic Folkecenter for Renewable Energy in Denmark maintains a catalogue of small windmills, which is updated regularly. It can be a good tool for planners to choose the right model. Practical Action has training material on use of small windmills for South Asian countries for mechanical work (pumping water), and community electricity.

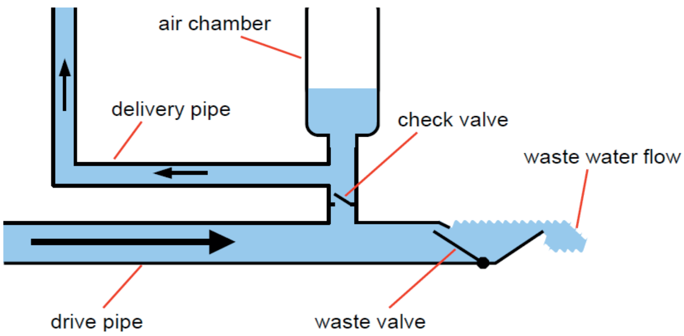
In some cases, a combination of wind and solar electricity is the most optimal to use as it is described in the case study from India, where a 500-Watt vertical axis wind turbine was installed together with a 70-Watt solar panel for a medical center. See case study in appendix.

B) Hydraulic Ram Pump (Hydram) Technology

Hydraulic ram pump or Hydram uses a larger flow of water falling through a small head, to lift a small fraction of the water flow to a higher head. It operates automatically using only the energy in the falling water itself. It is therefore, inexpensive, robust, has very low operating costs, cheap and easy to maintain. The pump can lift water up to the head of 100-120 meters for drinking water supply whereas 70-80 meters for irrigation water supply as large volume of water is necessary within short span of time. The pumps can operate continuously for 24 hours and can deliver between 1,000 and 72,000 litres of water per day. Hydram lifts only about 10 percent of water being drawn from the source to higher altitudes while remaining water is diverted to the water source itself. This way the technology does not affect the aquatic ecosystem and address the water right issues of the communities that depend of same water source for livelihood in the downstream.

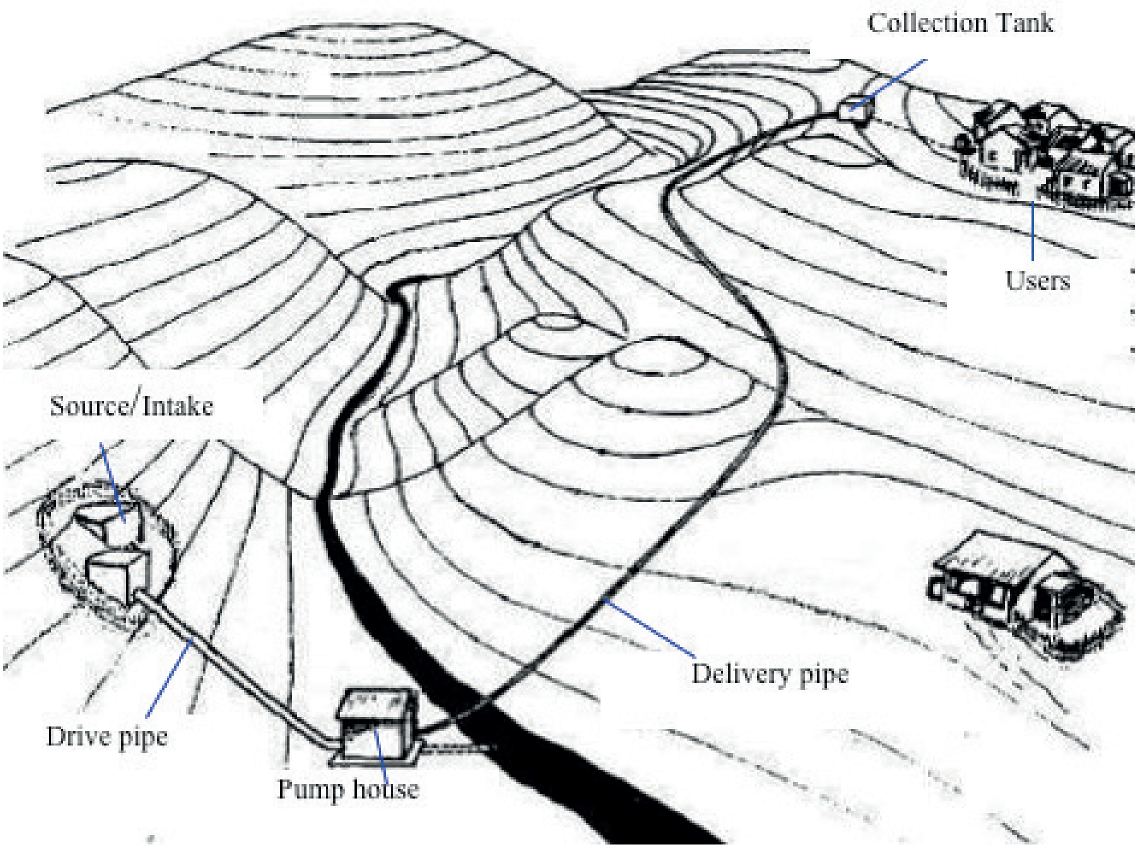
Benefits of Hydram:

- The water lifted by Hydram can be used for different household needs, for irrigation or to support livelihood activities like fisheries, raising livestock, etc.
- Improves health through access to clean water, enabling better hygiene and sanitation;
- Hydram can be integrated with micro-irrigation system like drip irrigation or sprinkle, to improve the productivity of land and increase agricultural yield for farmers.
- Hydram is appropriate water lifting technology to cultivate vegetables.
- Reduced drudgery for women and children who are tasked with collecting water.
- Hydram does not require any external source of energy to operate
- Hydram mitigates the emissions associated with implementing a conventional diesel-powered pumping technology.
- By lifting water to higher grounds, the Hydram helps communities to adapt with the climate change impacts on water resources and agriculture.
- The pump require minimum repair and maintenance therefore operating cost is very low.
- The pump is manufactured in some of the South Asian countries, including Nepal and India.



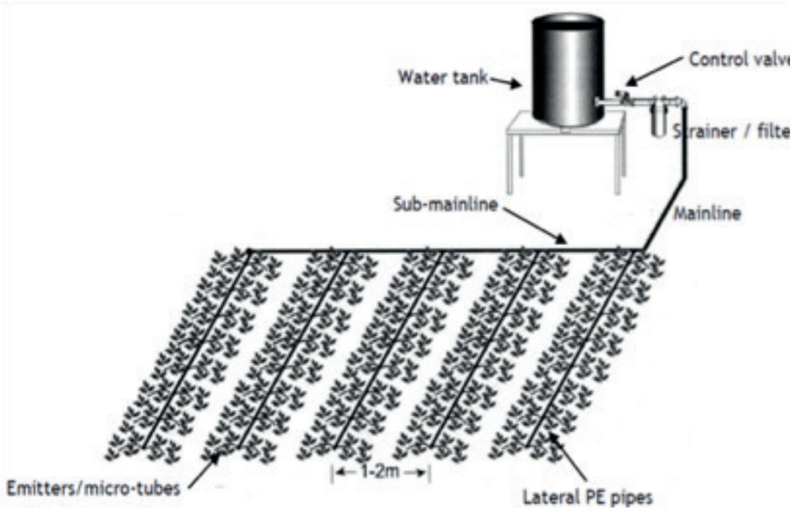
The main components of a Hydram and their functions are:

1. Intake: structure at source that diverts flow of water to the hydram system;
2. Feed pipe or canal: delivers water from the source to the drive tank;
3. Drive tank: provides storage to ensure a constant flow to the hydram and removes sediment from the water;
4. Drive pipe: feeds water to the hydram;
5. Hydram: pump unit that delivers a small amount of the drive flow to the delivery pipe;
6. Pump house: to protect the pump and fittings from accidental damage or theft;
7. Delivery pipe: delivers water from the hydram to the delivery tank;
8. Delivery tank or pond: stores the water pumped by the hydram. Can be a cement-based structure or a lined pond;
9. Distribution system: distributes water to the users. Piping can take water to households, tap-stands or fields.



C) Micro-Irrigation Systems

Drip Irrigation



Drip irrigation is a technique in which water flows through a filter into special drip pipes, with emitters located at different spacing. Water is distributed through the emitters directly into the soil near the plant roots through a special slow-release device. If the drip irrigation system is properly designed, installed, and managed, it may help achieve water conservation by reducing evaporation and deep drainage. Compared to other types of irrigation systems such as flood or overhead sprinklers, water can be more precisely applied to the plant roots. In addition, drip can eliminate many diseases that are spread through irrigation water. Drip irrigation is adaptable to any farmable slope and is suitable for most soils. In contrary to commercial drip irrigation, simple self-made systems are cheap and effective.

Advantages of drip irrigation:

- High water application efficiency and lower labour costs.
- Minimises fertiliser/nutrient loss due to localized application and reduced leaching.
- Ability to irrigate irregular shaped fields.
- Levelling off the field not necessary.
- Allows safe use of recycled (waste) water.
- Moisture within the root zone can be maintained at field capacity and minimized soil erosion.
- Soil type plays less important role in frequency of irrigation.
- Highly uniform distribution of water i.e., controlled by output of each nozzle.
- Usually operated at lower pressure than other types of pressurised irrigation, reducing energy costs.

Sprinkler Irrigation

The Sprikler irrigation system is used to irrigate a small and medium size farmland by making artificial rain through the use of sprinkler. The system comes under small-scale irrigation system and used basically for increasing the efficiency of scarce source of the water. This system is common for kitchen garden to cultivate vegetables. In order to operate this system water needs to be collected in a tank which is fixed at certain height. A gate valve is fitted to the water tank so as to control the flow of water. Pipes are connected with the tank which are aligned as per the shape of the land. If necessary secondary pipes can be connected with the main pipeline. Risers are raised through lateral pipes maintaining certain equal distance depending upon the capacity of the sprinkler to cover the area. Sprinklers are placed in such a way that there is overlapping of the coverage to certain extent. Finally sprinklers are connected to risers. Due to the head of the water, certain pressure is developed on the sprinkler nozzle and the pressure helps to rotate the nozzle and spray out water over the land. Different sizes of sprinklers are available in the market. The user needs confirm the coverage areas that they want to irrigate through sprinkler before buying the sprinkler sets.

Benefits of sprinkler irrigation:

- The system is very good when the soil condition is sandy or loamy which does not retain irrigated water for long.
- It helps in keeping the soil intact and does not erode during irrigation which is very common in the case of gravity flow system.
- It also does not take away the compost that is mixed with soil.
- Where gravity flow is not possible as in sloppy cases, this system can easily work.
- The system uses piping system for irrigation. As such, it does not need to have separate channelling system and thus saves lot of water from getting seepage.
- The system can easily be installed and operated.

D) Solar Street Light

Solar Street Light at Khowamuri Village in Bangladesh.

Most solar panels turn on and turn off automatically by sensing outdoor light using a light source. Solar streetlights are designed to work throughout the night. Many can stay lit for more than one night if the sun is not available for a couple of days.

Solar street lights consist of 4 main parts: (1) Solar Panel will convert solar energy into electricity; (2) Battery will store the electricity from solar panel during the day and provide energy to the fixture during night. Usually 2 types of batteries: (a) gel cell deep cycle battery and (b) lead acid battery are used; (3) Light- LED is used as lighting source of modern solar street light, as LED will provide much higher Lumens with lower energy consumption; and (4) Pole-Solar panels, battery and light is mounted on top of a pole, usually made of galvanised iron (GI) or MS material.

As part of EVD project, Grameen Shakti, Bangladesh has installed 4 Solar street lights (20 Watt each) at Khowamuri village of Singair Sub-district in Manikganj District.

E) Solar Water Pump for Drinking Water System

Solar water pump at Sudhkhira Village in Bangladesh.

Solar water pumps are electrically driven pumping systems, powered by photovoltaic panels.

A solar drinking water pump system has 3 major components (1) Pump (2) Solar Panel (3) Charge controller.

Usually two types of solar powered pump is used: (1) Submersible water pumps which can be used to lift water from depths of up to 700-feet deep; and (2) Surface water pumps which can be used to pump surface water from 10-20 feet deep. The type and capacity of the pump is determined based on the water level and required water output.

After selecting the solar pump, using the available information capacity of the solar panel is calculated. The purpose of the controller is two-fold. Firstly, it matches the output power that the pump receives with the input power available from the solar panels. Secondly, it usually provides protection from a low voltage. If the voltage is too low or too high for the operating voltage range of the pump, the system is automatically switched off. This also increases the lifetime of the pump thus reducing the need for maintenance.

As part of EVD project, Grameen Shakti has installed a solar water drinking pump (2000 litre reserve capacity with 1.5 kW Solar System) at Sundhkhira Village of Singair Subdistrict in Manikganj District, as it would fetch water from deep to avoid the water contamination especially iron and arsenic.

F) Parabolic Solar Cooker

There are several models of parabolic solar cookers, but all of them are based on the same principle of concentrating solar rays at a certain area with the help of reflectors. There are a number of high quality reflecting sheet (reflector) aligned together at the inner side of the cooker frame on which sun rays are reflected at certain area in a concentrating manner. At this particular concentrated junction, the cooking pot/pressure cooker rests with the help of an iron bar that passes horizontally through the cooker. The reflector is mounted in such a way that it can be easily adjusted towards sun. The concentrated heat results into very high temperature inside the vessel which is placed on the focal point. The maximum air temperature was obtained inside the cooker (without any load) is 140°C in winter and 150°C in summer in Kathmandu, Nepal. The food/water inside the cooking pot gets heated and eventually cooked using just solar energy.

Benefit of parabolic solar cooker.

- Avoids or limits the use of traditional fuel types and petrolem based fuels for cooking and boiling water.
- The cooking procedure does not emit any smoke so the technology is environment friendly.
- Cooking in somkeless environement prevents users from Acute Respiratory Infections.
- Besides boiling/heating, the cooker can be used also for roasting and frying of food.
- It can be used for continuous source of boiled water in a sunny day.

Limitation of parabolic solar cooker.

- The Parabolic Solar Cooker can not be used in location where the sunrays are blocked by hills, buildings or tress.
- The reflector need to be adjusted regularly dacing towards the sun's orientation.

G) Kitchen Improvements

Worldwide, around 2.8 billion people - mostly poor rural and urban communities-still rely on solid fuel for cooking and heating. Inefficient combustion of solid fuels in kitchens with inadequate ventilation results in exposure to high levels of Household Air Pollution (HAP) causing various respiratory diseases such as Chronic Obstructive Pulmonary Disease (COPD), cardiovascular diseases and cancer. Women and children are most vulnerable to high levels of exposure of Indoor Air Pollution (IAP). It is estimated that nearly 4 million premature deaths are reported annually due to HAP caused by cooking and 4.3 million deaths in 2012. Hence, is identified as one of the major environment risk factors. Moreover, HAP contributes nearly 12% of total ambient air pollution. In terms of Sri Lanka, biomass is the main source for cooking. Apart from a minority-mainly from the suburbs-who uses LPG and electricity for cooking, still a majority depends on firewood due to its abundance and cost effectiveness. Though interventions such as the Improve Cook Stove programme has reached the rural communities, improvements in household kitchen infrastructure have been hindered due to poverty and low awareness on the health risks and other aspects. The kitchen improvement projects from IDEA seeks to introduce affordable, convenient and simple technologies to people, which would make their use of biomass more efficient while keeping the kitchen environment clean, hygienic, safe, comfortable and with less harmful air pollutants such as respiratory Particulate Matter and Carbon Monoxide. In simple terms, the idea is to provide adequate ventilation, improved cook stove, "Anagi", chimney and setup an organized arrangement of kitchen accessories. This in turn could help to improve the living standards of the households.

Positive Impacts:

- Health risk reduction,
- Reduction of carbon emissions to the atmosphere
- Reduction of cooking time and exposure times
- Lowered consumption of firewood and cost savings
- Improvement of kitchen management and living standards

Designing an Improved Kitchen

Generally cooking with biomass is easy and affordable. Having only three stones and enough firewood, allows anyone the luxury of cooking. However, given its simplicity such a traditional practice consumes a significant amount of firewood and time while emitting high levels of harmful pollutants to the atmosphere. An improved kitchen acknowledges health, comfort, sanitation, drudgery and safety aspects. Prior to designing a kitchen, the required information should be gathered and analysed carefully. Household information such as household number, cooking information such as number of meals, meals and curries being cooked, people involved in cooking, stove type and details, firewood usage and collection details, chimney availability, kitchen space and location, kitchen type and details, are collected and analysed prior to an improvement.

Any kitchen improvement programme should necessarily provide opportunity for a high degree of user participation and incorporate activities for education of users, training of artisans, publicity campaigns, credit facilities or recycling funds. Moreover, the social and cultural background, traditions and rituals are equally important in order to implement improvements effectively. At most instances, behavioural changes are necessary through awareness workshops which would carefully seek to gain the beneficiary acceptance through proper awareness.

Kitchen improvement transformation - before and after.

Improvement of the kitchen entails:

- Use of improved stoves, Improved lighting, air circulation and smoke extraction within the kitchen arranging the interior of the kitchen for ergonomic efficiency of cooking activities.
- Proper storage and preservation of food and spices.
- Storage of utensils, plates, fuel and water.

The general setup of an improved kitchen:

- Improved Cookstove with chimney and ventilation which enables sufficient extraction of smoke.
- Fuelwood storage near the stove and bin for ash collection.
- Optimum use of natural lighting.
- Cooking utensils stored close to food preparation and washing area.
- Rack to store spices and other ingredients near the stove.
- Rack for dishes placed amid stove and place for washing.

Appendix

Case Study 1

Collecting Baseline Information and Planning in five Villages around Rani Chauri Centre in the Tehri District of Uttarakhand State of India.

Baseline Information and Planning exercise.

For the collection of base line information, village mapping and doing the problem and need assessment, WAFD and INSEDA followed the Participatory Rural Appraisal (PRA) methodology which is described in the following section in a case study from Chamba block of Tehri district of the Uttarakhand state in India:

Preparing Social and Resource Maps of the Five Villages

Constructing Social and Resource Maps was the first step in our collaborative approach. Drawing these maps helps give the practitioners more insight into the socio-economic landscape of the community and allows better targeting of various interventions.

As a first step, the WAFD and INSEDA staff, who had been trained in information collection methods using PRA, had a meeting with some of the youth, women and m en of the community to explain that we would collectively make a pictorial map of their village which showed all the houses, paths, wells and hand pumps and other key resources and buildings. To get the correct picture, we asked the group to take a transect walk around the village, from east to west, and from north to south, so that every part of the village could be covered. The main road or highway connecting the village as well as the direction of this road was taken for transact walk.

After the transact walk was completed, we divided the rather large group into 2 and gave the villagers chart papers and coloured sketch pens and asked them to draw a picture of their village as they had observed it. The picture was to also to show all the houses, so the local people could identify their homes, the village temple and the school if there was one. They were also instructed to show the roads and paths and the highway with the direction of where it was going to, so any outsider could get their bearings looking at this illustrative map.

Once completed, both the maps prepared by the two groups, were laid side by side, allowing the participants to compare them and make corrections or additions where required. This process involved a lot of discussions amongst the two groups with them pointing out whenever a house was left out or if a path was shown wrongly. Finally, once we reached consensus that the village was correct and complete, it was decided that a small group would make a final consolidated map using the 2 original maps, which the larger group had made. This map also included a key indicating symbols for various landmarks and buildings. The key also showed the temple or school or dispensary if there was one, or the houses where a school teacher, Anganwadi worker (village level day care and basic education workers in India) and the health worker or midwife lived. It also showed the houses belonging to different castes. These were indicated with different colours.

This exercise took about a week as other people from the community would drop in to see the social map and would contribute something that was left out of the map. This was the first step to prepare a realistic social map of the village together with the village community.

The next step was to make a resource map using the basic social map. Here again, the staff of WAFD and INSEDA guided the groups of youth, women and men to identify the resources in their village. This involved finding out the number of trees in the village, various fruit and other trees, livestock owned by different households, water sources for the houses, the number of houses where women had to go far distances for collecting water, houses which had gas connections and those who depended completely or to a large extent on firewood for cooking energy, the number of vegetable/kitchen gardens, the status of farming units and skills available in the village.

This exercise also took about a week to complete. At the end of these two weeks the village community, especially the women, had become quite aware of their village situation, in terms of their resources. Using this information, we could also do a simple wealth ranking together with the women. For example, a family with scarcely any agricultural land but with the head of the family in the armed forces or in a Government job was better off and had a better economic status than a family where no member had a job and that was entirely dependent on their land.

Using this information, we had discussions with the people especially with the women who are the key stakeholders, so that they can talk about their problems and how they were coping with these. We also steered them towards problems related to climate change which they could relate to, drawing out a “then” and “now” comparison that showed how they were being impacted by climate change. Once the problems and needs were established the next step was to discuss with them the possible solutions.

The specific problems which came out were (1) water shortage (2) deteriorating soil quality and depleting agricultural production (3) lack of fresh vegetables throughout the year so they had to depend on buying produce from the market (4) The wild animal menace that resulted in the destruction of whatever they grew (5) women’s health issues due to smoke filled kitchens (6) soot covered walls and utensils from using traditional wood fuelled cook stoves.

We then shared information with our intended beneficiaries about simple, low carbon, green technologies like the greenhouse, compost baskets, improved cookstove, roof top rain water harvesting unit, solar dryer, and so on which would help alleviate some of their listed problems. The women were very excited and wanted to see and experience these. Together with the women we decided that we would install some of these technologies, which were developed and innovated by INSEDA, in a few homes in each village. We also asked the beneficiaries to contribute a small amount of money or labour towards the construction of these technologies. This request for contributions followed from our previous experience of giving freebies and handouts, which had often resulted in the beneficiaries neglecting the technologies soon after their installation. The women agreed and decided on the amount to be given as contribution. They were also very happy to learn new skills to participate in the building of technologies where ever possible.

We simultaneously also formed women's groups "Mahila Mandals" in each village, so women could share information and we could provide them with required trainings such as making organic manure, the planning of proper vegetable gardens so they could get fresh vegetables round the year for their families, neighbours, as well as earning income by selling the extra produce.

At the monthly meetings the women also spoke of the need for credit and how they had to take loans from money lenders. The solution was a self-help group for thrift and credit.

Thus, through this process (of evaluating the scenario, understanding the needs and problems of the target beneficiaries, analysing them and designing an appropriate action plan with interventions and technologies and, finally, ensuring that the beneficiaries are active partner in such process) we could develop a much more effective and successful project.

Case Study 2

“Anagi” Improved Biomass Stove in Sri Lanka.

Beneficiary Mrs. Podimanika.

Anagi is the most popular Improved Cook Stove (ICS) in Sri Lanka is marketed under the trade name “Anagi”. The word “Anagi” in Sinhala language means precious or excellent. The “Anagi” stove is very useful as it saves fire wood and cooking time.

Mrs. Podimanika is a resident of the village Galahitiyagama in the Matale District of Sri Lanka. She is a housewife. She has been one of the beneficiaries of the Rural Kitchen Improvement Programme conducted by IDEA under the Eco Village Development (EVD) project.

As per the experience of Mrs. Podimanika, the “Anagi” stove saves a lot of firewood and cooking time. Moreover, there is less smoke coming out of the stove. She says that cooking became much more enjoyable now, when she is cooking with the “Anagi stove”. It is worth mentioning that IDEA’s Laboratory tests carried out on the stove indicated a technical efficiency of 21% and numerous field cooking tests indicate an average firewood savings of over 30%.

Case Study 3

Utilisation of Biomass Waste for the Production of Bricks in Rural Area of Sri Lanka.

Beneficiary Mr.Dharmaratne.

With the technical assistance of the Intermediate Technology Development Group (ITDG), IDEA implemented a pilot project on making bricks using waste biomass to fire the kiln in the Kandy district in Sri Lanka. In 1998 IDEA experimented on mixing paddy husk and saw dust with clay to manufacture bricks and improve the traditional kilns to reduce the use of firewood. This technological solution was further extended in the district of Matara, Galle and Anuradhapurain, Sri Lanka.

This case study is about one of the beneficiaries, Mr. N P Dharmaratne who is a small-medium scale brick producer residing in Anuradhapura district. Dharmaratne owns a brick preparation space, kiln and a dug well for the additional water requirements. He has been producing bricks for nearly fifteen years as a permanent income earning activity supporting his wife, two sons and daughter

The land area of Mr. Dharmaratne is nearly one acre. The land is rich with trees such as teak, jack fruit, coconut, king coconut, banana, betel, hog plum trees, bread fruit trees and black pepper. Apart from the income from brick production, he makes some money selling his agricultural produce.

Mr. Dharmaratne worked on his own and refused to take assistance from his family though they were willing to assist him in brick making. The dimensions of the bricks made by him are normally of the size of 9-inch length x 6-inch width x 4-inch height, and he normally uses a single mould made from wood; however, depending on the specific consumers requirement, he also changes the bricks dimensions.15000 bricks per season, currently selling these bricks at a price is Rs. 13/brick (Sri Lankan Rupees-SLR) where bricks are usually sold regionally.

Technology Transfer by IDEA to Mr. Dharmaratne and Up-gradation

The technicians of IDEA played important roles in collecting clay samples from the types of clay frequently used by the brick makers. The ratio of mixture is one of the major determinants of the quality and strength of a finished brick. Different mixtures of clay with saw dust or paddy husk are prepared and tested in the lab for strength and water absorption to determine suitable mixtures for production. Before transferring the knowledge about the appropriate mixture, the brick maker is asked to process a few samples of bricks in the field using different combination of clay and rice husk to get a feel on how various combination behave at processing and drying phases. In Dharmaratne case, 10-15% of rice husk by volume was recommended for mixing with clay to obtain the optimum mixture for brick making.

Temporary Kiln Upgraded to a Permanent Kiln with Awareness on Systematic Brick Stacking

Due to the seasonality of brick production activities, in the past, Dharmaratne, used to set up a temporary kiln for each season, like other brick producers who also followed this practice. However, poor heat circulation and inefficiency were the drawbacks of temporary kilns, resulting in high consumption of firewood and brick wastage (from under-fired or over-fired bricks). Therefore, he was introduced to a permanent kiln by IDEA that could use both firewood and rice husk as fuel. Basically, the structure consist permanently walls at three sides, a roof and three firewood openings. The dimensions of his upgraded permanent kiln facility are 24 feet (length) x 15 feet (width) x 9 feet (height). Now he is able to produce a maximum of around 12500bricks in one kiln turn.

With the construction of permanent kiln unit, Dharmaratne was educated and trained with efficient kiln practices. For instance, how bricks are stacked inside the kiln, in systematically with inter-layer gaps to be filled with paddy husk to improve the heat circulation and get the maximum heat-benefit.

Advantages for Dharmaratne

Earlier, when using temporary Kiln, Dharmaratne required 6-7 yards of firewood to burn 3000 bricks, but in permanent brick kiln he requires only 1 cubic feet of firewood and 60 bags of rice husks waste to burn 3000 bricks. Now the transportation cost has been reduced due to reduction in the weight of bricks. The reduction in the firewood cost is 21,000 SLR (Sri Lankan Rupees) as compared to 31,000SLR per season earlier and percentage reduction of firewood in each season is 67%. The efficient permanent kiln has cut down (reduced) in the number of trees and emission. There is also significant reduction in wastage and saving in time, so he is very happy now.


Moulding and drying bricks,

Case Study 4

Hybrid Wind Turbine for Power Generation at Chamba Block HQs, Tehri Garhwal District of Uttarakhand State in India.

Hybrid Wind Turbine at Masih Hospital at Chamba, Uttarakhand.

WAFD and INSEDA had been jointly implementing eco-village development program in 12 villages of Bharatpur district of Rajasthan state of India since 2002-2010 in partnership with the Student Union of University of Jyvaskyla, Finland.

Based on the success and learning from the experience in Bharatpur district, INSEDA and WAFD decided to extend and up-scale EVD program in six villages of Chamba block, New Tehri district of Uttarakhand state in the sub-Himalayan region of India. From 2011 to 2016 the EVD project was implemented in Chamba Block of Tehri Garhwal, in partnership with a Finnish NGO ASDA who got funds from the Finnish Ministry of Foreign Affairs. WAFD had been working in these villages with women program and had recognised the need to empower the local women.

Due to building of one of the highest hydropower dams about 20-km from the project area, a large land mass with forest had been submerged in the artificial lake (over 40 square kilometres). The lake had also drowned the old Tehri city, to create as reservoir to store the water on the upstream side of the dam. This had affected the micro climate of the area in the surrounding mountainous region that had also affected the area of operation.

The fragile eco-system of the area, large-scale deforestation, and frequent landslides (especially during the monsoon) due to massive construction work, and destruction of habitats of wild animals caused by the submergence in the artificial lake had created man-animal conflict, leading to destruction of crops by wild animals and birds. Together with climate change and erratic rains, people were not able to earn a livelihood from agriculture anymore.

These led to the migration of men and youth to urban centres in the plains and other big cities in search of gainful employment. Thus, only women, children and older people were left in these villages, and the entire burden of agriculture, horticulture & animal husbandry, together with household chores fell on the shoulder of women, leading to long working hours and drudgery, affecting their health and quality of life.

This situation provided an excellent opportunity to the two NGOs (INSEDA and WAFD) to demonstrate the concept of eco-villages development (EVD) by integrating several low-carbon, low cost, green technological solutions, innovated earlier by them and field tested for number of years in Rajasthan state. These were promoted as local green solutions for climate proofing, and sustainable village development.

Background

After discussing and talking to local people, it was realized that despite the big dam in its vicinity, the electrical power supply in the area of operation was very erratic due to problems and cost of taking transmission lines to some of the semi-remote areas and scattered villages, many of which had to be reached on foot, as there were no motorable roads. Due to this, for the first time we included funds for installation of a low carbon, very small wind turbine to act as a demonstration unit to supply emergency power to meet power needs of a household.

However, it was found that the type of wind generator/turbine design with vertical axis, which could work at very high as well as low wind speed, without noise or getting damaged, appropriate for the region was not available in India at that point of time. Therefore, it was decided to import a 500-Watt wind turbine from a small company in Finland, using the earmarked funds. We also invited a retired wind specialist from Finland as volunteer to install this wind turbine.

Various sites in the project areas were surveyed, a few sites were shortlisted and out of these a small local hospital located at the block HQs in Chamba in the New Tehri district was selected by the expert, the hospital staff and the 3 partners jointly.

Reason for Installation at the Hospital Site

This hospital was serving the villages in almost the entire New Tehri and was the only hospital in the district with facilities to carry emergency operations. The hospital is located at a higher spot with no obstructions on any side, so the wind can flow freely and thus generate un-restricted electrical power. On the recommendation of the wind expert, we also agreed to convert this wind turbine in to a hybrid wind turbine by incorporating a solar PV unit, so that whenever the wind speed was not enough during certain months, even then the system could be operational using the power from the storage battery charged using the PV panel.

For a hospital, one of the most important necessity is regular uninterrupted power. This is needed as critical operations cannot be interrupted when power goes off for even a few minutes as it takes some time to start the generator. Critical patients on oxygen also need uninterrupted power. For a small hospital in a remote little town which doesn't have enough funds, it is not possible to have the entire hospital covered by either a diesel generator or invertor.

The Masih Hospital in Chamba, Tehri Garhwal, Uttarakhand is one such small hospital which has 20 beds and caters to mostly very poor below poverty line patients. These patients come from distant and remote villages of the district including the program area as they cannot afford to go to big hospitals in the other parts of the state. Tehri District is 90% rural and only 10% is urban which is concentrated in Rishikesh. This is also the only hospital, which has a qualified surgeon, Dr Rajesh Singh, the head of this hospital, in the district. He also is called by the Government hospitals when they need surgery.

Today the hospital uses the power generated by both the wind turbine and the PV panel for the entire emergency unit and operation theatre of the hospital. Now It is not using any regular electrical power supplied by the state electricity board for these two units as that is unreliable, and the hospital can't afford to have any critical operations interrupted. During the daytime there is also a lot of fluctuations as regular power is also supplied to welding units in the area, this makes it difficult for the hospital to function properly on regular power supply.

Since all the patients and their family members come from the surrounding areas as well as from the entire Tehri district to this hospital, the system is acting as a very good demonstration system, and many enquiries have been made to the hospital for getting such a system, but at an affordable cost, as it becomes expensive importing it from Finland and paying the custom duty. Therefore, we are also looking at the possibilities of transferring this technology from Finland to India so that later it can be fabricated in a medium size workshop at 1/4th the cost.

Wind turbine powered batteries and machines at the hospital.

Utilisation of Power

The power produced is used for operating the Ultra Sound machines, X-ray machines, and Oxygen concentrator machine, Coloscopy, as well as a small fridge for storing vaccines which need to be kept in the sub-zero temperature all the time as the cold chain cannot be broken even for an hour. They also use 4 emergency LED light bulbs in emergency room, and 2 emergency LED bulbs in the corridors of the Hospital.

A side benefit of hybrid system is also the money saved from cost of diesel which the hospital used earlier for the generator. Their regular consumption of diesel for this was 150 to 200 litters per month which cost nothing now. Quantified this comes to a saving of Rs.9, 000/ per month or Rs.108, 000/ per year.

When asked if he is happy, Dr Rajesh Singh pauses, and says "Of course, this vertical axis hybrid wind turbine is a boon".

Case Study 5

Change of the Life: Solar Powered House of Mrs. Rasheda Begum in an Off-grid Village of Bangladesh.


Mrs. Rashida Begum and her daughter in their house, which has a light and a fan powered by solar home system.

Mrs. Rashida Begum lives at Char Azimpur village in Manikganj District of Bangladesh. This village is 40 km far from the capital city Dhaka. The village area is not connected to grid and the people of this area mainly use kerosene for fuelling the kupi and lantern. It is hard to perform any task at night without electricity and children find difficulties to study under kupi (small kerosene lamp) and lantern. Therefore, an 85-Watt solar home system was installed by Grameen Shakti on February 2013. Due to this, she was able to switch her daily activities to a very comfortable and healthy environment. Now she does not need to clean her 3 kerosene fuelled lamps every evening like she had been doing during the last 25 years.

All three rooms of Rasheda's house are now lighted. Rasehda also has a small DC fan operated on the PV home system because of which her family feels comfortable even during a hot day in summer. However, for her one of the most important benefits of the solar home system (SHS) is that her 11 years old daughter Soma can study till 10:00 pm at night which was almost impossible earlier while using the kerosene based kupi/lantern. Rasheda says "We are very happy now with this solar home system. I don't need to waste time cleaning kerosene lamps every day. Now there is no problem of smoke inside the room. My daughter can study well in the lighted room. We enjoy television program and get cool air from fan during the hot summer day, and our "Quality of Life" has been improved".

The package price of the solar home system was BDT 38,450 (USD 493). After down payment of BDT 9500 (USD 122), she has been paying rest of the money in 36 monthly instalments.

Case Study 6

Solar Water Pump Brings: Access to Clean Drinking Water in a Village in Bangladesh.

Children collect water for their houses.

Contaminated water is a history for the student and nearby households of Sudhkhira village in Bangladesh. Now they enjoy drinking clean and pure water and students also take home the drinking water for themselves and other members of family.

This is a story told by a group of students in class 4, named Papiya, Sumaiya, Saiful and Fuyad, of Uttar Bockchar Primary School located in Sudhkhiravillage of Singair Sub-district in Manikganj District. They are sharing their experience on a sunny day of March 2018. With smiling faces, they were telling how they've got access to clean drinking water, and what changes they are witnessing due to clean water. Previously there used to be a tube-well close to the school which was the only source of drinking water for the students. However, like most of the other tube-wells in the village, this tube-well was also contaminated with high concentration of iron and Arsenic. People were drinking this water year after year. Many students and even teachers of this school used to bring water every day from next village as it was quite tough to drink iron-content water.

Considering the view of community-based approach and discussion with stakeholders as part of Eco-Village Development (EVD), a Solar Water Pump (2000 litre reserve capacity with 1.5 kW Solar System) for clean drinking water has been installed in the school located in the village in 2017. Deep boring in the tube-well facilitates iron and arsenic free water in that area. The primary school in that village was using tube-well where the concentration of iron is high and moreover, a couple of classrooms had no light and fan facility even during summer. Taking all these into account, a solar PV system was installed that run a 1 HP (0.75 kW) water pump and provide electricity (250 Watt) to light & fan in the class room.

A solar water pump and a group of students benefitting from it.

The women who live close to the school also take the water for their household drinking. Previously they were using sand-filtration for iron-free water which was cumbersome and time consuming. Now around 250 schools going students and 20 nearby households get hassle free drinking water from the solar water pump which has made their lives easy.

Ms. Amena Begum (housewife) was recounting how much time she used to spend filtering the water to make it iron free. Now she takes the water every day from the solar water pump for her family members. She was showing the reddish coloured water pot and describing their misery of drinking and using high iron contend water earlier. Now they feel happy with the clean water from the solar pump.

EVD solutions has provided a model for a community-based school with clean drinking water within sustainable frame work.

Case Study 7

Village Development Plan (VDP) outline of Hapugasyaya Village, Naula Divisional Secretariat, Matale District, Central Province, Sri Lanka.

Mapping exercise.

Introduction to the Case Study

In 2015, Integrated Development Association (IDEA) initiated the Eco Village Development (EVD) project in Sri Lanka. Three Villages from the Matale district (one of the 25 districts in Sri Lanka) were selected to carry out the tests and demonstrations of EVD Solutions. Prior to integrating EVD solutions at ground level, one of the key activities was to develop community based village development plans in a participatory manner using PRA (Participatory Rural Appraisals) tools and approaches. This process was to give better understanding to the core needs, issues and resources of the given village. Under this activity, Village Development Plans (VDPs) were developed for each village selected under the EVD programme. One such village was "Hapugasyaya" where PRA approach was used to develop the VDP with active involvement of its community. This case study does not include the complete plan of the village "Hapugasyaya" but gives the essence of the elements which would typically be included in one. For the ease of readers, the elements of the VDP is divided in to 20 sections where at some instances the findings are included. Usually, in addition to the information gathered through PRA tools, supplementary information should be collected from various primary and secondary sources as well for the construction of a VDP. The reader should note that, PRA tools used in a planning process should not strictly confine only to the tools utilized and presented under this case study. Given the context and need of the planner, the types of PRA tools could be selected and utilized appropriately. After conducting the PRA exercise, findings and supplementary information collected through other primary and secondary sources would be collectively analysed in formulating a realistic development plan for the village.

1. Objectives of the Plan

Long term objective: Improve the living condition of families in Hapugasyaya village using Eco friendly development strategies.

Short term objectives: (1) Create awareness among villagers on climate change issues and its consequences and the responsibility of every citizen of the world to participate in addressing it, (2) Create awareness on energy sources that emit less carbon and motivate them to use them,(3) Minimize use of chemicals that pollute environment for agriculture and encourage more organic methods, (4) Conduct training and demonstration to improve the productivity of agriculture, (5) Encourage communities to develop required infrastructure facilities in a sustainable manner, (6) Introduce and facilitate to start new sustainable income generating activities to increase family income, and (7) Establish a community centred strong organizational structure at the village level to mobilize required resources for the plan and implement and monitor it.

2. Planning Methodology

Several participatory planning tools have been used to get the peoples participation for information generation and analysis. Followings are the tools used during the process.

1. Collecting secondary information
2. Semi structured interviews
3. Social mapping
4. Venn diagram
5. Matrix
6. Seasonal calendar
7. Walk across village/ Transect walk

For this process there should be a good participation from the community. This exercise was carried bringing together around 50 families- more than 80% of the whole population of the selected region-, representing the village, into a selected house with sufficient facilities to conduct a meeting. Initially awareness was raised about the whole process emphasizing briefly the importance participatory village planning and development which could be achieved in a more ecological and sustainable approach. Then the PRA exercises were carried out. Prior to conducting the PRA, information about the village were gathered through the village head/ Grama Nildhari for the use of facilitators/resource personnel and used as information in the process of developing the Village Development plan. Moreover, before the main document was finalized, more village meetings and surveys were carried out to extract information which were needed. Grama Niladari, Divinaguma Officer, Agriculture Research and Production Assistant, Economic Development Officer, Vidatha Officer, Community Development Officer of Arunalu and President of the Arunalu community development centre also participated in the planning exercise,

The community members are divided into several groups under the guidance of facilitators to generate information, analyse, identify problems and solutions. During this process following analysis was conducted.

- Analysis of present situation of the village
- Problem and needs identification and prioritization

- Identification of solutions and prioritizations of them
- Prepare 3 year plan with prioritized programme and projects

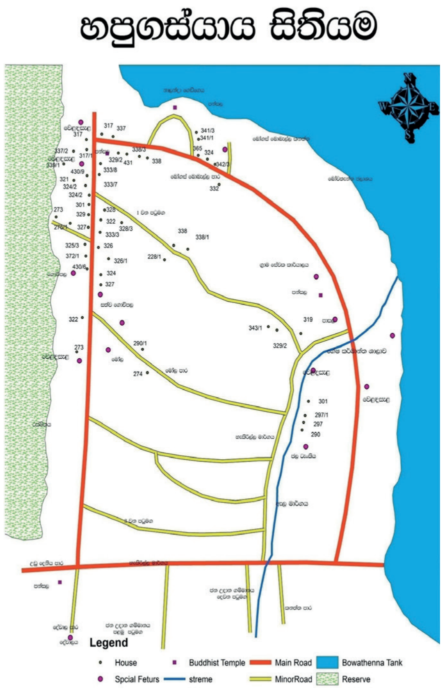
In a village planning exercise, though PRA tools are used specifically to extract information directly on an area of focus, all PRA tools assist in providing information on other issues and aspects as well, which help in verifying and ensuring the accuracy of the information gathered through the process and of secondary data. It is the responsibility of the facilitator to note down all information gathered through each PRA tool, to be used in the analysis and village plan formulation.

In each group activity/PRA tool it is a must to note down the participants in the group.

3. Profile of the Hapugasyaya Village

Information related to this category are primarily from Findings from PRA tools and exercises and secondary sources collected through Village heads/officials prior to conducting the meeting.

PRA Tool: Community Map



3.1 Location and access to the village

3.2 Population

3.3 Population according to age groups

3.4 Population according to races

3.5 Families and Population according to the distribution of assets

3.6 Family information: Male/Women headed, Samurdhi beneficiaries, Receiving public assistance, leigible for assistance but not receiving

3.7 Housing information: According to nature (permanent, semi permanent, temporary), roofing material, type of walls, ownership

3.8 Education information: School going children according to the level of education, Education level of the villagers above 18 years old , other educational information

3.9 Health

3.10 Drinking water

3.11 Sanitary facilities

4. Land and Land Use

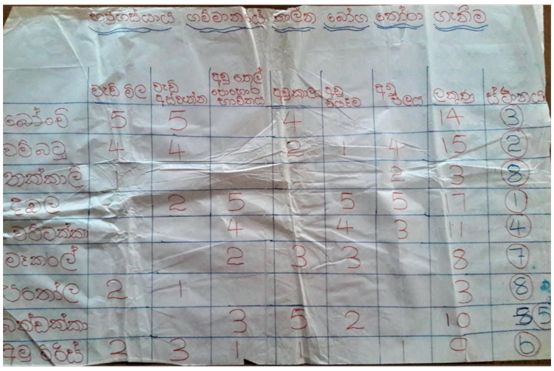
Information related to this category are primarily from Findings from PRA tools and exercises, specifically from Transect walks ,Village mapping, Semi Structured interviews and secondary sources collected from Village heads/officials prior to conducting the meeting.

PRA Tool: Transect Walk

5. Cultivation: Main Crops, Permanent Crops, Types of Vegetables, Most Productive Crops, Issues, etc.

While information on crops grown in the village could be gathered from other primary and secondary information sources, the "matrix" PRA tool could be adopted in finding and verifying appropriate vegetables for the village.

PRA Tool: Matrix - Identification of most productive crops for vegetable cultivation



Crops	High price	High yield	Less chemical and fertilizer	Short duration	Low cost	Less water	Total	Ranking
Wing bean		2	5		5	5	17	1
Brinjal	4	4		2	1	4	15	2
Beans	5	5		4			14	3
Pumpkin			4		4	3	11	4
Ladies finger			3	5	2		10	5
Green chilies	3	3	1	1		1	9	6
Long beans			2	3	3		8	7
Tomato	1					2	3	8
Snake gourd	2	1					3	8

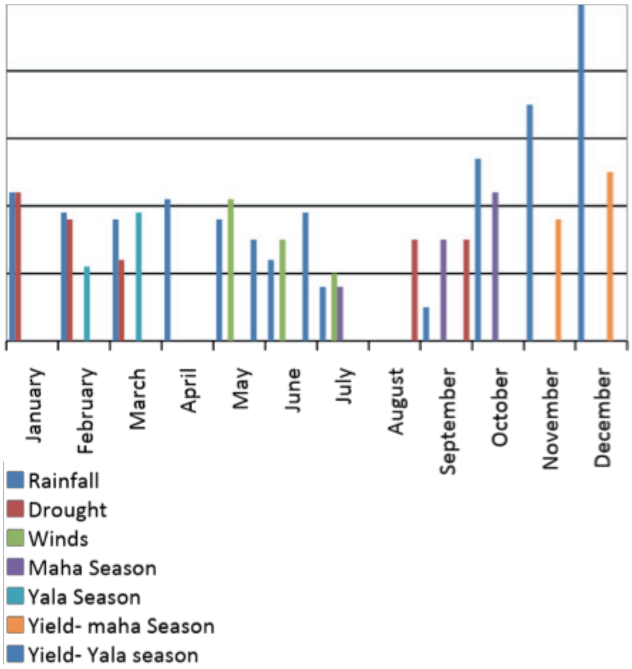
Suitable crops identified for Hapugasyaya village according to priority.

Participants: 1. Wasantha Udaya Kumari 2. Sakunthala seneviratne 3. Herath Manike 5. Jayanthi Ekanayake 6. Yasawathie Manike 7. K.L.A. Dayawathie 8. Jayanthi Manike 9. W.M.P. Mala 10.H.G. Karunawathie 11. R.B.R. Pryadharsana 12. M.G.Karunaratne 13. W.M.Bandara Menike 14. P.G.Sumnaratne 15G.G.Yasawathie 16. R.S.Chandrasena

6. Changes in Climate, Seasonal patterns,Cropping Pattern and Income

In finding the variations in climate, weather and other factors with time, the Seasonal calendar PRA tool was utilized.

PRA Tool: Seasonal Calendar



7. Animal Husbandry: Information, Issues

This information is obtained through information gathered though ground level government, non-governmental officials and other local bodies. Some information could also be gathered and verified through the PRA exercise as well.

8. Resources: Local Availability

PRA tools such as "Transect walk" ,"Semi structured interviews" and "community mapping" is used to extract this information. Regional information sources could also be utilized to collect and verify relevant information.

9. Livelihoods and Employment: Types of Employment and Numbers and Facts

Primary and secondary information sources are also utilized in finding the numbers. Some of this information could be collected through the "wealth ranking" PRA tool and other interviews.

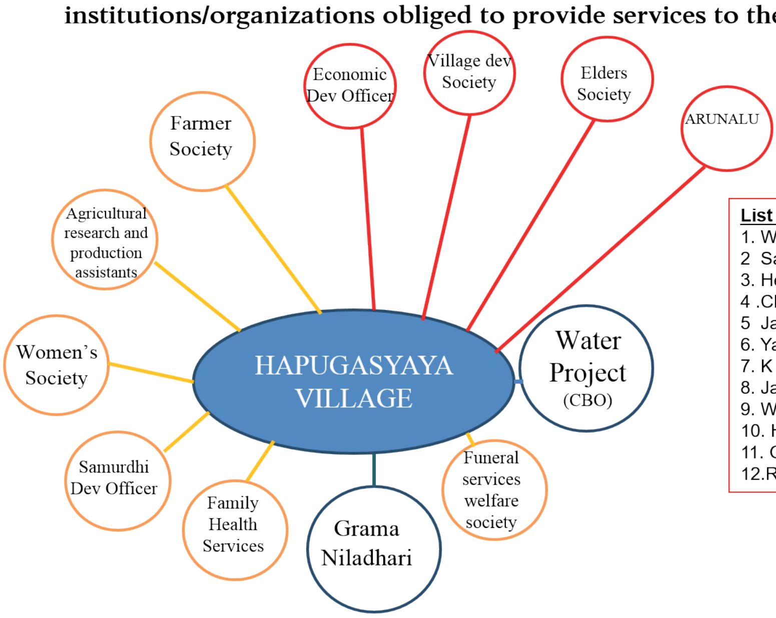
10. Business and industries

Primary and secondary information sources could be utilized in finding this and further verified through the PRA exercise.

11. Organizations, Institutions and Persons Providing Services to the Village and the Relationship between Them and the People

PRA Tool: Venn Diagram

Relationship between village community with officers and institutions/organizations obliged to provide services to the village



List of Participants

1. Wasantha Kumari
2 Sankunthala kumara
3. Herath menike
4 .Chandra kumari
5 Jayanthi Ekanayake
6. Yasawathi Menike
7. K L A Dayawathi
8. Jayanthi Menike
9. W M C Mala
10. H G Karunawathi
11. G G Yasawathi
12.R S Chandrasena

12. Energy Use: Lighting, Thermal Practices, Cooking

The relevant information could be collected through structured surveys prior to the PRA exercise. Some information could be collected by the government officials of the village who periodically collect similar information.

13. Environment of the Village

This information is gathered as sub information while applying PRA tools such as the community map, seasonal calendar, historical timeline, transect walk and matrices. Other secondary information could also be utilized.

14. Categorization of Families According to Wealth

The "wealth ranking" PRA tool is utilized to categorize families according to their economic status through a constructive dialogue and consensus of community members.

PRA Tool: Wealth ranking

This exercise was conducted with a group of villagers who know in detailed about each and every family. This analysis is needed to understand the socio-economic condition of the families and the reasons for their present status. Firstly the group agreed upon on a set of criteria to categorize families according to their economic status and thereafter using HHs list of the village with the wealth ranking tool, families were categorized into three categories, poor, medium and rich. The final product of this exercise is given below.

Categories	Families	%
Poor	18	30.5
Middle	39	66.1
Rich	02	3.4
Total	**59**	**100**

POOR	MIDDLE	RICH
• Having Not enough income for living • Engaged in casual work • Suffering from illnesses • Though land is there no cultivation • No valuable assets • Not being able to maintain the available house	• Having more than one-acre cultivable land • Having an adequate income from cultivation • Having family members at working age • Having a good house • Having adequate assets	• Having cultivable land • Having large home garden with permanent crops • Having high monthly income • Having a good house • Having employed family members • Having valuable assets • Having a good standard of living

Criteria Used for Family Categorization.

15. Loan Facilities

This information could be gathered through "semi structured interviews" PRA tool and as sub information when conducting other tools such as the "Wealth ranking".

16. Infrastructure Facilities

The information below could be collected before and after the PRA exercise to help in formulating the plan. These information are obtained through primary and secondary data and information gathered though ground level government, non-governmental officials and other local bodies. Some information could also be gathered and verified through the PRA exercise as well.

16.1 Roads : Status, Issues and Recommendations

16.2 Electricity : Access to electricity and status

16.3 Transport: Status, Vehicle ownerships, and Issues

16.4 Community hall

16.5 Communication facilities

16.6 Distance to common and other facilities

16.7 Anti-social activities

17. Historical Profile of the Village

In obtaining the historical information and changes the "Historical Timeline" PRA tool was utilized.

PRA Tool: Historical Timeline

During a discussion conducted with a few elderly people in the village regarding the evolution of the village and important events taken place, following information were revealed.

Time period	Special events and changes
1970-1980	• 80% of the village was under forest • Access road to the village was a foot path • There were only about 10 temporary houses • There was enough rain and well had enough water & cultivation was done even in Yala • Tobacco and Banana were the main crops • Livestock was developed and no shortage food for animals • Clearance of forest took place to small extent and used that land for beans and vegetables. • Mainly organic fertilizer used for cultivation • People were happy and peaceful • People were not keen on education • 1977 there was a reduction of number of families
1980-1990	• Forest clearance increased • Bean cultivation expanded, and income increased • Paddy lands were inundated with the reservoir and reduce the extent • About 20 families left the village to get land from other areas • A few ne families came in to the village • Livestock at a peak and outsiders came to collect milk • Increased forest clearance and small streams dried up, teak planted on cleared land • Soil erosion increased reduced soil fertility • Started to use chemical fertilizer, pesticide and herbicide and polluted environment • Vegetable cultivation expanded • Village access road widened • Pressure built up against forest clearance from different organizations
1990-2000	• Vegetable cultivation diversified • Started to use Imported seeds • Cost of cultivation increased, and yield reduced • Forest clearance reduced, community organization started a programme to reforest • On land owned by outsiders planted with teak • Increased the number of families • Pepper cultivation increased • Coconut cultivation too increased as a permanent crop
2000-2015	• Electricity came to village • Big paddy mill came to village • Main road improved • There were employment opportunities for villagers • Chemical fertilizer and use of pesticide increased • Forest reduced teak cultivation increased • Rainfall reduced • Soil erosion increased fertility reduced • Crop damages caused by too much water and drought • Wild animal damages increased • Increased firewood consumption with the increased population • Most of the houses became permanent • Agriculture started to decline, and people went for casual work • Educated young went out of the village for employment • Reduced livestock • Increased village societies • Connection with other villages increased • Increased connection with other organizations

18. Common Problems of the Village

Core problems and issues of the village are discussed and found out through Semi structured interviews.

PRA Rool: Semi Structured Interviews

Using the primary data generated during PRA through semi-structured interviews and secondary data obtained from village level officers, the present situation of the village was analyzed and problems faced by the village were identified. The occurrence of these claims of problems when carrying out different PRA tools were utilized to verify their accuracy. The problems identified has been summarised in the following manner.

Problems:

- Crop damages caused by wild animals
- Reduction of soil fertility due to soil erosion
- Increased Firewood consumption
- Reduction of prices during harvesting time
- Reduction of extent cultivated due to wild animal damages, low fertility and diseases.
- Difficulty in getting good quality seeds
- Transport difficulty due to bad roads within the village
- Water logging and drought
- Difficulty to get access to section of the village during rainy season
- Inadequate extension services
- Lack of income generating opportunities
- Most of the village societies have become not active

19. Objective Analysis

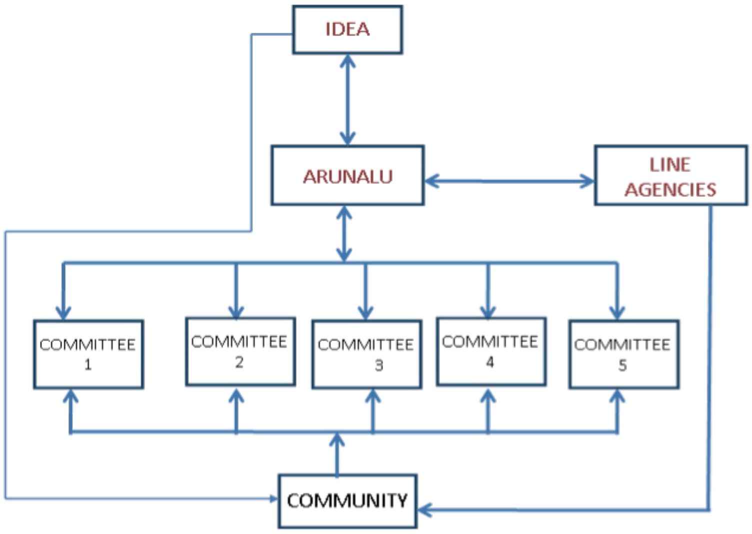
Based on the issues identified the objectives are formulated with a set of indicators to measure the achievements.

SHORT TERM OBJECTIVES	INDICATORS
1. Soil conservation measures are introduced, and soil is conserved	• Soil conservation bunds are in place on xx land plots over the 3-year period
2. Chemical fertilizer and chemical used for vegetable cultivation is considerably reduced and organic fertilizer use increased	• xx families adopt organic methods and reduced agro chemical used by 40% over the 3-year
3. Firewood use is reduced	• 40 Houses use efficient fuel wood stoves for cooking and xx HHs use LP gas
4. Organic home gardening increased	• 30 families started organic home gardens
5. Agriculture extension services to the village improved	• Vegetable cultivation systematically maintained • Management of pepper cultivation improved, and yield increased by 25% • New crop introduced cropping diversified • Farmers get a better price
6. Resource utilization improved	• Income from Graphite increased by 50% • Forest clearance reduced
7. Crop damages minimized	• Soil conservation measures maintained • xx farmers have air rifle • Extent cultivated increased by 30% • Yield increased by 20%
8. Access to services improved	• Number of visits by officers increased by 40% • 90% of the people are happy with the services
9. Farmers organization strengthened and become active	• New set of office bearers appointed • organiation meet monthly with 80% attendance • 80% of farmers are happy with the organization
10. A small bridge is constructed across Moranthenna canal	• Families are happy and accessibility improved
11. Poor families income increased	• XX new families engaged in dairy farming • XX new families engaged in sweet making • XX new families engaged in poultry farming
12. Children who finished education followed vocational training courses	• Number of women weaving clothes increased by XX • XX children attend vocational training • XX trained in heavy vehicle driving

20. Village Development Plan (VDP)

Based on the information, findings and other learnings included above, the VDP would be developed accordingly. The main elements of the VDP are as follows.

1. *Vision:* Make living condition of Hapugasyaya community improved with improved access to services and higher income
2. *Area of authority:* Section of the village as indicated in the map
3. *Beneficiaries:* The families living in the above section of the village
4. *Planning period:* Three years
5. *Organizational Structure - proposed*



6. *Coordination and Monitoring*
    - Plan preparation and Financing by IDEA
    - All coordination activities are carried out by Arunalu community development centre (Local CBO) which already has a presence in the village
7. *Implementation*
    - Total responsibility of Resource mobilization and plan implementation and monitoring is assigned to 5 committees comprised of community members. These committees will be a part of Arunalu organization operating in the village.
    - Conducting awareness for the committees and providing guidance for them will be a responsibility of Arunalu.
    - Linking line agencies and other authorities for services and resource mobilization will be a responsibility of Arunalu.
    - IDEA will guide Arunalu to operationalize the plan.

Five Committees appointed by the Community are given below:

1. Agriculture Development Committee
2. Nonfarm activity/Livelihood Development Committee
3. Infrastructure Development Committee
4. Environmental Development Committee
5. Social Development Committee

The Village Plan would consist of 5 sections under the five comittees appointed / village development society

1. Environment Development Plan
2. Agriculture Development Plan
3. Livelihood Development Plan
4. Socio- Cultural Development Plan
5. Infrastructure Development Plan

Appropriate EVD solutions are introduced in the Development Plan, based on the requirements/ issues/needs identified through the PRA process.

In order to implement this Plan, Arunalu Organization has to do the followings:

- Create awareness among the Committees on the development plan
- Explain made aware of their responsibilities
- Explain the activities planned for different objectives
- Prepare a Time Frame for activities
- Prepare estimate for activities
- Present the plan to different authorities and negotiate with them for possible funding.

See the following pages for extracted examples of the Hapugasyaya Eco Village Development Plan.

Environmental Development Plan (Example)

No	Problem/need	Long term objective	Short term objective	Activities	Targets	Time frame	Respon-sibility	Estimate	Other
01	Increasing soil erosion, water and air pollution due to ongoing economic activities	Minimised environmental degradation caused by economic activities and improve socio economic well- being of village community	Increased use of renewable energy for socio-economic activities in an efficient manner	Introduction and propagation of efficient fuel wood cooking stoves	40 families				
				Conduct demonstration	68 families				
				Conduct awareness programmes on climate change for village communities and officers	68 families				
				Introduction of Improved large stoves for cottage industries	XX families				
				Introduction of energy and material saving technologies and quality improving for brick industry	XX families				
				Conduct demonstration on kitchen improvements and awareness	68 families				
				Mobilize resources for kitchen improvements	XX families				
				Monitor the programme					

Agriculture Development Plan (Example)

No	Problem/need	Long term objective	Short term objective	Activities	Targets	Time frame	Respon-sibility	Estimate	Other
01	Increasing cost of production Low productivity Low income Agriculture becoming less attractive	Make agriculture attractive making it high productive and income earning using sustainable practices.	Increased use of organic fertilizer and Integrated Pest control methods in place chemical fertilizer and agro chemical for vegetable cultivation Minimized soil erosion and increased land fertility	Conduct awareness programme on adverse effect of chemical fertilizer and agro chemical and advantageous of organic agriculture Conduct demonstration on organic fertilizer and cultivation Conduct awareness on degradation of land caused by soil erosion and preventive measures Train farmers to mark contour bunds on land and construct bio fences	40 families 40 families 40 families xx farmers				

Livelihood Development Plan (Example)

No	Problem/need	Long term objective	Short term objective	Activities	Targets	Time frame	Respon-sibility	Estimate	Other
01	Lack of additional income sources for families	Selected families engaged in self- employment nonfarm activities	Several families engaged sweet making Several families engaged in cloth weaving through the families already engaged in. Several families started dairy farming	Conduct a training programme by Vidatha (Technical officials) on processes and Fuel-efficient solutions Facilitate training and provision of required services such as loans and raw materials Facilitate provision of animals, loans and vet nary services	XX training XX families XX families				

Infrastructure Facility Development Plan (Example)

No	Problem/need	Long term objective	Short term objective	Activities	Targets	Time frame	Respon-sibility	Estimate	Other
01	During raining season houses on the other side of the Morgahatenna canal will be in accessible due to inundation	Accessibility is improved throughout the year	Construction of a bridge across the canal	Make aware the political authority and Mahaweli Authority about the need and its importance Organize and offer com-munity participation for the construction	01 bridge 59 families				

Socio-cultural Development Plan (Example)

No	Problem/need	Long term objective	Short term objective	Activities	Targets	Time frame	Respon-sibility	Estimate	Other
01	Several families are faced with problems and the women of those families are subjected to violence	Alcohol consumption and violence against women reduced	Number of men addicted to alcohol reduced Quarrel within families reduced Number women subject-ed to violence reduced	Obtain services of an NGO working on this field to Work in the village Conduct awareness programme on drug and alcohol	All the families affected by the pro-blem				

Case Study 8

Ram Bahadur Tamang Enjoying the Opportunities of Organic Vegetable Farming within the Village in Kavre, Nepal.

Ram Bahadur Tamang and his wife standing alongside plastic pond built for vegetable farming.

As opposed to many young people, who are migrating to towns and abroad, seeking opportunities, Ram Bahdaur Tamang (36 years) from Bethanchowk Rural Municipality Ward no-4, is fully occupied with opportunities within the village. Having spent five years of his life overseas (Malyasia and Saudi Arabia) and learnt the hardships, he is one of the most energetic citizens who have resolved to do something at home. After returning to Nepal 2 years ago, he started seeking local opportunities to earn money. Organic vegetable framing was one of initiative he started during that period.

For the village that has scarcity of even drinking water during the dry season, how would the irrigation requirement be fulfilled? As the saying goes, "where there's a will there's a way", he learnt about micro-irrigation technology from the Eco Village Development (EVD) project in the village. He learnt about the technology of collecting rain water and waste water (from public tap and household usage) in a plastic pond and use it for the vegetable farming. Recently he participated in the training on "Composting and organic pesticides making from household biomass waste and animal waste". Armed with the new knowledge, he has resolved to start producing compost fertilizer and organic pesticides at home within a week.

Initially, he found it hard to believe that his sloppy farmland for harvesting one season corn alone with rain water could be transformed into smart vegetable farm. However, the EVD program operated by the facilitation of Centre for Rural Technology, Nepal (CRT/N) and coordination of various bodies ignited the hope for this transformation. It all began two years ago when his wife, Bimala Tamang (35 years) received training on "Household waste management, collection of waste water and utilization of sewage, and organic farming technology". She even purchased a 500-litre plastic drum with her investment for starting organic vegetable farming. With collection of rain water and waste water from household usage in the tank, she started testing the micro irrigation method with plantation of NPR 300 worth off-seasonal cabbage seedling (during dry season) last year. This trial farming turned out better than expected. Due to lack of adequate knowledge, the harvesting began a little late, resulting in rotting away few of the last harvest batches due to rain. However, she was able to earn NPR 4000 within three months from the same land, which was not even harvesting NPR 2000 worth of corn every year. This success paved way to start a commercial vegetable farming by building a pond near the farm. Investment also has to be focused on reconstructing their home damaged due to earthquake in 2015. But in the following years, he is planning to expand the organic farm.


Trial off-seasonal framing started by the couple during the time of plantation (left) and harvest (right).

Case Study 9

High-Value Tree Plantation Generates Income in a Village in Nepal.

Buddhachitta is a holy tree, whose grains can be used to make prayer beads.

Photo on the right is of Mr. Lok Bahadur Tamang (53 years) of Bethanchok Rural Municipality, Ward No. 4 Chalal Sikriyang Kavre. While visiting the village, often he is found doing some work in the field. Following agriculture as an occupation since his childhood, his vigour for learning and practicing modern farming techniques is unmatched to the youths around, despite his age. Among the locals, who had not seen any alternatives to traditional farming practices, whether it is about vegetable and fruit farming or growing of high value trees, he has become the pioneer.

The massive earthquake in 2015 did huge damage to the entire village. During that hard time, youths from the village started going abroad for opportunities to earn. His younger daughter was also among them and since his son was studying in Kathmandu, the couple was left alone in the village. In the absence of working men, he was compelled to seek new ideas, although he had been seeking alternatives to traditional agriculture all along. At the same time, "Eco Village Development (EVD) Program" started in the village by Centre for Rural Technology, Nepal (CRT/N). He was delighted to find the solution when he participated in the capacity building trainings focusing on modern agriculture technologies, high value trees plantation, renewable energy promotion and waste management. Having learnt about high value tree plantation before, he purchased the Buddhachitta mala seedlings and started plantation soon after receiving the training.

The plants generally taking three-four years to flourish, started bearing grains just after two years thanks to the care and labour of Lok Bahadur. Out of 10 seedlings purchased at NPR 400 per seedling, 4 started bearing grains since last year and 4 started from this year. The harvest from last year has earned him NPR 300,000 (3 Lakhs) approximately. Besides that, he has produced 20 seedlings on his own and planted which are expected to start bearing from the next year.

What is Buddhachitta Mala?

Buddhachitta is a holy tree, which can be grown in natural garden in tropical regions. The tree starts bearing grains after three years of plantation. Buddhachitta are organic holy beads used to make prayer beads, meditation beads and Buddhist prayer beads. 108 ripe seeds (grains) of similar size is used to make prayer beads or Japa Mala used as customary tool for counting the number of times a mantra (Buddha quotes) is recited whilst meditating and remembering the Life of Buddha.

Lok Bahadur says that the value of the grain is determined by the size of the beads. Smaller beads are very expensive. According to him, one of the most popular size (7 mm) prayer beads costs more than NPR 200,000 (two lakhs) while bigger beads of sizes larger than 12 mm costs only NPR 400 to 500.

During the conversation, Lok Bahadur also mentioned notable experience, by selling about 5 kg of bead grains, he managed to make more than Rs. 300,000 (three lakhs). This year, he has targeted to earn even more. However, the market rate may be affected by the production quality.

With the annual income from his small investment, he is confident in being rich from the Buddhachitta farm. This alternative to traditional farming has earned him a comparable amount to what he could have earned working abroad. People who has followed his footsteps are also happy with the returns, while others who did not believed that this is possible are regretting now.

Improvement in Living Standard of Lok Bahadur with Growing Income

Lok Bahadur learned not just how to earn big sums only, but he also knows how to utilize the earned income. He was living in a temporary shelter due to the damage caused by the earthquake to his old house. He recently started building a new house partly with the relief grant support from government. He will be getting NPR 300,000 (3 lakhs) from government. He is going to invest his own savings for the new house which is estimated to cost NPR 1,300,000 (13 lakhs).

Installation of Solar Power System in his Shelter

Due to problems in distribution line from national electric grid, he had installed solar power system in his shelter few years ago by taking loans. Now with his income, he can pay back the loan as well as manage money for required maintenance. Due to regular maintenance, the system is functioning properly and saving money on electricity bills as well.

Construction of Bamboo Reinforced Cement Mortar Water Storage Tank

INSEDA has built five types of capacity tanks, but the most common one is 3000-liter capacity. Therefore, step-by-step construction of 3000-liter unit is explained below.

Material list:

- Bamboo, cement, sand and pebbles for making concrete.
- For weaving bamboo structure for 3000-liter tank: 25 bamboo of 2-inch diameter and 12-feet each are required.

Manpower required are:

- 4 trained women to weave this bamboo structure, Total of 10 days are required to build the entire rooftop rain water harvesting system

The day to day building of the rooftop rain water harvesting system is given in two main phases in the subsequent section.

Stages of constructing bamboo reinforced cement mortar water storage tank.

First phase of the work:

In the first phase of the work, four local women do the weaving of bamboo structures which takes five days, as explained step by step below.

Day 1:

- As a first step, the bamboo sticks are split length wise into 8 parts using sickle or any other tool which can help them to split the bamboo.
- After the bamboos are split, they are immersed in water. For this, one temporary channel of 5-meter length; 1-meter width and 0.5-meter depth is dug on the plain ground surface.
- A 2-meter wide and 5-meter length plastic sheet is placed inside this channel, so that the water doesn't seep underground and, also when the split bamboo is immersed inside does not get dirty from mud.

Day 2:

- The split bamboo is immersed in the water for 12-24 hours. When it has become flexible to give it a proper shape, only then it is used for weaving of bamboo structure.
- The two women split the bamboo and remove any sharp corners (edges) using the sickle. The other two women will continue to split the bamboo (longitudinally) into 8 strips. They will continue to do this activity.
- The width of these 8 split bamboo strips will be about ½ inch for weaving, which will be immersed in the water to make it flexible for easy weaving.

Day 3:

- Out of the 25 bamboo, only between 15-20 bamboo are split into 8 strips of ½ inch width each. The balance of 5 bamboo are split (longitudinally) into 4 strips so that its size is 1-inch width. And these 1-inch bamboo strips (27-29 nos.) are cut into 5-feet length.
- Before starting the weaving of the cylindrical bamboo structure for the water tank, the technical supervisor draws a circle on the plain ground as per the design.
- The technical supervisor then uses these 5-feet long bamboo strips and place them straight on the ground along the periphery of the circle. The number of strips required for this will be between 27-29nos.
- Once the straight bamboo strips are laid in place, the women use balance of bamboo strips to do the weaving. By the end of the day, the entire cylindrical woven structure for a 3000 litres water tank is ready.

  [Note: Out of the 25 bamboo, only between 15-20 bamboo are split into 8 strips of ½ inch width each. The balance of 5 bamboo are split (longitudinally) into 4 strips so that its size is 1-inch width. And these 1-inch bamboo strips (27-29 nos.) are cut into 5-feet long and used for making cylindrical shape. Then the women do the weaving of the mesh using the balance ½ inch strips to make cylindrical shaped structure, to be used later on for making bamboo reinforced cement mortar tank of 3000-liter capacity on the beneficiary's (prospective owner's) site.]

Day 4:

- On the fourth day, the weaving of bamboo mesh for the cover of the tank is done.
- For this, again the technical supervisor draws a circle on the plain surface for women to do the weaving using bamboo strips for making the cover of the tank.

Day 5:

- The weaving for the cover is continued by the four women under the supervision of the technical supervisor,
- By the evening, the entire woven (meshed) bamboo structure is complete.

Second phase of the work

Here, master masons are involved who use this cylindrical bamboo structure at the proposed owner's site to make the water harvesting tank. For this, one appropriately trained master mason and one labourer are needed. The masonry work takes 5 days to complete as explained step-by-step below:

Day 1:

- First of all, the master mason selects appropriate site under the guidance of the technical supervisor in such a way that the rain water from the roof can easily be collected at one spot and directed into the storage tank.
- As a first step, the foundation for the storage tank is made using bricks, stone chips, cement and sand. Width of the foundation is made between 1-feet to 1.5-feet depending on the location. The diameter of foundation should be 1-feet more than the outer diameter of the tank.
- On top of the foundation, about ½-inch width of a mixture of 20-mm gravel, cement and sand is spread, so that it becomes stronger to take the load of the tank. On top of that a 3-inch thick plaster is done using cement and sand mortar. To prevent moisture from seeping inside, the cement mortar is mixed with the damp proof powder, bought from a good company.
- As soon as the foundation is made, the same day the bamboo structure is fixed (inserted) on top of it so that it gets fixed properly and the next day work can be started.

Day 2:

- The entire bamboo structure must be checked and if anything is protruding out, it is removed and then, a water tap is inserted at about 6-inches height of the tank from the inside bottom surface of the completed tank. After fixing the tap inside the bamboo structure, it is properly joined using appropriate mixture of cement mortar.
- After this, cement slurry is poured on the outside of the structure and spread evenly using a brush on the entire structure from outside.
- Then, a rough (coarse) plaster is done on the outside of the tank using cement and sand ratio of 1:3. Also adding water proof (damp proof) powder in the mortar. This plaster is the first coat of plaster.

Day 3:

- On top of the first coat plaster done on the previous day, cement slurry is poured and evenly spread using a brush.
- After this, a second coat plaster is done, which is a fine and more smooth plaster using cement and sand ratio of 1:3 after adding water proof powder in the mortar mixture.
- After finishing the second coat plaster, once again the cement slurry is poured, and using a brush, proper finishing is done.
- After this, the woven bamboo structure for the cover is laid on a levelled ground using a cement sand ratio of 1:3 mixed with the water (damp) proof powder, the plaster is done to make the cover of the water storage tank.

Day 4:

- Work is done Inside the tank, by pouring the cement slurry and evenly spreading it using a brush.
- Now the first coat of coarse plaster is done inside the tank. The cement and sand ratio of 1:3 is used mixed with water proof (damp proof) powder.
- Water is poured on the cover of the tank that was plastered the previous day.

Day 5:

- On top of the first coat of coarse plaster, cement slurry is poured and spread evenly using brush.
- The final plaster (which is a fine/smooth plaster) is done inside the tank using 1:3 cement and sand ratio mixed with water proof (damp proof) powder.
- The outlet from the roof to the tank is connected at an appropriate place, so that during the rainy season, the rain water from the roof can be directed into the tank.
- Now the construction of the rooftop rain water harvesting system is completed except the curing, which is to be done by the owner of the tank.
- The owner of the tank is trained to properly cure the bamboo reinforced cement mortar tank, by pouring water on the outside and inside of the tank every day for at least 10 or more days. This process is most important for the fool-proof construction of the tank, otherwise it will develop cracks at a later stage.

Construction of Bamboo Woven Compost Basket

Day 1:

1. The two women split each bamboo into 8 parts.
2. After splitting the bamboo, they are immersed in water for 8-10 hours. For this purpose, women can make simple channel of 8ft length x 1.5ft width x 2ft depth and cover it with plastic lining so that the water doesn't seep down.

Day 2:

1. Take out the split bamboo from the water and clean the side.
2. On the plain surface, make layout 1m diameter and place 1m height bamboo round the circumference of the circle.
3. Cut 1mt long, 21-23 bamboo in to half in size. Split these bamboos and place them along the circumference. This will provide the base for waving the bamboo the next day.

Day 3:

1. Both the women will do the weaving using bamboo strips and complete the entire basket.
2. If they are going to use the basket for making compost, either the same day or the next day, then, they should place the thick black sheet inside it around its periphery.
3. Now the basket is ready for making compost.

Following step should be followed for filling and emptying the bamboo compost basket to ensure it gives good quality manure:

1. Before filling the basket, the basket should be fitted with thick black colour poly sheet, so that no biomass touches the bamboo part of the basket.
2. Filling of basket: The basket should be filled with waste biomass (biodegradable material) in layers which should be filled in the same day itself or maximum within 24 hours.
3. After filling the basket in layers with biomass, bovine (cattle and or buffalo) manure/dung, leaves and grass etc.
4. Once it is filled just below the top level of the basket, it should be plastered with mud, on top of this, the black poly sheet should be used as a covering material. This way, good quality compost can be produced in about 45-60 days period.
5. Emptying the compost basket after organic manure is made:

- After this, both the black sheet and mud should be removed, and compost should be taken out. Since the height of the basket is only 1m (3 ft), the beneficiary/women can easily take out manures, standing outside.
- Care should be taken to gradually remove the compost from inside the basket so that the basket is not damaged.

Enough organic compost is produced from this size bamboo basket in 45-60 days to manure about one Naalie (Note: - The term Naalie is used in the state of Uttarakhand, and one Naalie is equal to 220-250 square yards or 1/20th of an acre). It is ideal for undertaking organic agriculture on small land and is most suited for hills and mountain regions of India. From one basket of manure one can easily do organic kitchen garden even in plains of India.

Stages of constructing bamboo wowen compost basket.

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60 pp., 4th Edition, 2017. ISBN 978-87-970130-1-4.

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Download in English, Hindi, Nepalese, Bangla, and Sinhala from:

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45 pp.2018, ISBN ISBN: 978-87-970130-0-7.

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