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Education for people and planet: Creating sustainable futures for all

The Leapfrogging Opportunity: Role of Education in Sustainable Development and Climate Change Mitigation

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Introduction

Recognizing that the current paradigm of development - which is heavily fossil fuel based, and high on consumption and waste -, is not a viable option for the future, developing countries need to take an alternative path towards sustainable development. All too often developing countries merely imitate solutions which are already being discarded in the west. The confidence levels in their own traditions and good practices are often low. With knowledge which is available today, it is possible to leapfrog from low levels of development to sustainable development without going through conventional fossil fuel based economies. Education plays a critical role in this transition. This paper gives examples of how education plays and can play a vital role in this process.

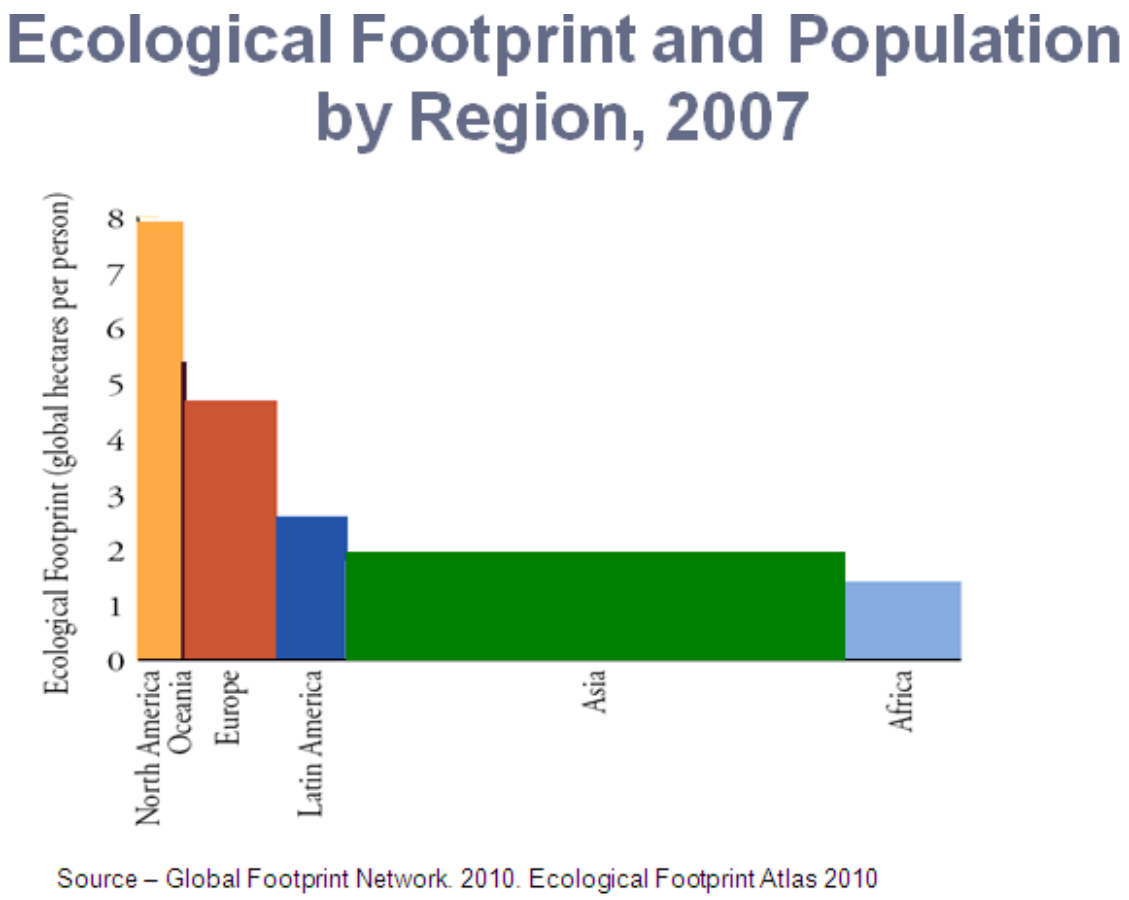
With the finalization of the sustainable development goals (SDGs), we have, perhaps for the first time, globally agreed upon goals and targets for sustainable development.

It took many millennia for the planet's population to reach the one billion mark sometime during the beginning of the industrial revolution. The next one billion was much faster – it took around 125 years to reach two billion by 1927 (UN, 2015). Soon after World War II, when a large part of the planet was coming out of years of colonial rule, the population started to grow much faster. Modern medicine rapidly brought down death rates, while birth rate continued at earlier levels. Education and especially women's education, which is a key determinant to family size, was still very low. With the rapid growth in developing countries, one saw the next billion population reached in just 33 years; after that in quick succession of just 12 years (Population Institute, 2011) it rose to reach the current population of seven billion people. By the time the number stabilizes, it is likely to be closer to 10 billion.

The accelerated population growth has been exerting tremendous pressure on natural resources. The pressure that humans are putting on the planet can be measured in terms of ecological footprint represented in hectares. The average ecological footprint of a North American is nearly 7 global hectares (Global Footprint Network, 2014) compared to the Asian average which is close to 2 global hectares (WWF, 2014) (Figure 1). Even among the developed world there are major differences. For example Europe's average ecological footprint is just under 5 global hectares, much less than that of the US. In terms of carbon footprint (measured as tons of carbon dioxide equivalent) the American footprint is twice that of Europe. The human race, as a whole, already needs one and one third planets to maintain our current level of development. The business-as-usual scenario suggests that at our current rate of consumption we will require nearly two and a half planets by 2050 (Global Footprint Network, 2015).[1]

[1] This paper was written by Kartikeya Sarabhai and Purvi Vyas of the Centre for Environment Education (CEE) Australia Incorporated.

Figure 1



Source – Global Footprint Network. 2010. Ecological Footprint Atlas 2010

Compared to pre-industrial level, the average temperature of the planet is already up by 0.85 degree Celsius. Scientists have clearly said that a temperature rise above 2 degree Celsius would be disastrous. However, all indications are that we are likely to cross this number and face an increase of 3 to 4 degree Celsius. Clearly the current paradigm of development based on fossil fuel-centric economy, high consumption and high waste, and linear thinking model is not sustainable. If the large population of the developing world were to imitate this pattern of growth, the consequences would be disastrous.

Much of the developed world is trying alternatives, and as the UNEP Campaign called it "Kick the Habit", the attempt is to find solutions when consumption levels are already very high. In

most of the developed countries, infrastructure for populations is in place. Applicable solutions in such situations are like retrofitting as there is too much at stake in the existing infrastructure. Thinking of solutions for providing public transport in a city like Los Angeles is very different than planning a public transport network in a city which is at a much earlier stage of development.

Figure 2

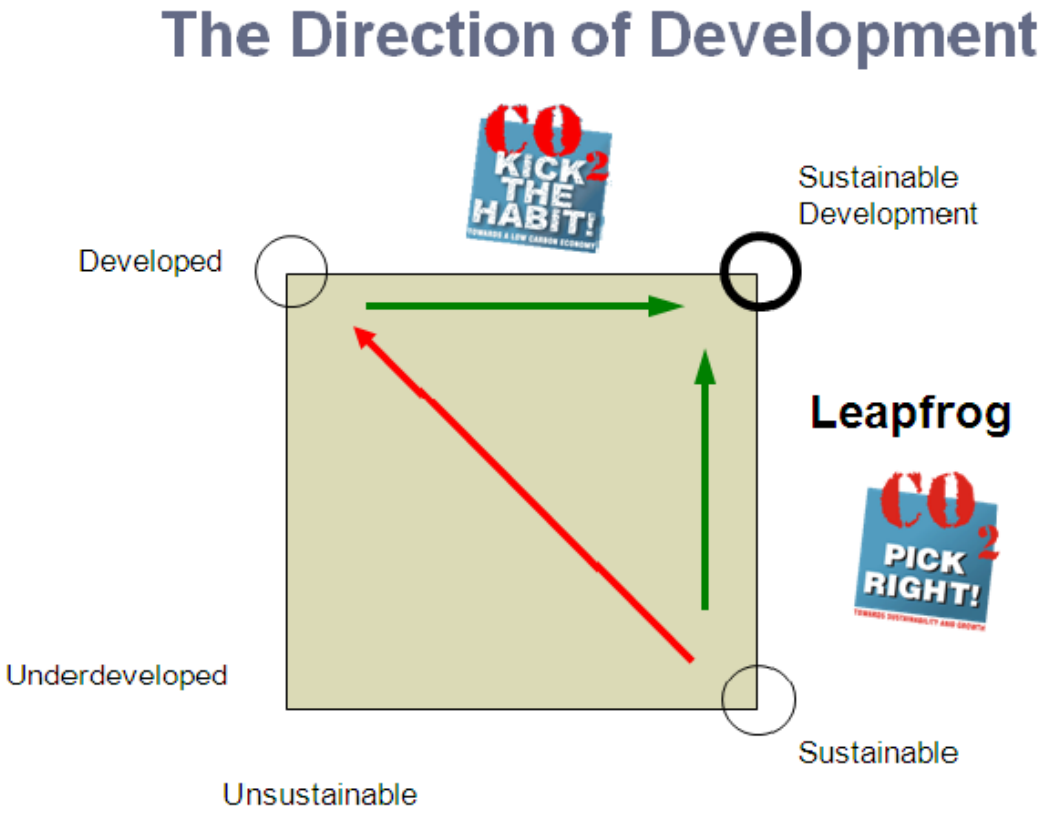


Figure 2 shows a simple diagram indicating the path for progress and development. In the figure, the terms 'developed' mentioned at the top and 'less developed' mentioned at the bottom are in the context of the human development index (HDI). The left and right sides of the figure represent unsustainable and sustainable solutions respectively. Most developing countries start off being sustainable but not developed (i.e. low on human development index). In the process of rapidly developing, these countries unfortunately imitate the current paradigm and try to become developed, thereby losing the aspect of being sustainable. The challenge and, indeed, the opportunity is to go straight to a state of sustainable development without having to make "mistakes" similar to that of developed countries. The campaign for World Environment Day

2008, therefore replaced the slogan "kick the habit" with "pick right" to indicate that we could choose good solutions and leapfrog. Leapfrogging involves choosing from among the best practices around the globe and adapting these to local conditions. It also encourages linking these solutions to local traditions where relevant and helping evolve suitable solutions for development that do not place the planet in peril.

This discussion on leapfrogging as well as Figure 2 are based on the talks and papers of Kartikeya Sarabhai.

This paper analyzes 21 case studies where we see leapfrogging approaches to development and where education plays a crucial role. The role education plays varies from educating decision makers, creating public awareness, training local communities, public involvement through consultations, visit to demonstration sites, to larger efforts at empowerment and capacity building. In many cases, education also impact other drivers of change helping resource mobilizations, policy formation, creation of financial mechanisms and technology selection. The impact of education varies in each case. In some, the project would not happen but for education, in others it enhances effectiveness and participation.

Case Study 1 - Brazil and Colombia: Making a success of a new urban transport system

In 2010, greenhouse gases (GHGs) emitted by the transport sector was 14 percent (IPCC, 2014). An increase of 11 percent GHG emissions had been observed in this sector in a decade (2000-2010). Within the transport sector, Light Duty Vehicles (including passenger cars) have the highest share of GHG emissions (GEA, 2012). In the US, there are about 800 vehicles per 1000 people, whereas for Western Europe this number is 500. Compared to these figures, much of the developing world is only now witnessing the steep rise in personal vehicles. For instance, countries like China and Indonesia saw a significant rise in vehicle ownership in a decade 2002-2012 (US Department of Energy, 2014).

The SDGs, especially target 11.2, talks of providing affordable, safe and sustainable public transport to all urban citizens. The challenge is that: will we see the number of private vehicles rise from under 50 (vehicles per 1000 people) in most developing countries to those similar to the west leading to huge cost, not only due to vehicles but also the infrastructure to sustain mobility of these vehicles? The leapfrog will only be possible if efficient public transport becomes a viable option for the majority of citizens. The traditional choice of buses were affordable but slow, while the metro trains are fast but more expensive. New solutions were required in order to leapfrog and provide an alternative to the car for people. Bus Rapid Transit (BRT) system is considered innovative in a way as it provides the speed, efficiency and capacity similar to light rail/metro system but with an alteration in the simple bus system (Anadkat and Bhatt, 2013). The way it differs from the conventional bus system is due to the provision of a dedicated bus corridor segregated from mixed traffic on the road, bus stations and off board fare collection system (ITDP,

2015). This case study highlights the importance of learning from experiences or best practices, role of organizations in sharing knowledge and acting as a catalyst in the adoption of an appropriate model, information provision and stakeholder engagement while planning the system and role of education in the acceptance of the new model of public transport and changing behaviour of citizens.

Mr. Jamie Lerner, in his role as the mayor of Curitiba, Brazil, in the 1970s, pioneered the BRT system to provide an inexpensive alternative to urban train/metro system to address mobility issues (Reed, 2015). Being aware of the success of Curitiba's BRT system, Mr. Enrique Penalosa, the mayor of Bogota, Colombia, identified this model to address transportation issues in the city. Delegation visits to study the Curitiba model and to adapt it to the local situation was the key approach used by Bogota to design a suitable BRT system for the city (The World Bank Group, 2011). The system in Bogota was initiated in the 1990s and it serves as a good example of scaling up and adapting a transportation model for a large and complex city. Curitiba and Bogota advocated the BRTS model which went on to become an exemplary initiative for many cities around the world to provide an innovative transportation solution. This led to visits of government officials or transport professionals from different parts of the world, including Mr. Gordon Linton (Administrator of the United States Federal Transit Agency in 1998), to these cities to understand the model and identify the possibility of its implementation. Following such visits, various cities started planning and implementing this model. However, experiences of some of the cities like San Jose in Costa Rica and Puebla in Mexico were not successful as they implemented the same Curitiba model (The World Bank Group, 2011). This draws attention to the fact that adaptation of this model to the local context of cities is required. It also highlighted the importance of engaging experts who can help and facilitate the adaptation of the BRTS model to the specific requirements of cities.

Organizations like the Institute for Transportation and Development Policy (ITDP) and the World Resource Institute's EMBARQ network have played a crucial role in promoting the BRTS model as well as implementing it (Pardo, 2012). For example, ITDP has designed BRT in Guangzhou - China; provided technical support to Mexico city – Mexico, Rio de Janeiro and Belo Horizonte – Brazil, and Jakarta – Indonesia in the preparation and implementation of the system; helped Jakarta - Indonesia to develop a communication strategy for stakeholders; and developed BRTS rating standards identifying key elements from the best practices that can guide decision makers to opt for an appropriate model for delivering quality services (Hook, 2013; Kumar et al., 2012). Similarly, EMBARQ has contributed by providing support to various cities including Ahmedabad – India, Guadalajara – Mexico, Istanbul - Turkey, Mexico City – Mexico, and Rio de Janeiro – Brazil, in the planning and implementation of BRTS (Michell, 2013). These organizations share their research and experiential learning through seminars, workshops and publications. The knowledge shared and support received through these organizations benefit cities in reducing time and cost in the planning and implementation of BRTS projects (Dalkmann in Michell, 2013). There are useful resources such as 'The BRT Planning Guide' developed by

these institutes helping decision makers and designers to plan such a system. ITDP and EMBARQ have initiated C40 BRT Network with the aim of providing a platform to cities for the sharing of experience, skills and knowledge through workshops and webinars, enabling improvements in the BRT model and faster implementation of this model in cities (Bates, 2013). There are 197 cities around the world that have accepted BRTS model as a suitable option for public transport (EMBARQ, 2015). Some of these cities have implemented this model and others are at the planning stage or establishing infrastructure.

The success of any public transport depends on its use by citizens. Education can promote acceptance of a new system as well as influence people to change their travel habits. In case of Bogota, Mayor Penalosa encouraged the use of BRTS by raising awareness of the inhabitants by highlighting its benefits and providing user instructions. He conducted public education campaigns that led to acceptance and successful implementation of this system. The daily ridership has increased from 800,000 in 2001 to 1.7 million in 2013 (Cervero, 2013). In Bogota, 9 percent of commuters have shifted to BRTS from using private vehicles (UNDP, 2012). Mayor Penalosa considers advocacy and campaigns important to reduce any stigma associated with the use of alternative mode of transport (public transport and bike) and encourage its use (Grunow, 2012).

For acceptance and use of BRT system, engagement of different stakeholders from planning to post-implementation stages of the system is crucial. Different ways of engaging stakeholders through communication strategy include: stakeholder consultation; provision of information through brochures, seminars and workshops; information campaigns; using media to disseminate information; and providing free bus trip trials. In India, Ahmedabad and Delhi had put communication strategies in place. The way these strategies were implemented impacted the outcome. In the case of Ahmedabad, a "…continuous, interactive and comprehensive (engaging advocates and antagonists alike).." strategy was used throughout the process continuously from planning to post implementation stage (Rizvi, 2014). It harnessed the potential of media to address concerns and put forward balanced views related to the system to gain support from citizens. For Delhi, the strategy that was implemented was fragmented with gaps in between and did not include private vehicle owners and metro train users. The awareness raising initiatives about the system were inadequate. During the operation of the BRT system in Delhi, private vehicle owners criticized the system blaming them for reducing available road space for these users and generating congestion. This was highlighted and publicized in the media leading to discussions of scrapping the system (Rizvi, 2014).

The Jakarta BRTS project in Indonesia, anticipating the possibility of resistance from private vehicle users, designed an aggressive communication plan using different media which covered the planning, delivery, and operation stages of the project. It also recruited a media manager that worked with journalists to build a positive image of the system. This has benefited in gaining wider acceptance of the public transport among people (Kumar et al., 2012). A survey conducted

to understand the impact of this new system in Jakarta revealed that 20 percent private vehicle users shifted to BRTS (Kumar et al., 2012). All these examples suggest that communication is critical for successful implementation of public transport systems. Communication and public participation have become key components of developing and implementing the BRTS model as propagated by various agencies (Wright and Hook, 2007).

During planning and operationalization stages, engagement of existing transport service operators (e.g. buses, taxis, and other informal modes) through various ways (e.g. communication strategy, consultation) is essential to generate an understanding of their integration in the new system and create a sense of acceptance/ownership. This can help in reducing any fears generated among these stakeholders regarding the negative impact of this new system on their livelihood. For example, in the case of Johannesburg, South Africa, inadequate communication among stakeholders (local government and two private taxi organizations) at an early stage of the discussion of implementation of public transport systems led to lack of trust among the parties. Once the local government identified BRT system as a suitable option and in spite of a communication strategy in place, it took a long time to engage the private taxi operators and reach an agreement. Finally, the taxi operators were made shareholders in the company operating the BRT system and drivers were trained and integrated in the system (Allen, 2013). In the case of Lagos, Nigeria, the local government engaged different stakeholders in a communication programme right from the beginning of the project (including planning and implementation stages). The communication programme used a variety of means such as electronic and print media, and developing ambassadors, and trained private mini bus drivers to be part of the new transport system. In fact, the government continued with the communication programme to share information about the operation of new systems (e.g. fare collection) through television. This helped Lagos to avoid any deadlock with stakeholders and the project was implemented relatively quickly (Kumar et al., 2012).

The impact in terms of modal shift from private vehicles to use of BRTS in Curitiba, Brazil, indicated a shift of 28 percent of car users to BRTS, based on a survey conducted in 1991 (Goodman et al, 2005). However, in the case of Ahmedabad, India (Mahadevia et al, 2013) and Istanbul, Turkey (Yazici et al, 2013), a similar study conducted to understand the impact of BRTS suggest that there has been minimal shift in terms of private vehicles opting for BRTS. In Ahmedabad 12 percent of private vehicles users shifted to BRTS, whereas, in Istanbul it was just 4 percent. In both cases, the majority of BRTS users were public transport users before introduction of this system. In Ahmedabad this share was 47 percent* and in Istanbul it was 83 percent**. In this case, academic institutions and other organizations can play a role in inquiring into the challenges that are preventing the modal shift and collaboratively come up with a suitable solution. Education has a key role to play in terms of encouraging people to use public transport.

* In Ahmedabad, 47 percent of users shifted from Ahmedabad Municipal Transport Service buses to BRTS.

** In Istanbul, 55 percent of users of Istanbul Public Transport Authority (IETT) buses, 18 percent of users of private public buses, 9 percent of users of minibus shifted to BRTS/Metrobus.

Case Study 2 – Africa and India: Training local communities to make energy self-sufficient villages

(i) From uneducated to solar engineers

According to the estimate of the International Energy Agency (IEA, 2015a) 1.2 billion people did not have access to electricity as of 2013 and more than half of this population is residing in Sub-Saharan Africa, China and India (IEA, 2015b). The challenge that lies ahead is provision of access to energy to the remotest parts in these regions. However, at the same time it is an opportunity to come up with innovative and alternative solutions to address the issue of energy poverty. This case study highlights the efforts of the Barefoot College (non-governmental organization, India) to provide off-grid solutions to access basic services like electricity, water and education. But considering the scope of this paper, we discuss only about access to solar energy here. The leapfrogging aspect in this case is access to electricity generated using renewable source of energy. The period of implementation of the Millennium Development Goals has clearly demonstrated that a top-down and donor-dominated approach is a weak one to achieve targets (Higgins, 2013). Thus, it is imperative to opt for an alternative approach which is more inclusive and bottom-up. This case study emphasizes that the methods required to achieve SDGs demand a paradigm shift from the mainstream systems - formal education and dependence on grid solutions to provide basic services.

The organization – Barefoot College - follows the Gandhian philosophy of achieving self-reliance through a decentralization model enabling the community to gain access to basic services that fulfill their needs. The emphasis is on using traditional knowledge of communities and empowering them to solve their own problems (Remedios and Rao, 2013).

This case study highlights different education components – (i) personal experiences that led to the foundation of the Barefoot College, (ii) refinement or improvement in the model/approach by exploring possibilities, and (iii) hands on experience or learning by doing model to empower women with skills to become solar engineers. Mr. Bunker Roy's encounter with sufferings (e.g. poverty) of people at grassroots level, during his volunteer work experience as a post graduate student in Bihar at the time of a famine in mid 1960s, left an impact on his mind to an extent that he took the decision to work in villages (Roy, 2011; Barefoot College, 2015). Following this experience, in 1967 he moved to Tilonia, a remote village in the state of Rajasthan in India, to find ways to address the issue of poverty. During the span of five years (until 1971) he stayed with the local community and understood their problems and requirements. He realized that the education and knowledge he possessed through formal the education system was of no use in this situation. The 'unlearning' process taught him that the local communities have knowledge and

skills which formal systems do not value or recognize. The key learning was that if people are empowered with the required capacity, then they can "solve problems, make choices and have the confidence to act upon them" (Roy and Hartigan, 2008).

In 1972, Roy along with a farmer from Tilonia initiated the discussion on "…grafting formal urban knowledge on rural wisdom to create a world without want" (Barefoot College, 2015). This led to the foundation of Social Work and Research Centre (widely known as Barefoot College) whose substantial work began in 1974-75 focused on health and education, with enthusiasts (e.g. doctors, social workers, economists) from urban areas joining the team. The programmes addressed the ground realities and were context specific, addressing the need of the community. For example, night school provided education to those children that missed day school to perform chores and helping their family (Roy and Hartigan, 2008). The curriculum includes content on learning about democracy, measuring land, and treating sick animals (Roy, 2011). However, by the early 1980s, the members from urban areas in the team gradually left the college and the rural community (especially illiterate youth) took charge of decision making, planning and implementing different activities (Barefoot College, 2015). It was a lesson learned - it stressed the importance of the rural community taking leadership as "…dependence on urban expertise and paper credentials did damage the mind-set of the rural poor…" (Remedios and Rao, 2013). Thus, the initial years of learning have played an important role in informing the ideology of the college. These include four key components – "alternative education, valuing traditional knowledge and skills, learning for self-reliance, and dissemination of knowledge and technology" (Roy, 2012).
The Barefoot College started promoting the use of solar energy since the late 1980s (Roy and Joshi, 2003). The college runs on electricity generated from solar panels installed on the campus. The community selects semi-literate and illiterate/unschooled women from remote rural areas without access to electricity, to participate in the Solar Engineer Programme offered by the college. This college is for the poor and managed by the poor. Anyone with a degree is disqualified to participate in programmes offered by this college. Women are given preference for this training as it is likely that they will stay in their village and serve the community; but if men are trained, then chances are high that they leave the village for better opportunities (Roy, 2015). These women undergo a six months training programme in which they acquire the skills to become solar engineers. The programme uses a hands-on-learning or learning by doing approach to impart training. Methods like colour code, drawings and memorization are used. The tutors are local community members who have been through this programme and now act as master trainers. After undergoing this training, women can fabricate, install, maintain and repair systems (e.g. solar lanterns). On completion of the course, these barefoot solar engineers are given a solar equipment/kit (consisting of solar lanterns, fans, TV) the one time investment for which is made by funding agencies (e.g. UNDP). The village has to form a committee which monitors the progress of the project and ensure provision of salary (collected from community members as maintenance charges) to the barefoot solar engineer. Not only electrification but other provisions like solar heater, solar cooker, and solar powered desalination solution for drinking water are

taken care of by these engineers (Remedios and Rao, 2013). The barefoot engineers play the role of trainers in their village to build capacity of youth and other women (Remedios and Rao, 2013). There are 859 barefoot solar engineers trained as a part of this programme from 64 countries (including India) from Asia, Latin America, Africa and the Pacific region. There are 1081 villages around the world which solar engineers have electrified using solar energy (Remedios and Rao, 2013). The success of this programme in India led to the participation of women from other countries in it since 1989 (Barefoot College, 2012a). These women and trainers overcome the language barrier by using gestures/sign language and demonstrations to learn (Bhowmick, 2011). As Roy (Slavin, 2015) says, the aim is not only to make these women solar engineers, but the idea is also to build leadership capacity and confidence in these women by putting them in a new environment and meeting peers from other countries. Funding for this activity (building capacity of women from other countries) comes from various donor agencies such as the Ministry of External Affairs and the Ministry of New and Renewable Energy, Government of India; UN Women and UNDP; ENEL: Green Power; and Skoll Foundation, which covers various costs like fees for the training programme and airfare (Remedios and Rao, 2013).

There are 14 other organizations in India that have followed the Barefoot college model to address local problems. For example, Himalaya Vikas Samiti Mission in Uttarakhand which implements rainwater harvesting and solar energy solutions (Remedios and Rao, 2013) is using this model. These organizations and Barefoot College have formed a network called SAMPDA to develop, facilitate exchange, promote and implement innovative low cost solutions. At the international level, discussion and planning is going on to develop more learning centres – six in Arica, one in the Pacific region and one in Central America (Remedios and Rao, 2013).

There are several socio-economic and environmental benefits associated with this programme. This case study shows how education and training of semi-literate and illiterate women has helped to break the stereotype that women are not good at dealing with technology and a formal degree is required to handle technology. Women have been able to overcome social barriers like caste system and purdah system (covering face) to take up this opportunity. This programme has empowered women with skills that enable them to earn their livelihood. The income generated from this activity provides economic benefits that help in family well-being. For example, in India, income generation from this activity has helped Santosh Devi, one of the barefoot solar engineers to build her own house (Bhowmick, 2011). In addition to this, women take a leadership role and serve the community to fulfil its basic necessities. Other socio-economic benefits include substantial savings on expenses for purchasing kerosene or battery, and reduction in work load for women who would have had to get and use kerosene or biofuel. Women take advantage of this opportunity and invest time in productive activities which further provide economic benefits. As communities replace use of kerosene by solar energy, air pollution and related health risks are reduced. Mr. Dashrath Kumar, a local community member associated with the Barefoot College, states that "what the education system could not provide me, I achieved that in Tilonia….chance to go to Ethiopia for surveying, open-mindedness, communication skills, social interaction and

practical knowledge…" (Remedios and Rao, 2013). According to an estimation, 50 to 95 percent of communities have successfully replaced kerosene lamps with solar lanterns (Remedios and Rao, 2013). As estimated by Roy and Joshi (2003), use of solar lighting systems by rural households has helped to avoid 60,000 tons of carbon emissions during 1989-2001.

The experience in Sierra Leone suggests that this programme has also had policy level impact. In 1989, Sierra Leone's Minister of Education Mr Minkailu Bah's encounter with three barefoot solar engineers/solar grandmothers who were trained in India, and their work to electrify their village using solar energy, drew his attention. He shared this information with the President Mr. Ernest Bai Koroma, and cabinet members visited the village to learn more about this initiative. This led to the government of Sierra Leone investing USD 820,000 to start the first Barefoot College in Africa (Barefoot College, 2012).

The scaling up efforts of this initiative are at two levels. The first is when barefoot solar engineers, after undergoing the course in Tilonia (India), train other community members in her village. There is an implicit component of capacity building for leadership in the training programme that contributes to the scaling up efforts and sustainability of the project. The programme has been able to showcase substantial and very tangible outcomes. This has enabled to gain financial support from governmental, non-governmental and international donor agencies. For the sustainability of the project, the community members, especially barefoot solar engineers, played a crucial role as they had acquired necessary skills to address any issue encountered with the equipment, post implementation of the project. Thus, it is important to educate and build capacity of the local community to maintain the system instead of just introducing new technology. A case of Niger delta demonstrates that in spite of successful introduction of solar-powered water pumps for access to drinking water, the project failed due to lack of community's capacity to sustain it ,as stated by a senior researcher from the International Institute for Environment and Development in London, UK (Best in Slavin, 2015). The second level of scaling up is establishing more learning centres like the Barefoot College in different parts of the world. As the programme has already demonstrated its impact and outcomes, it becomes easier to mobilize financial and human resource.

(ii) Dharani – Solar Village in India

The village of Dharanai in Bihar, India, which had been living in darkness for 30 years, achieved illumination through micro grids operated by solar powered panels. These panels were based on distributed micro grid setup (bottom up approach) and community ownership. Micro grids running on solar powered panels were installed on government buildings, private buildings and rooftops of residences, to provide energy independence to the village. Training and capacity building along with awareness amongst the community has contributed to the success, sustainability and scalability of the project.

Community acceptance of the project was gained through campaigning for creating awareness about the concept of solar energy and its utilization amongst the villagers, leading to their involvement from the start of the project. Mobilizing the people of the village to operate and maintain the micro grid was achieved through face to face interactions and demonstrations at group meetings where the benefits of the same were communicated.

As skill based training is an integral part of the operation and maintenance of the micro grid, training was provided to local technicians enabling them to set up, monitor, repair and support the micro grid and resolve any technical issues. The working of the micro grid is handled by the Village Electrification Committee (VEC) formed in four clusters (*tolas*) of the village. The VEC is a 20 member committee in charge of maintenance and tariff fixing based on consultation with the villagers, and acts as an interface between the operators and the residents.

Demand based scale up of the micro grid emphasizes its bottom-up approach. This model is being used as a successful demonstration at various levels. Scaling up of the concept through communication with policy makers is also being undertaken, ensuring better replication and policy intervention.

(iii) Solar Sister – Renewable Energy Project, Africa

As mentioned earlier, with a large population that do not have access to electricity residing in the sub-Saharan Africa region, especially rural areas, it is a challenge to provide them access to This case study draws attention to the innovative approach used by the social enterprise Solar Sister to provide access to safe and affordable clean energy to the population in Uganda, Rwanda, South Sudan, Kenya, Tanzania and Nigeria (UNFCCC, 2012; Climate Reality Project, 2015). The leapfrogging aspect in this case is the provision of electricity using a renewable source of energy through off grid solutions. The education components that have made a difference were at three levels: (a) experience and learning at the personal level that led to initiation of the Solar Sister, (b) training, capacity building, personal experiences and communication used in the programme to bring about environmental and social change, and (c) organizational learning that is helping to improve the work of the organization.

The process of social innovation suggests that the 'need not being made' has to be identified through various means including careful observation, followed by identifying new ways or possibilities to meet the need through deriving new knowledge or trying unrelated ideas. Piloting these ideas is an important step as "the experience of trying to make them work speeds up their evolution, and the power of example then turns out to be persuasive as written argument or advocacy" (Mulgan, 2006). Ms. Katherine Lucey, as a banker earlier, was engaged in projects that built large scale power plants to provide electricity. From her experience, she learned that these plants were benefiting cities and industries, but a large number of the population still lives in darkness without access to electricity in rural areas. Ms. Lucey's experience of working in rural Africa made her realize the potential of solar energy to reduce energy poverty through

engagement of women in this task. Women are considered as key stakeholders because they are most affected by the lack of electricity while also being the decision makers in choosing from the available energy sources (usually kerosene) to light their household (Lucey, 2015). The lack of access to the conventional source of energy (electricity grid) gave way to an alternative solution in the form of products like solar lantern and solar charger through Solar Sister's work. The 'Avon style'[2] business model of direct marketing of these products was used by Solar Sister, thus making women entrepreneurs reach out to the community and filling the gap of 'last mile distributor' in the market, which was marked by an absence of distribution channels (David South, 2011; Misra, 2011). Solar Sister started with a small pilot phase in rural areas of Uganda in 2010 engaging women to test the idea. Following a successful trial, a full-fledged programme was initiated in 2011 covering a larger rural territory in Uganda (Solar Sister, 2013).

The main office of Solar Sister overlooks the functions of the programme, with regional coordinators keeping in touch with women entrepreneurs. The organization gets solar energy products from firms like Angaza Design and D.Light Design which are bought by women entrepreneurs at wholesale prices to sell in their community. These women rely on their social networks for sale. The organization uses 'Micro Consignment Model' (MCM) for recruitment (Arc Finance, 2012). Any woman that joins this initiative is given a start-up kit which consists of inventory (solar lanterns and chargers), and training and marketing tools - like flyers, posters, stickers, t-shirts, business bag and ledgers to keep sales record – to use when communicating with individuals or showcasing at an event. The entrepreneur/partner can pay for the inventory once she starts earning or return the kit in case of no sale. Solar Sister provides training for marketing and business skills. With increase in sales, and when earning reaches up to USD 300, the entrepreneur can be part of the local micro finance institution (Arc Finance, 2012) and can further expand her work.

The Solar Sister entrepreneurs market and sell solar equipment through sharing of their experience in using them and highlighting their benefits in the context of the customer. These women know their community very well and trust already exists between them and their customers, which helps to gain sales. In addition to this, personal experiences also drive changes. For example, Ms. Umoh Ebango from Nigeria came to know about the solar equipment from her sister who was already a Solar Sister entrepreneur. She not only bought and used these products, but she also became an entrepreneur herself (Solar Sister, 2015a). Information sharing through word of mouth by customers has also helped in reaching more community members. An example of this is Mr. Martin Oketayot, a school teacher in Uganda, who has been using a solar lantern, and spreads the word among his students about its benefits (Albi et al., 2013a). Solar Sister also keeps some of the

[2] Avon is a company that sells beauty products through direct marketing.

clean energy products for demonstration in schools, clinics and community centres so that community members can see the benefits (Lucey, 2015) and promote the use of this technology.

The approaches used by the Solar Sister can be associated to transformative learning. As stated by Taylor, (in Schapiro et al., 2012) dialogue is crucial to bring about change. It "…becomes the medium for critical reflection to be put into action, where experience is reflected on, assumption and beliefs are questioned, and habits of mind are ultimately transformed" (Taylor in Schapiro et al., 2012). Here the author refers to dialogue as "…relational and trustful communication" (Taylor in Schapiro et al., 2012).

The organization gives importance to training – formal and informal - and mentoring to enhance the capacity of entrepreneurs make them skillful salespersons. For formal training, it has a 'Training and Talent Development' programme, which includes a specific curriculum for training entrepreneurs, field staff and staff in office. Through this programme, trainings are implemented directly as well as using 'training of trainers' model through which the capacity of regional coordinators are built to train entrepreneurs (Solar Sister, 2015b). As a part of this training, women entrepreneurs learn to map their social network as much of their sales are dependent on it. The channel of communication between regional coordinators and entrepreneurs/partners is maintained well which helps in problem solving (Harris and Kor, 2013). Also there are group meetings where the regional coordinator meets partners and encourages the peer learning process in terms of learning from each other, to increase sales or tackle any challenge (Arc Finance, 2012). As described by Levitt and March (1988), "organizations are seen as learning by encoding inferences from histories into routines (e.g. procedures, rules and strategies) that guide behaviour". For Solar Sister, their experiences over time have informed their strategies of work. Interactions of the regional coordinators with partners have provided insights and knowledge that has helped them to adapt their model. For example, inventories are assigned depending upon the regional coordinators' understanding of their partners' sales capacity (Arc Finance, 2012). The feedback from entrepreneurs proves valuable. For example, one of the entrepreneurs provided a feedback related to queries regarding post sales service - e.g. repair (Petersen, 2012). This led to addition of a new component in the distribution channel. In 2012, some of the selected entrepreneurs from all over Uganda participated in a technical training to gain skills in providing post-market service (e.g. repair) for the products they sell (Lucey, 2012). The solar equipment producers who sell their products through this network also benefit from the feedback of women entrepreneurs as it them to better design their products or devise strategies to address the needs of the local community. For example, Angaza Design used Solar Sister to evaluate the feasibility of their new product SoLite3 based on the model of incremental purchase of energy (Albi et al., 2013b).

This case study brings out the multiple benefits of introducing clean energy products in the African community to address issues related to energy poverty, climate change, women empowerment, economic empowerment and family well-being. Replacing the use of kerosene by solar lanterns helps to avoid 1.5 tons of carbon dioxide emissions, on an average, during the

lantern's lifetime (SEED, 2015). Avoiding use of kerosene and promoting use of efficient cook stoves reduce indoor pollution benefiting the health of individuals. There are about 1200 women entrepreneurs in Uganda, Tanzania and Nigeria earning an income from their association with Solar Sister (SEED, 2015). Use of products that run on renewable energy source helps save cost on electricity or money spent to buy kerosene. As women start earning an income, they become less dependent on their husbands and can make choices (e.g. using extra income to educate their children) to improve their family's well-being. This gives women decision making power in their family and community. Women and communities are empowered by transferring skills and enabling them to address their own problems rather than being dependent on external agencies or financial resources. Solar Sister has managed to provide benefits of access to energy to 180,000 people (SEED, 2015) in sub-Saharan Africa including the ones residing in remote rural areas. Solar Sister has been able to reach out to the community because of networking and partnerships with local NGOs, as well as women directly approaching the community. It started work in Uganda and within a duration of five years, it has spread its operation to four other countries (Rwanda, South Sudan, Tanzania and Kenya). As stated by Contes (2015), "…one of the reasons of its (Solar Sister's) success is the continuous investment in its entrepreneurs' leadership skills." This case study demonstrates very well that investment in skill development of women and renewable energy can help achieve multiple sustainable development goals (SDGs) related to energy, climate change, poverty, education, gender equality and employment.

Case Study 3 – China: Building capacity of key stakeholders to harness clean energy

China, one of the largest economies of the world, consumed nearly 20 percent of global energy and emitted more than 20 percent of carbon dioxide in 2012 (Lawrence Berkeley National Laboratory and China Energy Group, 2014). For energy generation, China is heavily dependent (more than 50 percent) on non-renewable sources such as coal and oil (Lawrence Berkeley National Laboratory and China Energy Group, 2014). However, the country has been putting in lot of effort since the 1990s (initiated by the Chinese government and the UN agencies) to use renewable sources for energy generation. The initiative undertaken by China is in the right direction and it could help to achieve the SD Goal 7: "…increase substantially the share of renewable energy in the global energy mix" (UNDESA, 2015), which is essential to reduce GHG mitigation by adopting new and cleaner technologies. Since 1990s, China has managed to provide electricity to 99 percent of its rural population (Niez, 2010) and 400,000 households were electrified using renewable energy (solar energy) from 1999-2010 (The World Bank, 2011). Thus, it has managed to avoid the use of coal/oil and directly harness the potential of renewable sources for electricity generation. The case study also looks at the increasing share of energy generated using renewable sources and energy conservation.

From 1950s to 1990s, China had initiated small scale hydropower plants, and use of wind, solar and biomass for energy generation to electrify rural households. This shift towards the use of renewable energy sources was initiated to strengthen long term use of such available local

resources; during and after the 1990s, the aim was to achieve energy security with importance being given to environmental conservation (Luo, 2004). The introduction of alternative sources of energy began with trial and error (e.g. failure of adequate utilization of biogas) followed by conscious efforts to change the energy scenario in the country. In the 1980s, the World Bank's engagement with the Chinese government helped to boost investment in the energy sector with focus on energy efficiency. It also helped to train some of the Chinese officials in project management. The United Nations Development Programme - Global Environment Facility (UNDP-GEF), along with other government agencies, co-financed a grant that helped to initiate renewable energy projects in 1999. As a part of such projects funded by international agencies, a key benefit for China was studies conducted in the energy sector to enable an informed decision making process for designing energy strategies (Martinot, 2001). Andrews-Speed (2010) stated that the World Bank influenced the policy formulation for energy sector by convincing the Chinese government that "…market forces could and should be introduced to the domestic energy sector, even to the electrical power,..". In addition to this, the Chinese government referred to learnings from the European Union and the United States (UNESCAP, 2012) to gain knowledge on policies related to renewable energy. The government also promoted capacity building of workers by training them in these countries with the aim to enhance their technical skills for wind and solar energy sector (Vos and Sawin, 2012).

The UNDP-GEF co-funded project "Rapid Commercialization of Renewable Energy in China" was initiated with the aim of introducing and commercializing renewable energy technologies in the identified sectors. In this process, capacity building, demonstration projects and formation of an enabling body/institution to provide support for facilitation, formed the key education components. The Chinese Renewable Energy Industries Association (CREIA) was established to facilitate acceptance of the renewable energy technologies in the market on a large scale. It geared up the market by offering training programmes for industries, sharing information on technology and market development, and organizing study tours. It also acted as a platform for networking and helped to connect research institutes, regulatory authorities and industries. Demonstration projects for biogas production and bagasse cogeneration plants of industrial scale were set up in a few places. Workshops and study tours at these sites or in other countries organized for developers, financers and end users helped accelerate the spread of these technologies. This project built the capacity of local organizations for wind resource assessments; shared international best practices for the use of wind energy; set up standards for solar heathers; and helped initiate testing and certification centres. To raise the awareness of financers and get their support to fund the implementation of renewable energy technologies, several training programmes and workshops were held on business development and financing (UNDP/GEF, 2007).

Building on the experience of the Chinese government, and with an aim to strengthen efforts for rural electrification, demonstration projects for provision of power through hybrid systems in villages were set up at five-six locations initially. Capacity building exercises were conducted for

different stakeholders such as engineers, operators and manufacturers to help smooth functioning of the systems. Further, a curriculum and training programme was developed for engineers and system operators on the basis of the evaluation of this project and the entire experience (UN, 2007). All these efforts suggest that education was explicitly used as a tool to put in gear systems for change.

The available literature states that policy learning takes place for policy makers and other stakeholders associated with the policy making process. Here policy learning refers to "a process that helps deliberately adjusting goals, rules and techniques of a given policy in response to past experiences and new information" (Hall in Mah and Hills, 2010). The study on 'pricing policies for wind energy in China' which was conducted by Mah and Hills (2010) illustrates and gives us an idea about the policy learning that happened throughout the transition phase (introduction of renewable energy and incremental replacement of non-renewable energy sources) for policy makers and other stakeholders. The key observation made by the authors suggests a progression in learning, from technical to conceptual. As explained in this paper, drawing from the literature review (Gouldson et al; Fiorino; Glasbergen in Mah and Hills, 2010), technical learning pertains to acceptance, implementation and addition of a new policy instrument without deliberating on its objectives, adaptation and contextualization. Conceptual learning is the successive level of learning which refines policy and its goals after deliberation on problems and adjusts strategies accordingly. An example of technical learning in this case is use of "repay plus profit" policy which was used for other energy projects but without any reflexive activity. The pricing policies for wind energy were sunsequently changed in response to environmental concerns (policy formulation reflecting on the problem) which demonstrates conceptual learning. New knowledge, information and availability of data aided the transition from the technical to conceptual level of learning. For example, availability of wind data enabled the government to make a well informed choice - to opt for fixed price policy for wind energy (Mah and Hills, 2010). However, it was noticed that the social learning (the highest form of learning) was constrained. As described by Glasbergen (in Mah and Hills, 2010), social learning "…emphasizes social context and social forces in shaping the policy process". Andrews-Speed (2012) has mentioned that policy making in China lies in the hands of a few stakeholders which makes discourse on policy formulation communicative rather than coordinative discourse, which engages the wider society.

The central government provided a broad framework for pricing policy in the wind energy sector. The provinces were free to choose an appropriate pricing policy at the local level. This enabled experimentation in the implementation of policy measures, generated learnings and helped in refining policy instruments (Korsnes, 2014). Some of the successful local policies were adopted at the national level (Andrews-Speed, 2012). There were some unintended outcomes of this process but as Mah and Hills (2010) state, these learnings were important in designing better policies. Over the years, the energy policies have been revised and constantly updated (UNESCAPE, 2012).

In 1990, the electricity generation mix included approximately 100 terrawatt-hours of energy generated from renewable sources, while in 2008 it increased to nearly 500 terrawatt-hours (Zhang et al., 2013). China's power generation capacity from renewable energy sources in 2013 has increased more than three times, compared to the base year 2005 (International Renewable Energy Agency, 2014). This project has substantially influenced policy making. One of the outputs - 'China Biogas Project Development Guidebook' - was used by the government authority to develop a Biogas National Action Plan and Biomass Strategy (UNDP/GEF, 2007). CREIA also provided inputs to the government for policy formulation. For example, it developed a white paper on renewable energy policy which was referred in the renewable energy policy review. A Village Power Project Development Guidebook was used by the government for the training on the 'National Township Electrification Programme' (Martinot, 2003). The overall impacts of this project suggest that it has helped to generate demand for renewable energy and convinced financers to invest in these technologies, while experience and knowledge sharing facilitated policy makers to set up or improve legal frameworks and programmes.

Case Study 4 – Guatemala: Building capacity and raising awareness of the community to consume local food

The different stages of food systems, including agriculture, pre-production (e.g. production of fertilizers) and post-production (e.g. packaging), contribute to GHG emissions accounting for 19-29 percent of the global emissions (Vermeulen et al, 2012). Agricultural production activities contributes the maximum to the emissions, whereas emissions from pre- production and post-production processes vary, but are lower than production (especially agriculture) processes. The post-production stage includes processing, storing, packaging, transport, refrigeration and retail activities which have GHG emissions associated with it. The challenge lies in "ensuring sustainable consumption and production patterns" (SDG 12).

This case demonstrates that along with climate change mitigation, other goals like promoting nutritious food for good health, empowering women and reducing poverty, and sustainable management of natural resources (e.g. forests) can be achieved simultaneously. In this case, consumption of native edible seeds - Maya nuts - is revived by the introduction and promotion of new recipes and use of low carbon intensive processing methods, instead of conventional ones. The education component in this case is sharing information and building capacity by conducting workshops on using the nuts; conducting campaigns to raise awareness on the nutritional benefits of Maya nuts and encourage its use; and sustainably managing forests. The Maya nut trees are native to Central America and their nuts were widely used by the ancient Mayan people. Its use had declined over the years due to lack of knowledge and its association as the poor man's food or famine crop (Walker, 2010). However, through the efforts of several institutions (Maya Nut Institute, BanRural, Rainforest Alliance, the Ministry of Education, and the Ministry of Agriculture) and the local community, consumption of these nuts which have more nutritioon value than other crops is being revived. Traditionally, these nuts were used in the ground up form

or mixed with the core meal, but this project has helped to use new techniques and introduce Maya nut flour to prepare a variety of items such as cookies, breads and cakes.

Once available in abundance, these trees are now threatened due to pressure from various human activities like land being used for agriculture and use of Maya nut trees as firewood. Hence, sustainably harvesting these nuts is important. Members of the women's cooperative ANSA – Alimentos Nutri-Naturales Sociedad Anonima - buy nuts from rural women collectors and engage in various processes such as washing, drying, roasting, grinding andprocessing, besides administrative and financial activities. Women are trained using an 'action learning' approach to acquire the relevant skills for these processes through workshops; they also gain an understanding on topics such as health benefits of these nuts and the importance of forest conservation. These women go on to conduct awareness campaigns to promote inclusion of Maya nuts in regular diet. To provide training in the community, these local women use pictographs as teaching material and convey new concepts by relating it to the local context, thus increasing chances of acceptance. Besides, the women already trained through this programme act as educators to train nearby communities. This has helped in sustaining and scaling up the efforts with minimal financial resources (Vohman, 2015). Different ways of processing Maya nuts, use of storage facilities and post-harvest handling were experimented on resulting in 20 percent reduction in loss of nuts. These tried and tested methods will also be shared by developing manuals (Vohman, 2014a).

The institutes and collectors have developed forest monitoring tools which the ANSA women use to estimate harvest quantity, and manage their business sustainably avoiding negative impacts on the ecosystem (Vohman and Buffle, 2011). As a part of this project, 35,000 trees have also been planted (UNDP, 2006). ANSA provides school lunches and snacks made from Maya nuts as a part of the 'Healthy Kids, Healthy Forests' programme initiated in partnership with the institutions. It also has a component to promote reforestation by planting two hectares of land or 2000 Maya nut trees. The programme also aims to reduce the social stigma associated with consumption of this nut by introducing school children to a variety of edible items made from Maya nuts. Thus children can be considered change agents influencing their parents to include nuts in their diet and appreciate the use of these trees for purposes other than firewood. This in turn promotes reforestation and conservation of these trees (Vohman 2014b). With the success of this programme, the Guatemalan Ministry of Education passed a law to serve Maya nut lunches weekly in schools and sell cookies made of Maya nut flour (Vohman and Buffle, 2011). In addition to this, the government has provided funds to plant more Maya nut seedlings.

The success of this programme has helped the Maya Nut Institute to start such initiatives in other countries like Colombia, El Salvador, Haiti, Honduras, Mexico, Nicaragua and Peru. Women trainers from Guatemala have trained communities, especially women, in other countries to implement similar programmes. A study conducted by Walker (2010) in southern Mexico to understand the knowledge and use of Maya nuts by community, indicates that the majority (96 percent) of the respondents had heard about the nut but only a few community members (11

percent) were using it in different ways. These few respondents were either educators of the programme offered by the Maya Nut Institute or were associated with it. Many respondents considered the workshops of the Maya Nut Institute crucial for gaining knowledge and developing capacity to use these nuts (Walker, 2010). Efforts are also made to train government officials in Hondouras, Nicaragua, and El Salvador, to work with the community for the sustainable harvest and management of Maya nut trees through the Participatory Maya Nut Forest Management programme (Vohman, 2013). Cross country sharing of learning in this context enhances the knowledge of communities in processing and using these nuts. The programme also implicitly benefits from the research conducted by students from academic institutions associated with the Maya Nut Institute, in the USA, El Salvador, Guatemala, Nicaragua and Mexico (Vohman, 2015).

The overall impact of this programme is that it has provided food and income to 20,000 women and girls (Vohman, 2015) in a few countries of the Latin American region. It helped to encourage consumption of local products contributing to emission reductions from the food systems and enabled large scale plantation of native species to strengthen carbon sinks (Maya Nut Institute, 2011). In addition to this, as the Maya nuts can be naturally preserved for up to five years and these native trees can sustain well in the local climatic conditions, it can enhance resilience of the community by providing food security (UNDP, 2006). This initiative not only provided explicit benefits to communities, but helped to drive policy changes as well as gained funds from the government to be used for mitigation and adaptation activities.

Case Study 5 – Peru: Demonstration and change to achieve energy efficiency in brick production

SDG target 7.3 aims 'to double the global rate of improvement in energy efficiency by 2030'. With the developing countries set to see a rise in GDP, it would be important to change the energy intensive path that these countries are following. Thus, energy efficiency would form a crucial component in opting for an alternative developmet path. Brick producers in Latin America are small scale indivudual-driven enterprises that produce bricks in energy inefficient artisanal kilns using dirty fuels including tyres or plastic, which causes pollution, GHG emissions and health problems. In 2010, the EELA (Energy Efficiency in artisanal brick kiln in Latin America to mitigate climate change) programme was initiated with the objective of reducing GHG emissions and improving the quality of life. Breaking the long held traditional production practices for achieving energy efficiency called for a dual driver for change, i.e. technology and education. EELA's approach was not simply to introduce a modern and clean technology but also make people believe in these technologies by educating them and making them aware of the problem and its solution.

A pilot project under this programme is located in San Jeronimo, a district in Cusco, Peru, where a major producer of bricks with 194 productive units and the region's second largest source of

GHG emission to the tune of 232,522 ton CO_2/year is operating. The tools used for educating the San Geronimo brick producers were based on the '*seeing is believing'* concept. To make the producers believe, the programme set up a clean energy efficient kiln next to their kiln and let people see the difference. EELA also trained the president of their brick production association on how to use a fan to stoke fire, in the use of clean fuel like saw dust, and other improved practices, making him the model producer for change and letting others follow him. Thus, in no time, more than 400 families joined the project and started adopting sustainable production practices. Now, San Jeronimo acts as a demonstration site and learning school for other such clusters. The success of the project can be measured in the 50 % emission reduction which was achieved and a law that was formulated prohibiting the burning of tires as kiln fuel. This model is being promoted in other countries in the Latin American region and the lessons learned through pilot projects will help to scale up these efforts.

Case Study 6 – Nepal: Stakeholder consultation and training of local communities for composting organic waste

Organic waste constitutes 40-65 percent of the municipal solid waste in low and middle income countries compared to 30 percent in high income countries (UNEP, 2011). But in the case of Nepal, organic waste constitutes 70 percent of the total waste (myclimate, 2015). It is estimated that organic waste alone from total solid waste contributes about 5 percent of global GHG emissions (UNEP, 2011). Reducting emissions from degrading waste therefore poses a challenge, but it also provides an opportunity to utilize waste as a resource. In nature, the concept of waste does not exist and the processes/systems are cyclical. Thus, the possible solution lies in changing the linear systems of consumption and production to circular systems, thereby minimizing negative environmental impacts. This has a potential to contribute to Goal 12 on sustainable consumption and production patterns. In addition to the Goal 12 of SDGs, this case study also contributes to Goal 2 which emphasizes promotion of sustainable agricultural practices.

Kathmandu deals with the issue of organic waste of the city by composting it to reduce the pressure on the landfill site and improving farmers' produce with its use. Biocomp Nepal and myclimate initiated a project in 2011 in which the vegetable market waste of Kathmandu is converted to compost over a period of four months to be used by the local community in the place of chemical fertilizer for agriculture (UNFCCC, 2012). This model was chosen on the basis of Biocomp Nepal's awareness of the work done by Waste Concern and EAWAG, especially their manual on 'Decentralized Composting for Cities of Low-and Middle-Income Countries'. The Waste Concern office in Bangladesh conducted a training programme for the engineers from Nepal on the composting process, which included a field visit and ideas for scaling up of the facility (Waste Concern, 2011).

Before implementation of the project, a consultation of stakeholders consisting of farmers, people living in nearby areas, community leaders, land owners, local authorities, local NGOs working on

waste and climate change experts was conducted, wherein benefits of compost and drawbacks of chemical fertilizers, status of waste and its effects were discussed (myclimate, 2015a). This helped to generate support for the project. The plant in Kathmandu recruits local people and provides them with regular training for operation and maintenance of the facility. During the pilot phase (2011-2012), the facility produced 15 tons of compost and it has since been scaled up in 2013 (myclimate, 2015b). The input of organic compost has improved soil quality and benefitted farmers. This project aims to reduce up to 7328 tons of carbon dioxide by the year 2022 (UNFCCC, 2012). It has also generated jobs for the local community.

Case Study 7 – Senegal: Localized communication for introducing solar cookers

Biomass fuel such as wood used for cooking not only causes health hazards but also contributes to climate change by emission of GHGs and black carbon as well as impacts uptake of carbon dioxide due to unsustainable harvesting of wood (Global Alliance for Clean Cookstove, 2014). Around 40 percent of the world's population still do not have access to clean energy for cooking and uses biomass fuel (Stockholm Environment Institute, 2013). Goal 7 of SDGs promotes affordable, reliable, sustainable and modern energy for all. The case of Mekhe, Senegal, is an exemplary initiative that demonstrates ways of overcoming the challenges and providing an alternative clean energy solution for cooking.

In Sinthiou-Garba, located in the north-eastern part of Senegal, community members used cow dung as fuel because of scarcity of firewood. Mr. Abdoulaye Toure's concern that cow dung is a source for vector borne disease led him to find an alternative to this cooking fuel. Mr. Toure, a school principal, had a basic understanding of the working principle of a solar cooker/oven and developed its first prototype in 1990. Following trials and testing of his solar cooker/oven, in 1992 he improvised his prototype (Toure in Cadasse, 2003). After the solar based technology was developed, the challenge was to convince people to use it.

Vanschoelwinkel (2013) in her literature review suggests that projects disseminating "non-traditional stoves" including solar cookstoves have failed due to nonacceptance of new technology by communities. In some cases, even if communities accepted a new technology, its use is not sustained after completion of the project. It has been identified in the litreature that socio-economic and cultural factors (e.g. purchase price, cooking outdoors, unable to cook traditional dishes, family size) can become barriers for acceptance and use of new technology (nontraditional cookstoves) but "communication about the product, user training and guidance" can play a crucial role in its adoption. The study conducted by Vanschoelwinkel (2013) in rural northern Senegal found that for the Sol Suffit project, inadequate communication related to the product - solar cooker - led to people not using the product or using it only occasionally. This was because people lacked the know-how of using the product and had very different perceptions about its use. The communication had focused on selling the product rather than informing the customer about the way it works and its various possibilities in using it. It is also important to highlight other

benefits like health and environmental, in addition to economic benefits. It was also revealed that engaging local women in a project which introduces any new cooking technology is very important as they are usually the end users.

Mr. Abdoulaye Toure initiated the dissemination of his solar cooking technology after some successful experimentation. The approach he used was to demonstrate the use of solar cooker/oven among communities. He developed the capacity of villagers to build solar cooker/ovens locally. To promote the product, community members were trained to market it. Women were engaged in the adoption of this new technology in two ways. They identified 30 local recipes that can be cooked using this cooker/oven. Five women who were trained in its use were deployed to further train other women in using the solar cooker/oven. This helped to sustain and catalyze the efforts of spreading this technology. Further, information and guidance on the use and maintenance of the cooker was made available (SGP, GEF-UNDP, 2015). By 2003, 250 models of solar cooker/ovens developed by Toure were in use in Senegal (Cadasse, 2003).

On Mr. Toure's proposal for implementing solar cooker/oven in Senegal, the Ministry of Education supported his work. He is now a government official at the Ministry of Biofuels, Renewable Energy and Scientific Research. He has played an influential role in promoting use of solar cooking technology through television shows, conducting demonstrations and training programme and sharing this innovative technology with neighbouring countries (Knudson, 2004). Other organizations like the Solar Household Energy Inc. collaborated with Mr. Toure to extend the adoption of this technology in villages near the city of Dakar (World Watch Institute, 2011).

The project led to significant environmental and socio-economic impacts. In one of the assessments, it was found that on an average each family saved 3 metric tonnes equivalent of carbon dioxide (SGP, GEF-UNDP, 2015). This project also helped in creating ten jobs, enhancing the capacity of 105 women and 22 men in using a renewable source of energy (SGP, GEF-UNDP, 2015). The solar cooker/oven developed by Mr. Toure costed 76 Euros which is 3-6 times lower than the conventional oven (Kumatoo, 2009). To enable people to buy the product, it was subdized as well as microcredit schemes were made available. Due to these positive outcomes, some of these villages have become learning sites for people, including government representatives. Further, other means such as manuals, DVD movies, and articles are being used to spread the learnings and knowledge from this project.

This project had policy level impacts too by demonstrating possibility of success in shifting to a new and cleaner technology with effective outcomes. The government officials, convinced by the transformation that this project has managed to achieve, decided to allocate resources to promote research, production and use of solar energy. Mr. Toure through the implementation of his innovation and demonstration of its impact, influenced the decision makers. In his position as a government official, he has continued promotion and facilitation to adopt solar cooking technology in Senegal and neighbouring countries like Burkina Faso, Nigeria and Mauritiana.

This example demonstrates that while ESD has direct impacts, it also influences other drivers of change (e.g. policy) for bringing about a paradigm shift.

Case Study 8 - India: Changing the thinking in pesticide management

Farmers in Punukula, Andhra Pradesh, India, were facing the crisis of overutilization of pesticides and were trapped in the vicious cycle of debt due to increasing use of pesticides for cotton crops. This malady and environmental distress was stopped and turned into a virtuous circle of sustainability by simple methods that were implemented carefully by cooperative actors. Non Pesticide Management (NPM) is a successful initiative which was able to achieve this shift.
Education for sustainable development for non-pesticide management started with one to one discussions between the NGO and the villagers to understand their problems. However the change in the thinking about pest management amongst the farmers of Punukula village was a slow process and was obtained over a period of time. It began from a farmer agreeing to use neem seeds, and proceeded till the entire village was declared a non-pesticide village, and finally the state taking it up as a model to be followed by other villages.

A local NGO named Socio Economic and Cultural Upliftment in Rural Environment (SECURE) organized an exposure trip for some of the villagers to visit a village in Nalgonda district where another NGO was helping implement NPM. This farmer to farmer exposure clicked with Margam Mutthaiah, an influential village elder with 1.2 ha of land, who became the first to opt for NPM. However, it was still a difficult task for the SECURE workers to convince farmers in the village. Initially, the NGO worked with 20 farmers, with two of their extension workers training them on NPM. The extension workers demonstrated the use of *neem* extract on the crops and also showed them how to prepare the extract from *neem* seeds. Gradually more farmers joined the effort, as they witnessed the positive results. Farmers were also taken on more exposure visits, and more training programmes were held in the village. It is important to note that the success of the effort was also because of the involvement of women Self Help Groups (SHGs) in the training programmes. The women in the SHGs, for instance, warned their men against going to the market for procuring pesticides, and would put pressure on them to use NPM. Once the farmers were convinced of the efficacy of the NPM technology, the women put in extra work in procuring material and preparing extracts for spraying. They would discuss the state of their crop in the meetings and get extension advice about what needs to be done. Similarly, farmers' *sanghas* (groups) organized by SECURE were actively used for extension services, surveillance of crops and active dissemination of solutions. So far, more than 200 farmers practice NPM and the method is being taught in 27 village schools.

This non-pesticide management helped the villagers in building resilience and increased the adaptive capacity of the farmers, as their debts were repaid, earning capacities increased, medical bill expenses decreased and ancillary activities related to NPM initiated by women. This helped in bringing in more financial resilience. People were able to expand their acreage of crop production,

pursue education, and engage in more entrepreneurial and community projects. The concept of Non Pesticide Management is introduced as education in schools, helping it become an established part of the village culture. All of these advances, along with the confidence engendered by success, increased community solidarity, a stronger social support (mutual help) system, and getting children back to school. This has made Punukula's villagers better able to withstand the challenges of climate change.

Case Study 9 – Thailand: Promoting cycling in Chiang Mai

In the Chiang Mai city of Thailand, the tourism sector contributes significantly to its economy. This sector also emits a substantial share of GHGs and it was identified that the transport activities contribute to these emissions largely. Some of the underlying reasons behind the emissions from transport activities are inter-city transport (to and from Chiang Mai), unplanned city expansion increasing the need for mobility, inadequate public transport and infrastructure for non-motorized mode of transport. The challenge for Chiang Mai is to opt for an appropriate low carbon alternative, promoting "…safe, affordable, accessible and sustainable transport for all" (SDG 11).

The Chiang Mai Municipality's interest in addressing the issue of GHG emissions from the tourism sector could be linked to its sensitization and capacity building on climate change issues that happened as a part of the project 'Action Towards Resource-efficient and Low-carbon Cities in Asia' (2009-2013) as well as political will. The municipality chose to engage and work in partnership with multiple stakeholders including researchers, private companies, NGOs, and community members, to identify an appropriate mitigation option based on consultation. It was important to engage different stakeholders as the livelihoods of many were dependent on tourism. As stated by Wals, "…ESD can help mobilize people's participation in sustainable development and their problem solving capacity through processes which enable collaboration and dialogue" (Tilbury, D. 2011). In this case, the stakeholder consultation helped to establish partnerships and identified development of non-motorized transport (NMT) system as a suitable option to reduce emissions from ground transport. Following this, an NMT campaign and plan for bicycle route and side walk has been prepared. This initiative has a potential to reduce 0.6-1.56 percent of GHGs from ground transport (Climate and Development Knowledge Network, 2014). In order to promote use of NMT, various activities such as imposing speed limits on vehicles in certain areas, introducing car free days, and exhibition to encourage cycling have been planned. The cycling club also conducted a bicycle festival to attract more people and encourage them to use bicycles.
This project has been able to influence policy decisions for providing further commitment to extend the NMT zone in the city. Public consultations, local language publications and information sharing through media have raised the awareness of people on climate change and the benefits of using NMT. The multi-stakeholder approach which was used since the beginning of the project proved to be beneficial. Such an approach provides an opportunity for "…people to learn from each other and collectively become more innovative and more resilient…become more

capable of finding solutions, withstand setbacks, of dealing with insecurity, complexity and risks." (UNESCO, 2014)

Case Study 10 – Vietnam: Media campaign to enlist support for sustainable tourism

Tourism is an important sector for Hue city in Vietnam, generating major economic benefits for the residents. The challenge for the city of Hue is to promote sustainable tourism through reducing its carbon footprint, conserving its rich cultural heritage and improving livelihood options. These are relevant to Goals 1, 11 and 13 of SDGs. Research on the local tourism sector of the city revealed a contribution of 0.15 million tones of CO_2 from this sector alone in the city (Climate and Development Knowledge Network, 2014). Through multi-stakeholder partnerships among researchers, local authorities, private companies, NGOs and local residents, the city of Hue was able to identify an option that could help in reducing GHG emissions as well as promote livelihood generation activities. The main initiative was that garden houses, being part of the historical culture of Hue city, was taken up for promotion as a sustainable tourism initiative.

Promoting garden houses in Hue city is a most viable solution and perfect for sustainable tourism because of the combination of natural and local cultural heritage with the provision of income generation. The ways in which the garden houses can help reduce GHG emissions are: they can function better as a carbon sink compared to the new form of urban housing; organic waste generated in the house can be recycled and used as compost; and the garden can produce local fruits and vegetables which can help reduce dependence on the market and in turn reduce emissions from freight transport. To reduce carbon emissions from local transport and promote visits of tourists to these garden houses, the municipality and the garden association have plans to encourage use of cyclo or bicycles. However, one concern that remains is whether, with the increase in tourist influx, the carbon emissions reduction would be impacted negatively.

A variety of approaches other than consultation was used to engage stakeholders in this project. A mass media campaign was designed which was used to attract organizations, individuals, house owners and tourists and to encourage preservation of garden houses. Tie ups with travel agents and development of structured tours along with a combination of non motorized transport for visits to the garden houses are being undertaken. Organizations and garden house owners will participate in establishing local clubs, groups and associations for the conservation and promotion of garden houses. Organic farming is promoted in the garden houses in order to attract tourists. All of these efforts are aimed at increasing the number of tourists.

Other promotion activities include dialogues with garden house owners and organizations working for the restoration of garden houses, to enable them to understand the historic and cultural value of garden houses. Broadcast of the meetings of government organizations and other stakeholders on television contributed to local authorities' swiftness in promoting garden houses and developing low carbon initiatives for sustainable tourism. Through all these efforts and plans,

the city of Hue aims to reduce GHG emissions and simultaneously increase income and job generation by attracting more tourists.

Case Study 11 – Ghana: Capacity building of farmers for bio-fuel production to restore degraded land

Some of the human activities such as unsustainable agriculture land use, uncontrolled pasture grazing, and improper soil and water management can contribute to land degradation. As estimated by the Intergovernmental Panel on Climate Change (IPCC), land use change and degradation contributes 20 percent to global carbon emissions. These emissions are due to vegetation loss as well as decreased capacity of soil to store carbon (Trumper et al, 2008).

In the Gomoa East district of Ghana, the ecosystem is under threat due to unsustainable land management practices including shift agriculture practice and illegal logging (SGP, GEF-UNDP, 2012). The project addressed these issues by introducing sustainable agro forestry practices aimed at sustaining agriculture practices to ensure food security and biodiversity conservation. It also provided alternative benefits such as biofuel production.

The Government of Ghana has mandated the use of a mix of conventional fuel and biofuel through its Strategic National Energy Plan (2006) to achieve its goal for increasing the use of renewable energy – up to 10 percent in electricity and transportation sector by 2020 (Hughes et al, 2011). As stated in the National Energy Policy 'use of renewable energy (including biofuel) can help Ghana to ensure energy security and climate change mitigation' (Ministry of Energy, Republic of Ghana, 2010). Thus, the government is encouraging use of biofuel to reduce its dependence on conventional fuel (Agyarko, 2012). The leapfrogging aspects in this case study are adopting sustainable land management practices and production and use of biofuel. These aspects contribute to Goal 7 on energy and Goal 15 on sustainable land management of SDGs.

The Ministry of Food and Agriculture (MoFA), Ghana had initiated the Sunflower Project in the 1990s when many citizens of Ghana returned to the country from Libya. These participants went through a workshop which built their capacity to plant and harvest sunflower and utilize its seeds for biofuel production. The training had ten modules which covered topics like 'planning and commencement of business, effective ways of crop cultivation, weather patterns and planting seasons, harvesting and storage, commercial aspects of business, and formation, organization, and benefits of cooperatives' (IOM, 2010). Following this training, participants put their skills and lessons into practice. This effort was unsuccessful due to lack of continuous support like guidance on storage of seeds and marketing from the facilitators of the project and lack of appropriate market to sell the products (Modern Ghana, 1999). The other reason stated for failure of this project was lack of inadequate scientific information regarding suitability of sunflower seeds to local environmental conditions (e.g. soil, climate) that led to unsatisfactory/poor harvest (Hashmiu, 2012).

In 2004, MoFA allotted a fund of 289 USD as a part of the Farmer Based Organizational Development Fund to restart sunflower cultivation. The Tropical Agriculture Marketing and Consultancy Services Sunflower Ghana (TRAGRIMACS) was a key partner in this project. It started with the creation of Farmer Based Organizations (FBO) in 18 districts. In addition to production of biofuel, the project also promoted the use of sunflower cake (co/by-product) that has high protein content as feed benefiting poultry farming. A reassurance of availability of market in European and North American countries was given. The government officials also emphasized that strategies devised for the implementation of this project have been informed by past experience. A stakeholder forum organized by MoFA and TRAGRIMACS highlighted these points to generate interest among farmers to cultivate sunflower on their farm lands (Modern Ghana, 2005). As stated by Tinsley (in Salifu and Funk, 2012), FBOs perform key functions such as "common property management, technology development and testing, design, financing and management of rural infrastructure, and marketing of production of inputs and farm outputs". Some of the reasons stated for the formation of FBOs are: effective mode for transfer of technology, sharing farming practices and getting support in the form of loan and training from the government agriculture extension agents and NGOs (Salifu and Funk, 2012). In this case, the cost of training for cultivation of sunflower was covered by MoFA (Modern Ghana, 2005). However, concerns were raised by government officials regarding transparency in implementation of this project making farmers disinterested in this initiative (Ghana Web, 2006).

In 2008, in Gomao district of Ghana, SGP GEF-UNDP with TRAGRIMACS initiated a project which used an integrated approach of addressing land degradation issues and simultaneously providing additional benefits like biofuel generation. Fifty farmers were introduced and trained to adopt the practice of sedentary farming and agro-forestry system. This solved the problem of land degradation by avoiding the practice of shift agriculture and instead planting sunflower and jatropha along with introduction of apiculture. The sunflower cake residue became a source of fertilizer as well as poultry feed. A workshop was organized with experts to introduce bee keepers and participants from NGOs to bee-keeping techniques and ways to boost honey production (Wanted in Africa, 2008). The farmers were organized in the form of an FBO registered to sell and trade in products (e.g. biodiesel, honey) and by-products (e.g. sunflower residual cake) from this initiative. A processing mill and bio-diesel digester was established for production of oil and bio diesel at Tema. Two local universities are also associated with this project, conducting research on production of biofuels and improved agronomic practice for sunflower production (SGP, GEF-UNDP, 2012).

The biodiesel generated from this initiative over two years was used for two farm tractors, which helped to reduce 200 tonnes of carbon dioxide equivalent emission. The sunflower residual cake helped to avoid the use of chemical fertilizers in farms to the tune of 50-60 bags. This initiative has helped to restore protected land (1500 ha), and 110 ha of farms have adopted sustainable agriculture practices. This project has helped farmers to gain additional income by selling various

products, while utilizing by-products in their farms has led to some savings (SGP, GEF-UNDP, 2012).

The Ministry of Environment and Science, in 2009, initiated the Youth in Agriculture Programme as a part of the National Youth Employment Programme, to encourage youth to opt for agriculture as their livelihood (CTA Spore, 2014). Sunflower production is also considered as a part of this programme and training is imparted for the same. A government official (Chief of Gomoa Adzentem from the Central Region) has allotted 500 hectares of land for sunflower cultivation to engage youth (Modern Ghana, 2009).

Case Study 12 – India: Labeling and consumer education for energy efficient appliances

According to Intergovernmental Panel on Climate Change - IPCC (2014), the building sector used 32 percent of final energy and emitted 8.8 $GtCO_2$ (17.9 percent of total emissions) in 2010. This includes direct and indirect emissions from residential, commercial, public and service sectors and excludes emission accounted from construction. For India, the residential sector (includes combustion of fossil fuel and biomass) emitted 12.6 percent of the total GHG emitted from the energy sector in 2007 (MoEF, 2010). In Indian households, electronic devices like bulbs, ceiling fans, refrigerators, air conditioners and televisions account for about 80 percent of the residential electricity consumption (Boegle et al, 2010). The penetration level of these electronic items is lower compared to the developed countries but there is steady growth in market size as well as its consumption (Little, 2014). Thus, enhanced energy efficiency becomes a key component for the energy management strategy in India.

The energy efficiency standard and labelling (EE S&L) programme implemented in 2006 by the Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power in India is a good example of demand side energy management strategy. This programme has been introduced to achieve market transformation through leapfrog in technologies in terms of making available energy efficient products. The label on products with the scale of 1 (least efficient) to 5 stars (most efficient) indicates energy efficiency of electronic appliances, enabling consumers to make informed choices which can result into energy and cost saving. During initial stages of this programme, labelling for 21 electronic appliances including air conditioners, tubular florescent tube lights, frost free refrigerators and distribution transformers, was voluntary, but these four items have been listed as mandatory for labelling since 2010 (BEE, 2015). This case study highlights different the education components required for different stakeholders, from manufacturers to consumers, engaged in the supply chain system. These components are – (i) developing technical expertise, (ii) raising awareness of citizens and (iii) raising awareness and training of retailers.

Several agencies like the World Bank, United Nations Development Programme (UNDP) and CLASP have played an important role in providing technical and financial assistance for

implementing the EE S&L programme in India. These agencies, in collaboration with BEE, conducted analysis of existing products in the market, put in place facilities and test procedures, conducted training workshops for agencies for standard setting, testing, and reporting (UN, 2007). BEE, recognizing the importance of the need for awareness generation about EE S&L among consumers to influence their choices, has been advertising on energy star labels through print and electronic media. Through engagement of non-government organizations, Consumer VOICE promotional materials in local languages were distributed. Sales executives, being the initial point of contact for consumers, were educated about this programme through half day workshops on National Educational/Awareness Programme on Standards and Labelling. In 2008-09, in 36 such workshops more than 2000 sales executives from different cities were educated (Chatterjee & Singh, 2012). In 2011, an All India Showroom Campaign further used the 'training of trainers' strategy which engaged college students as trainers to train sales executive in nine cities. A Showroom Salesman Training guidebook was also developed which was used by students as a resource material (BEE, 2011).

A recent survey suggests more than 40 percent of people in the country are aware of the EE S&L programme (Chatterjee & Singh, 2012). In 2009-10, the impact of the EE S&L programme accounted suggests a cost saving of 260.55 million USD (1740 crore Indian Rupees) and carbon dioxide emission prevention to the tune of 3,522,863 tonnes (Chatterjee & Singh, 2012). Success of EE S&L depends on consumers' awareness level. Thus, education and communication activities play a crucial role in enhancing consumers' understanding about labelling. In contrast, lack of understanding and inability to interpret the label was observed among consumers in Chile as the campaign used a single strategy a consumer handbook to educate them on product labels.

Case Study 13 – Rwanda: Training and raising awareness to create change agents to utilize waste as a resource

Education for sustainable development converted the waste of one person into a resource for another in Rwanda. Poor communities in Rwanda, ike many other developing countries, rely on fuel wood as a source of energy for cooking and heating, which threatens the forests, causing deforestation and adding tons of carbon into the atmosphere. About 80.4 per cent of energy comes form fuel wood in Rwanda.

Organic waste is found everywhere and, if managed sustiabally, it can be an energy source. This potential was harnessed by a women's cooperative organization (garbage recycler) in Rwanda. The cooprative was established in 2002 with the objective of conserving the environment by collecting garbage. Grabage collection was effected through community involvment, and undertaken mainly by street and sex workers. The group decided to find a way to recycle waste and transform it into resourceful poducts, mainly as fuel, and implemented the idea of producing briquets out of it. The process thus empowered and provided sustainable livelihood to those involved.

Right from the inception of the project, training and awareness programmes were conducted at various stages. Cooperative women groups initiated awareness raising activities on environmental issues and waste management while the members were trained on waste recycling, briquettes making and designing coke stoves. Through these efforts, the cooperation has not just improved waste management in the country but also reduced emissions due to deforestation. They also created livelihood opportunities for poor street workers, mainly women, by educating and employing them to be an agent of change and producing a cleaner and greener source of energy. The success of the project was such that it is now a demonstration site and has facilitated replication of other similar projects. Such initiative reflects how ESD and empowering communities can play a crucial role in climate mitigation.

Case Study 14 – India: Setting up of a pilot education strategy for solar pumps

The International Water Management Institute (IWMI) ran a pilot project in collaboration with a farmer in Thamna village in Anand district of Gujarat wherein a solar irrigation pump has been installed to address the concern of poor electricity access. This pilot project not only enabled the farmer to harness renewable energy for his own use but also in a way tried to promote judicious use of water for irrigation (Rupera, 2016). This new technology helps the farmer to leapfrog conventional water pump technology and by adding a financial incentive aspect – i.e selling surplus energy generated to power distributors (Madhya Gujarat Vij Company Limited - MGVCL) - this project has helped the farmer to earn a livelihood and use only the required amount of energy and water resources. Following the success of this pilot project, IWMI helped six farmers to form a solar cooperative society named 'Solar Pump Irrigators Cooperative Enterprise' (SPICE) in Dhundi village in Kheda district of Gujarat to adopt the model of the pilot project (Smith, 2015). The Gujarat Energy Research and Management Institute (GERMI) in its capacity as facilitator for SPICE, and MGVCL as an entity purchasing surplus power from SPICE, are partners in this initiative.

IWMI is the agency that worked with farmers to develop the knowledge and disseminate learnings to scale up the initiative. Farmers have been trained to use solar pumps and sell surplus power to power distributors. GERMI provides technical support regarding the operation of pumps and educates the cooperative to connect to the grid. GERMI also works with the power distribution company (MGVCL) to educate them in setting up the process to purchase energy from the cooperative. The partners are considering inviting farmers from Gujarat and other states to visit the site, understand this model and implement it at other sites.

This initiative helps farmers to save about Rs. 20,000 annually which they would otherwise spend on diesel, and also earn about Rs. 40,000 annually as an additional income. It is expected that SPICE will supply 250 units of power per day to the grid which the power distributors have agreed to buy at the rate of Rs. 4.70 per unit (Dave, 2016).

Case Study 15 – India: Mass campaign for adoption of LED bulbs on a large scale

Recognizing the potential of energy saving by LED lightings, the Government of India initiated the National Programme for LED-based Home and Street Lighting in 2015 to distribute LED bulbs at domestic levels and replace street lighting by LEDs, initially in 100 cities by 2016, which would be extended to other cities by 2018. As part of this programme, the scheme *Unnat Jyoti* by Affordable LEDs for All implemented by Energy Efficiency Services Limited, a government run joint venture, provides four LED bulbs to consumers at a price nominal price initially and gradually recovering the cost through consumers' electricity bill for the next 12 months (GoI, 2015). Thus, consumers get these LED lights at a subsidized rate compared to market rates. Provision of financial incentive overcomes the barrier of inability to purchase expensive alternatives and forms the core strategy to encourage adoption of LED lights, but awareness raising initiatives enables and accelerates the key objective of the programme.

The government has launched a campaign 'I LED the way' to raise awareness and encourage adoption of LED lights. A website for this campaign is available with relevant information. To create a momentum for this campaign, an initiative of taking a voluntary pledge to spread the message to be energy efficient and reduce GHG emissions is available on the website. More than 46 million people have taken this voluntary pledge.

Citizens in the cities not yet part of the scheme in the current phase can pre-register themselves by sharing contact details for availing LED bulbs under this scheme. Consumers can also use the energy calculator on this website to understand the benefits and positive impacts that they are able to create by adopting this sustainable product (GoI, 2016a). In addition to this, the Bureau of Energy Efficiency has included LED lights under its energy efficiency standard and labelling programme. It is on a voluntary basis until December 2016 but later it will be mandatory for manufacturers to put these energy rating labels on their products. This further empowers consumers by providing them the required information to make informed choices of buying an energy efficient product (Lin, 2015).

Until August 2016, under this scheme, more than 144 million LED lights have been distributed across India. This has helped to save 51.53 million KWh of energy per day and curbed emissions of 41,746 tonne carbon dioxide per day (GoI, 2016b).

Case Study 16 – Ethiopia: Transferring skills and empowering local community for degraded land management

Human activities like unsustainable agriculture land use, uncontrolled pasture grazing, and improper soil and water management can contribute to land degradation. As estimated by the Intergovernmental Panel on Climate Change (IPCC), land use change and degradation contributes 20 percent to global carbon emissions (Trumper, K., Ravilious, C., and Dickson, B. 2008). These emissions are due to vegetation loss as well as decreased capacity of soil to store carbon. Goal 15 of SDGs calls to "protect, restore, promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss".

The Abrha Weatsbha village in the Tigray region of Ethiopia, already a vulnerable land as it is a sandstone area, suffered from land degradation due to deforestation, and inadequate land and water management practices. This has impacted agriculture activities and livelihoods of people. The government opted for a decentralizated approach to sustainably manage land, water and other natural resources and introduced a practice called micro-catchment ecosystem management in a few villages with similar problems. The Abrha Weatsbha village, learning lessons from this model, initiated their own similar Abrha Weatsbha Natural Resource Management project focused on agro-ecology. Thus, the approach of decentralization and a new management practice formed the core strategy to address this issue differently. The educational component in this project is facilitation from the agriculture Ministry's extension system through knowledge management and technical capacity building for farmers and pastoralists. The activities undertaken by the community are tree plantation, construction of infrastructure (dams, wells, water catchment ponds) for water conservation, and controlled land grazing. Community participation at various stages of this project (planning, implementation and monitoring) also played a key role in achieving success. The community has also developed local rules looking at fair distribution of water and land grazing resources. Education and training helped in transferring skills to women in livestock production, forestry, soil conservation, agriculture and horticulture. It also helped to gain community participation to work collaboratively in addressing issues.

This project has some tangible positive outcomes. Regeneration of vegetation and water conservation practices have helped to recharge groundwater. Water is now available in wells used for irrigation which has helped to increase crop yields. Some of the observable changes in the attitude of people are retaining and planting native species and taking voluntary action for conserving grazing lands. Plantation activities have helped conservation of soil, arrested soil erosion and enhanced its capacity to hold carbon. The community has benefited from sustaining its livelihoods (dependent on agriculture and livestock), enhanced water and food security, and improved health due to consumption of a variety of nutritious food products. All these have increased the overall resilience capacity of the community as well as empowered women (UNDP. 2012).

At the policy level, this project has helped to mobilize financial resources from the government to implement this approach in other parts of the country. It has also facilitated adoption and spread of the use of ponds and shallow wells for irrigation as recommended by the government. This village is a learning site for academic and other institutions to understand sustainable land management practice and it also acts as a centre to train framers from the other regions (UNDP. 2012). Success of this project has encouraged other regions of the country to adopt this model of 'regreening' which has made significant progress. In 2014, Ethiopia pledged "to restore a further 15m hectares of degraded land…by 2030" at the UN Climate Change Summit in New York (Vidal, J. 2014).

Case Study 17- Honduras: Decentralization of water services through strengthening village committees

In water systems, there are several processes such as sourcing water; its storage, transfer, treatment, and distribution to end users; its use and wastewater treatment. Energy use and GHG emissions are associated with each stage of these processes. For a country like the USA, the energy used in water systems (excluding wastewater treatment) emits "…5 percent of the nation's overall emissions which is comparable to carbon dioxide produced annually by 53 million cars" (Huron River Watershed Council. 2014)[3]. In the year 2013, globally 783 million people did not have access to clean water (UN-Water, 2013)[4] and Goal 6 of SDGs advocates for "…universal and equitable access to safe and affordable drinking water for all" (United Nations Department of Economic and Social Affairs, 2015)[5]. The challenge remains for countries to ensure availability of clean water for all citizens through less carbon intensive options/systems.
The government of Honduras, to achieve their target for provision of access to potable drinking water to 95 percent of the population, chose the decentralization approach. Village level

[3] Huron River Watershed Council. 2014. The Carbon Footprint of Domestic Water Use in the Huron River Watershed. Available from http://www.hrwc.org/wp-content/uploads/2014/11/Carbon-Footprint-brochure_single-pages.pdf, last accessed 24 October, 2015.

[4] UN-Water, 2013, Facts and Figures, available from http://www.unwater.org/water-cooperation-2013/water-cooperation/facts-and-figures/en/, last accessed 24 October, 2015.

[5] United Nations Department of Economic and Social Affairs, 2015, Sustainable Development Goals, available from https://sustainabledevelopment.un.org/?menu=1300, last accessed 24 October, 2015.

committees have been formed for water management. Members of the village committees close to a national park formed the Association of Water Committees of the Southern Sector of Pico Bonito National Park (AJAASSPIB) to address the issue of water availability in the region. The local water sources are threatened due to human activities like deforestation and unsustainable agriculture activities. AJAASSPIB's aim is to collaboratively address the issue by sharing resources, expertise and management responsibilities, and sustaining its work by collecting user fees from households. AJAASPIB is a 27 member committee with the staff responsible for planning and managing implementation activities to ensure availability of water to communities. Activities include maintenance of infrastructure by engineers/plumbers, engaging community, coordinating and facilitating meetings with different stakeholders and training and capacity building for reforestation. The association uses micro-watershed management to improve and maintain quality of water reaching the households. Water purification is effected in community level tanks using chlorination tablets. It has also planted native plants to improve forest cover which provides ecosystem services (freshwater).

This initiative has benefited 11,000 people through provision of clean water. This helped the community to avoid expenses on packaged drinking water which is an expensive option. The community paid USD 1.50 as monthly user charges to get water, which is better than getting only 25 gallons of bottled water for the same price (UNDP, 2012)[6]. The association succeeded in raising awareness about water conservation and protecting forests to be able to get water. An environmental fund has also been established for reforestation and environment education activities. The success of AJAASPIB's work has led to a formal arrangement for it to work with the Municipality of Olanchito for conserving and managing watershed and providing water to the city, for which it would be paid. The association, in collaboration with partners (e.g. CARE), is working to introduce water meters in households. It has become an exemplary initiative and 80 village water committees are using this model.

Case Study 18 – Nigeria: Campaign and capacity building for adoption of an alternative cooling system for farm products

More than 80 percent of global food loss and waste occurs at different stages like production, handling and storage, and consumption (Lipinski, B., Hanson, C., Lomax, J., etal., 2013). Thus, energy used at each stage as well as degradation of food waste produces GHG emissions. As estimated, GHG emissions (carbon dioxide equivalent) from food loss and waste were between 3,300-5,600 million metric tonnes (Lipinski, B., Hanson, C., Lomax, J., et al., 2013). For developing countries, most of the food lost and waste occurs during agriculture production and in

[6] UNDP. 2012, Association of Water Committees of the Southern Sector of Pico Bonito National Park, Honduras, Equator Initiative Case Study, available from http://equatorinitiative.org/index.php?option=com_winners&view=winner_detail&id=34&Itemid=683&lanl=en, last accessed 24 October, 2015

the supply chain (Lipinski, B., Hanson, C., Lomax, J., etal., 2013). The challenge lies in reducing food loss and waste at pre consumption stage and "...ensure sustainable food production systems…" as stated in Goal 2 of SDGs (United Nations Department of Economic and Social Affairs, 2015). This case highlights the use of an alternative and low carbon cooling technology that helped reduce food waste and the role of education in obtaining acceptance of this cooling system in Northern Nigeria.

The food produce of the Nigerian farmers spoil before it reaches the supply chain as they do not use cooling systems due to lack of electricity and inadequate infrastructure for fast transfer of these products. To avoid produce spoilage and to sustain themselves economically, these farmers sell their produce at a very low rate.

Mr. Mallam Mohammed Bah Abba developed and introduced an alternative cooling system called 'pot-in-pot' that could help farmers store their produce for a longer time. This simple technology based on the evaporative cooling principle is developed using locally available material such as earthen/clay pots and some wet sand. A small pot is placed in a larger pot and the space in between these pots is filled with wet sand. The items placed in the small pot could be stored for a longer time due to the cooling effect of the system. Initially, to introduce communities to and generate demand for this new cooling system produced with the help of locally unemployed people, Mr. Abba distributed it free of cost. But, to generate acceptance of this new product, an educational campaign was introduced highlighting the benefits of using the cooling system. Local pottery makers are engaged to produce these pots. Mr. Abba hired and trained five people to sell this new and simple technology in various villages. To sustain this effort, Mr. Abba and his family made financial investments in the venture as well as received support from the government and UNDP. The Intermediate Technology Development Group and the University of Al Fashir in Sudan came to know about the success of this initiative and studied the potential of this system for food conservation. After this successful assessment, this pot-in-pot technology was introduced in Sudan.

This cooling system has been successful in storing a variety of products including vegetables, crops and meat for a longer time and reducing food waste. The farming households in Northern Nigeria are not only able to consume these products but also sell them in the market at a reasonable price, thereby improving their income. As the shelf life of the produce increases, children (especially the girl child) are exempted from selling products immediately and spend time in gaining education. It is cost effective and 90,000 pots have been sold during 1999-2005. It has provided employment to local people engaged in manufacturing pots. The pot-in-pot technology has been adapted in Eritrea, India, Haiti and Honduras to preserve medical products such as insulin, thus benefiting the remote rural communities (Oluwasola, O., UNDP, 2011).

Case Study 19 – Mexico: Education to gain support for green urban planning

Cities contribute 75 percent to the global carbon dioxide emissions. The high levels of emissions are attributed to energy use from transport sector, buildings and industries. As estimated in 2014, 54 percent of the world's population resides in urban centres and it is expected that 12 percent of population would be added to this number by 2050 (United Nations, 2014). Cities keep expanding to fulfil the demands for basic services of residents. The estimated increase in urban population suggests a comparable rise in energy use and GHG emissions. The key to keep emissions lower is to design cities in such a way that energy use reduces. Urban planning plays a crucial role in determining the energy use and GHG emissions of cities. It can contribute to achieve Goal 11 of SDGs to "make cities and human settlements inclusive, safe, resilient and sustainable" (UNEP, 2015). This case study highlights the implementation of a comprehensive plan by decision makers in the city to bring about change in the functioning of various systems, thereby reducing GHG emissions. The education and communication component of this programme aimed to influence the attitude and behaviour of people and gain support for the implementation of activities.

Mexico introduced the Green Plan in 2008 with mitigation and adaptation strategies, in order to address the issue of climate change. The aim was to encourage people to take action and reduce GHG emissions to 7 million tons in 5 years (Benignos, R. A., 2010). Inputs from various stakeholders (through meetings) were taken into consideration in formulating this plan. The plan focused on land conservation, public spaces, water, energy, transport, water supply, sanitation and solid waste. Adaptation and education formed an important component of this plan. Some of the activities under the Climate Action Programme (part of the Green Plan) included establishing a certification system for green buildings, promoting energy efficiency, encouraging water conservation, improving infrastructure to treat wastewater, provision of good public transport and non-motorized transport systems, promoting waste recycling and encouraging use of compost. Educational activities included conducting seminars for raising awareness on- climate change issues, efficient use of resources and promotion of measures related to adaptation and mitigation (Mexico City Climate Action Programme 2008-2012).

Some of the achievements of this plan are introduction of a public bicycle system and Metrobus Rapid Transit System used by many people; new housing units established with solar panels; and urban reforestation to create green space in the city (New York City Global Partners, 2012). As a result of this plan and its implementation, the city was able to reduce 6 million tons carbon dioxide equivalent emissions (Climate Action Program, 2014-2020). This success has led to the extension of the Climate Action Programme (2014-2020) with a target to reduce 8 million tons of carbon dioxide equivalent by 2020 (Climate Action Program, 2014-2020). There has been an important addition - "containment of urban sprawl" - in the strategy for this programme. The education and communication component has been retained as a crucial factor for the implementation of the programme.

Case Study 20 – Phillipines: Use of Information and Communication Technology (ICT) for GHG emission mitigation in agriculture

Agriculture is a sector that contributes significantly to global GHG emissions. As estimated by the Food and Agriculture Organization of the United Nations, carbon dioxide equivalent emissions from crop and livestock production saw a rise of 14 percent in a decade (2001-2011) (Food and Agriculture Organization of the United Nations, 2014). To address the issue of GHG emissions reduction, one of the possible options suggested by the Intergovernmental Panel on Climate Change (IPCC) is the use of suitable sustainable agriculture practices such as integrated annual crop-animal systems (Smith, P., D. Martino, Z. Cai, D. Gwary, H. et al, 2007). Goal 2 of SDGs also promotes sustainable agriculture (United Nations Department of Economic and Social Affairs, 2015). Education, communication, training and capacity building play an important role in sharing knowledge and bringing about change in agriculture practices. ICT can catalyze the process of knowledge sharing and can help in adoption of sustainable agriculture practices. This case highlights the use of an electronic platform - e-Extension - as an alternative to conventional extension for sharing relevant knowledge and information.

In Philippines, an e-Extension programme has been initiated in 2007 with the aim of providing advisory services to people whose livelihood is dependent on agriculture, fisheries and natural resources. It is a collaborative initiative of the Agricultural Training Institute and Department of Agriculture. Different components of this programme, as mentioned on their website, are e-learning, e-farming, and e-trading. In addition to getting advice from the experts, this platform has proved to be very useful in exchanging knowledge and skills among different stakeholders through interaction. This programme also offers online learning and training opportunities. It also provides an option of blended courses which are combination of online, field work and face-to-face learning methods. An example of an online course offered on sustainable agriculture in 2012 covered a variety of topics such as natural farming systems; rice duck integrated farming system; and organic rice breeding. Stakeholders can get expert advice on business profitability, information about traders and investors, and information about market prices, producers and suppliers. This programme also supports queries based on calls as well as mobile messages from farmers and fishers (The World Bank, 2011).

Some numbers regarding the use of e-Extension can help to understand the impact of this programme. As estimated in 2012, there were about 10,000 registered users of the e-learning site which offered 25 online courses. More than 35,000 queries received through messages and calls were related to organic agriculture, fisheries and e-learning (The World Bank, 2011).

Case Study 21- Cuba: Decentralized production of building materials through empowering local communities

Housing sector consumes a great amount of natural resources. It uses energy and emits GHGs during its construction and operation phases. As accounted, buildings use more than 40 percent of energy and emit about 30 percent of global GHGs (UNEP, 2009). For developing countries, it is

estimated that more than 800 million people are residing in slums (Building and Social Housing Foundation, 2007). Thus, the challenge that lies ahead is in providing "…adequate, safe and affordable housing.." as stated in Goal 11 of SDGs, but also coming up with alternative solutions for making the process of construction and operation of buildings less carbon intensive. This case study highlights the efforts of Cuba in the provision of basic and affordable housing facilities made from locally sourced sustainable building material. The key education components in this project are involvement of a higher education institute to develop alternative solution and transfer of knowledge, skills and technology of building material to local community through training.

During the special period (the 1990s) Cuba experienced a deficit of fossil fuels and in turn its economy was negatively affected. This led the country to come up with alternative low carbon solutions and reorient systems in various sectors like agriculture, transport and housing. The Centre for Research and Development of Structures and Construction Materials (CIDEM, earlier part of the University and currently an independent research centre) has been active since 1991 in developing and promoting alternative solutions. It developed low embodied energy building materials like micro-concrete roofing tile (MCR), lime-pozzolana cement (CP-40), pre-cast hollow concrete blocks (Portland cement partially replaced by CP-40), gravel and sand suitable for use in concrete, and low energy fired clay bricks using bio-waste as a fuel (Building and Social Housing Foundation, 2007). In the preparation of lime-pozzolana cement, sugarcane bagasse ash is used (Hernandez, 2013), which requires less than half embodied energy compared to the conventional Portland cement (Building and Social Housing Foundation, 2007). Thus, it has low carbon emissions. Community level workshops have been established and CIDEM trains and guides residents in producing these building materials. These materials manufactured at the local level are supplied to the local market. The municipalities play a role in providing financial resources and managing the process of manufacturing and marketing. As these products for housing are manufactured and sold at local level, it reduces the energy input required for transportation of materials. The system of housing in Cuba has gradually shifted from a very centralized model that existed in the pre-special period to a low carbon decentralized model.

The success of this model influenced decision makers to appoint CIDEM as an advisor on housing policies. This project has also helped to mobilize financial resources through a national programme aimed to create decentralized facilities for manufacturing sustainable building materials. In addition to environmental benefits, the project generated significant socio-economic benefits too. There are 48 municipalities that facilitate production of local building materials (CIDEM, 2011). From 2010-2011, 5,300 houses were constructed using this building material. About 138 building material manufacturing units have been set up which provide means of livelihood to many people. Three training centres have been established in universities. This model of developing sustainable building material has been adopted by countries in Latin America, Africa, the Middle East and Asia (CIDEM, 2011).

Analysis and Discussion

The case studies in this paper demonstrate examples of educational interventions that have accompanied other measures such as a change in policy, new financial mechanisms, introduction of new technologies and changing systems of distribution and doing business. Education in each of these cases enhances the effectiveness and in many cases is essential for the leapfrogging, scaling up and sustaining of the efforts.

We see a variety of educational methods used. These include mass education awareness campaigns, using demonstrations, person-to-person communication, training and capacity building, stake holder engagement and consultation, forming knowledge networks, valuing traditional knowledge and making institutional arrangements for sharing and adaptation of innovative ideas. The processes have involved documenting experiences and organizational learnings.

There is a strong case for more research on the role of education and its cost benefits compared to alternative methods to bring about the transformation towards Sustainable Development.

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