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# Ecovillages: Resilient Approach to Sustainable Rural Development In Indian Context

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A B S T R A C T

Nature was self-sustained by well balanced ecological cycle until human intervention disturbed the natural ecosystem resulting in environmental damage. Therefore, it is essential to develop a community living in a balanced harmony by resolving these issues at grass root level through adopting sustainable management practices. Keeping this as focal objective, this communication is intended to address the necessity and development of ecovillage to restore ecological sustainability, harmonious living and economic stability. The review holistically describes the principles, dimensions and components that can transform an existing village into an resilient ecovillage. Adopting these dimensions and components can explicit the connectedness of an individual to social and ecological structure. Each component of ecosystem has its own importance which is designed and integrated optimally linking economy, society and ecology that makes the system self-sufficient. The concept of ecovillage is self-reliant which aids to meet most of the self needs towards building a sustainable future encouraging ruralization.



## 1. Introduction

Rapid globalization, demographic change, climate change, urban migration, etc. are imposing constant stress on the rural fabric around the globe. In the Indian context, rural framework assumes greater significance as ~68% (2011 census) of its population lives in the rural areas as compared to the world rural population of 46% (Muggur, 2016). India population is increasing at rapid phase resulting in an unimaginable stress on the available resources (http://countrymeters.info/en/India). An estimate by the central statistics office (CSO), reported that the share of agriculture and allied sectors (including agriculture, livestock, forestry and fishery) in India is about 15% of the gross value added (GVA) during 2015–16 (Muggur, 2016). In contrary, the migration of population from villages leads to stress on natural habitat, farming, over-reliance on fossil fuels, etc. (Fotopoulos., 2000). Deteriorating environment and unpredictable weather have induced an agrarian crisis resulting in the collapse of livelihoods of the rural population. Urban economy alone might not be sustainable since the overall growth depends on the rural development also. India's economy is growing with 7.6% GDP in 2015-16, but GDP of rural India is growing at a relatively lower rate (4.2%, 2013-2014) (Ministry of Finance, GOI 2016). India lives in villages and therefore, the countries growth and development becomes synonymous with the rural development.

India with huge rural population requires a well-defined, planned and organized structure with disciplined communities to utilize the natural resource sustainably. Rediscovering the potential of villages is pivotal for sustenance of rural economy. A step forward in this direction, in the context of resilience, 'ecovillage' concept can help resuscitate rural India by metamorphose villages into efficient and managed communities with a goal of becoming ecologically and economically sustainable human inhabitations. The current rural communities can be re-designed, planned, built, or modified with the intention of improving the livelihood with a minimal ecological impact or regenerative impacts (Kasper, 2008). This can also bring the community to live in harmony with nature. This communication discusses the concept of ecovillage in the context of existing Indian villages setting. The dimension and components that are essential for the rural community and can be re-engineered towards making themselves self-reliant for most of their needs were delineated.

## 2. Ecovillage - Origin

An ecovillage is a community that holistically integrates ecology, economic, social and cultural dimensions of sustainability in order to regenerate social and natural environment by the local participatory processes. According to Robert Gilman, there is, at this time, no generally agreed-upon definition of an *eco-village*. Gilman set out a definition of an ecovillage that became standard… *"human-scale full-featured settlement in which human activities are harmlessly integrated into the natural world in a way that is supportive of healthy human development, and can be successfully continued into the indefinite future*' (http://www.context.org/iclib/ic29/gilman1/).

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The motivation behind these ecovillages is to bring the people back close to the nature and reverse the gradual disintegration of supportive social structures (Dawson, 2010). The concept of ecovillage basically gives importance on the low-impact approach of living harmoniously with the nature choosing an alternative and sustainable mode of functioning. It will be ecologically integrated into the natural world that facilitates a healthy human fabric and leads to development of ecologically harmonious and economically viable communities with the eventual aim to sustain themselves infinitely (Kasper, 2008; Dawson, 2010; Ashlock, 2010). Ecovillages are gaining rapid recognition as demonstrations sites of sustainability in practice and as places of inspiration for the society. Jarna in Sweden (1931), Solheimar in Iceland (1932), Findhorn in Scotland (1962), Auroville in India (1968), Damanhur in Italy (1970), Govardhan in India (2003), Hallingelille in Denmark (2005), etc. are some of the ecovillages developed in conjugation to the urban living.

## 3. Scope of Ecovillage in India Context

Initially 'ecovillage' have originated globally with a strong base of spiritual foundation, empowerment of women, societal benefits, focusing on peace, harmony living, etc. In the present scenario, the 'ecovillage' concept due to its vast scope can be prudently upgraded to India rural community in general to re-connect with the nature with an aim of sustainable ruralization. The domestic and agro functions traditional practiced since ages are ecologically sustainable. Due to burgeoning industrialization (for past 200 years), the traditional functional activities were redundantly replaced with new technological innovations, which endangered the ecology, environment, social and cultural fabric to a greater extent. To re-introduce the traditional practices into the rural framework, 'ecovillage' will catalyze as a smart and resilient platform to re-engage with nature and to reinvent Indian villages.

## 4. Dimensions of Ecovillage

Eco-villages will grow out of the needs and opportunities caused by the new ecological constraints, new techniques and technologies for better understanding of ecosystems, efficient technologies for renewable resource and new levels of consciousness and awareness in terms of global consciousness (http://www.context.org/iclib/ic29/gilman1/). Ecovillage can represent a resilient community designed, planned, built or modified to promote sustainable living (Jurleit, 2015). The sustainability of a community also depends on creating and maintaining its economic and environmental health, promoting social equity and fostering broad-based citizen participation in planning and implementation (Roseland and Spiliotopoulou, 2016).

Ecovillages are basically designed with organized pillars that address sustainability and resilience/regeneration of the villages that basically provides importance to the low–impact approach of living closely with nature. Ecovillage embraces four dimensions as pillars viz., ecology, economy, culture and social sustainability (Litfin, 2013) and allows people to experience their personal connection to the living on earth and earning their livelihood. The ecological dimension leads to the principles of living harmoniously with the nature. The social dimension undertakes the responsibility of people to feel supported by and responsible to those around them making everyone empowered. Culture dimension deals with the respect, support, cultural, artistic enrichment, expression and spiritual diversity. Economic dimension keeps the money in the community, circulates it through as many hands as possible, earns it, spends it, and invests it in member-owned retail, saving that money in home-grown financial institutions (Hart., 2006; Litfin., 2013). These dimensions are well understood as reliable indicators to measure the progress towards ecovillage recognition (SDSN., 2015) and broaden the conceptual reach of villages toward pragmatic expressions of social experimentation with an intentional communalism.

The following sub-systems should considered consciously towards building a strong, healthy and self-reliance rural society

- Living with the nature in harmony
- Conserving and restoring natural capital
- Restoring traditional practices
- Reliable food and water security
- Micro-level governance and leadership
- Low carbon footprints
- Sustainable and integrated farming
- Healthy living
- Reliable livelihoods
- Reliable community sanitation
- Sustainable lifestyle
- Energy resilient
- Community level skill and capacity building
- Access to education
- Waste recycling
- Circular Economy
- Women and youth participation and empowerment
- Economy upliftment
- Localized disaster management
- Location specific business models
- Adopting Eco-technologies
- Community participation
- Macro-level governance and leadership

## 5. Design of Ecovillages

Natural capital is the stock of the natural resources (air, water, soil and all living organisms) providing a wide range of free goods and services often called as ecosystem services (Aronson et al., 2007). Natural capital underpins economy and society and makes human life vulnerable on the Earth. Sustainable development minimizes the likelihood of dynamic natural and/or man-made systems to exceed tipping points, when exposed to disturbances (Bloesch et al., 2015a).The concept of resilience and reaching the respective targets provides the method needed to maintain identity and integrity, and to manage system´s dynamics.

A village can be re-designed to resilient (sustainable/eco) village by adopting the components and its sub-systems with a defined goal that perpetually assist sustainability of the rural setting. Of concern are three interwoven systems: environment, society and economy, forming a complex super system coined eco-social triad (Bloesch et al., 2015b). The intersection of sustainability, economy, environment and equality are necessary for the creation of a sustainable community. All dimensions should be integrated into the natural world that facilitates a healthy human community and development leading to ecologically harmonious and economically viable communities with the eventual aim to sustain themselves infinitely (Kasper, 2008; Fotopoulos, 2000; Kirby., 2013). The components that can be considered in the context of ecovillage are listed below (Fig 1).

- Sustainable Water Management
- Sustainable Agriculture
- Sustainable Infrastructure
- Sustainable Energy Management
- Sustainable Health
- Sustainable Waste Management
- Sustainable Empowerment

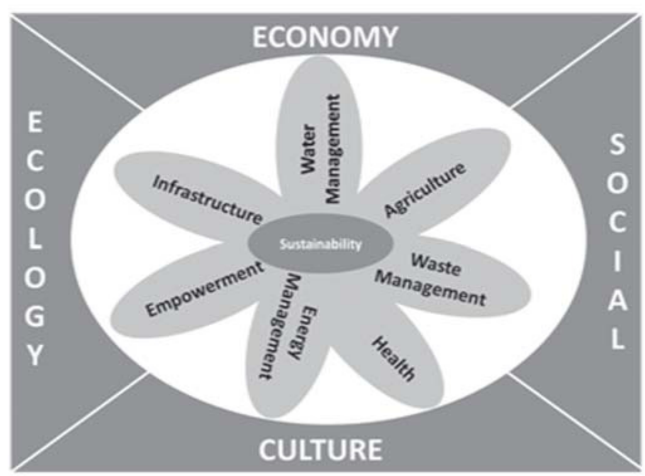


**Fig 1:** Dimensions of ecovillage: Synergetic representation of various components governing the design of sustainable village

### *5.1 Sustainable Water Management*

Agriculture is the backbone of Indian economy and water plays an crucial and integral part of agricultural/farming based activities. In India, the groundwater levels are falling 70 meters or more over the past 30 years and there is significant increase in tube well share in irrigated areas from 1% (1960) to 40% (2007) (Chandrashekhar and Das., 2016). In this context, watershed management and rain water harvesting helps to harvest water in places where rain fed/irrigation based crops are cultivated through ground water. Aquifers can be recharged with rainwater to conserve the ground water. Rainwater can be harvested either by storage of rainwater on earth's surface for future use or recharged to ground water. Roof top harvesting is less expensive and easy to construct, operate and maintain. According to a rough estimate, an average rainfall of 1,000 mm, approximately 4 million liters of rainwater can be collected in a year for an acre of land (kvgktrailblazers.weebly.com/rainwater-harvesting.html). This technique is neither energy-intensive nor labor-intensive and thus offers a cost-effective alternative to other water-acquiring methods. Rainwater harvesting helps to overcome water scarcity and is the most reliable solution for augmenting groundwater level to attain self-sufficiency in both rural and urban settings. This also improves the quality of ground water through dilution when recharged and reduces soil erosion. In desert, saline or coastal areas and islands, rain provides good source of quality water.

Apart from water harvesting, drinking water management is equally important for healthy community. Safe drinking water should be given a priority by constructing a water treatment plant in village community in the frame work of self-employment. Failure to ensure the safety of drinking water may expose the community to the risk of outbreaks of waterborne and infectious diseases. Safe sources of water aims looking for alternate water sources, dual water supply and waste water treatment, exploring simple, lowcost treatment technologies, revival of traditional water conservation structures and community based water management (RGNDWM, 2010, PEO Report No. 210). Effective storing and diverting of water to maintain or restore the ecological integrity of river and pond ecosystems also form part of the sustainable water management program. The goal of ecovillage is the willingness to live within the limits posed by ecosystem flow requirements, undergo refinement to efficiently use available water supplies, and commit to long-term water planning and adaptive management strategies.

### *5.2 Sustainable Agriculture*

Sustainable agriculture advocates farming practices that follow and apply the ecology principles and thereby integrating the economy and society. Practicing sustainable methods for farming improves the ecological resilience and environmental quality of the village. It also enhances the quality of life of farmers and society as a whole. Some of the factors that influence the sustainability in agriculture practices are water quality and quantity, soil management techniques, farming practices, reducing or replacing chemical fertilizers, protecting soil from runoff, pest control practices, etc. (Kibblewhite et al., 2008). Organic farming and permaculture approaches promote ecosystem function and biodiversity needs is a priority mode. Monoculture farming could be shifted to poly culturing with proper rotation of crop for sustainable agriculture (Connor et al., 2011; Henkel., 2015).

Apart from agriculture, small gardens can be an efficient means of providing access to crops such as greens or vegetables that are easy to grow and can be an excellent source of food security, even in times of drought. A kitchen garden also serves as source of income to rural women. Integrated farming practices such as agriculture with animal husbandry helps yielding manure for farming along with fodder for the animals. Strategies to enhance income through agriculture activities such as value addition, product diversification and entrepreneurship development helps to sustain and retain farmer who is the backbone of a village (Mamun et al., 2011; Kesavan and Swaminathan., 2008).

#### *5.2.1 Biofertilizers*

Fertilizers are the source of nutrients to the soil which enhance the yield productivity but over usage cause ecologically detrimental functions. Greenpeace reports that the unconstrained usage of synthetic nitrogen fertilizers resulted in high levels of nitrate deposits in ground water and posed serious health risks. The high solubility of chemical fertilizers aggravates their tendency to degrade ecosystems, particularly through eutrophication leading to the environmental damage.

Biofertilizer composed of microorganisms (Rhizobium, Azotobacter, Azospirilium, blue green algae (BGA), etc.) in the form of latent cells or living cells helps to uptake nutrients effectively (Mohammadi and Sohrabi., 2012; Mazid and Khan., 2014; Vessey., 2003). It aids nutrients addition through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances (Khan et al., 2009; Reddy et al., 2015). Biofertilizer like anabaena in association with Azolla contributes nitrogen up to 60 kg/ha/season and can enriches soils with organic matter (Fulekar, 2010). Usage of these fertilzers in the fields provides various ecological benefits and improves soil quality and also livelihood generation.

#### *5.2.2 Biopesticide*

Extensive usage of pesticides in farming practices for pest control also disturb the balance of an ecosystem, causing harm to both man and animals. Conventional pesticides are synthetic in nature and kill or inactivate the pest. The indiscriminate application of pesticides in agriculture resulted in bio-magnification and bio-accumulation in the environment. Human exposure to chemical pesticides causes serious health implications evening leading to cancer. Biopesticides derived from animals, plants, microorganism, and certain minerals (canola oil, baking soda, etc.) (Sarwar ET al., 2015) offers several advantages over the conventional pesticides and are inherently non-toxic. They affect only the target pest and closely related organisms and are effective in very small quantities and often decompose quickly. In 2014, there are more than 430 registered biopesticide active ingredients and 1320 active product registered (http://www.epa.gov/pesticides/biopesticides/whatarebiopesticides.html). Biopesticides fall into two major classes. Microbial pesticides consist of a microorganism which may be a bacterium, fungus, virus or protozoan and act as the active ingredient. Microbial pesticides are able to control pests, though each separate active ingredient is relatively explicit for its target pests. Widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, or Bt (Gupta and Dikshit, 2010). Next class includes biochemical pesticides which are naturally occurring substances that control pests by non-toxic mechanisms. Adoption of biopesticide in India by farmers still needs education for maximizing its gains. Some of the biopesticides like Bt, NPV, neem based pesticides, etc. are registered in India and being practiced.

Biopesticides have a vital role in ecovillage domain as an alternative to the conventional and commercially available chemical pesticides. It is estimated that the total world production of biopesticides is over 3,000 tons/yr, which is mounting at a rapid rate (Gupta and Dikshit, 2010) which directly provides livelihood to the rural population.

#### *5.2.3 Composting*

Inappropriate use of synthetic fertilizers, pollution, soil infertility, biodiversity loss, etc. have manifested towards organic practices. Organic biomass generated from agricultural activities, dairy practices and animal shelters can be deployed properly by composting it into a valuable end product called manure. It application offers benefits viz. enhanced soil fertility and soil health, improved soil biodiversity, reduced ecological risks and a better agricultural environment. There are many techniques of composting viz. cold and hot composting, worm composting, fermentation and Raised bed faming (Epstein., 1996; Stoffella and Kahneds., 2001). Regular composting (cold composting), involves usage of compost bin, enclosure, or even just in a large heap for placing a variety of organic materials in them, and leaving it there until it breaks down several months later. Alternate to this approach 'hot composting', is next option which produces compost in a much shorter time, where it gives an advantage of killing weed seeds and pathogens (diseases), and breaking down the material into very fine compost (Trautmann and Krasny.,1997). Popular hot composting methods includes are Indore composting, Bangalore composting, Berkley composting, etc. Each technique varies in the nutrient content and the time taken for compositing (http://ecovillage.org.in/ecopedia/composting).

Worm composting exploits the usage of worms like red wigglers, white worms, and earthworms to convert the organic into finnier particles. The resultant product of worm composting called vermin-compost and is rich in nutrients and forms the best alternative when there is need to process huge quantities of waste/biomass (Edwards et al., 2010). Another composting technique is the fermentation process which takes place at lower temperatures by mixing microbial consortia under prevailing anaerobic conditions. Another popular technique can be used is the raised bed faming. This involves creating a raised soil bed comprising of wood, sticks and dry foliage and covered with soil. Constraints of efficient expeditious technology, long time span, intense labor, land and investment requirements, and economic aspects restricts the farmers to utilizes the resource available to them in a sustainable manner.

#### *5.2.4 Ancient Farming- A way towards Sustainable agriculture*

Modern farming involves massive acreages managed by huge machinery to speed up the processes in an unsuitable way. This leads to the development of futile land that could not be recovered easily. Therefore, there is need to revert for ancient farming which has been practiced with less machinery efforts in a sustainable execution and provide a new horizon to the present agriculture status harmony with the environment. Ancient farming methods from ancient India like Homa farming (Agnihotra), Green manuring, cover cropping, crop rotation, polyculture, composting, reduced tillage, etc. are more practical in the present context (Sofia et al., 2006). These methods are inexpensive and simple to undertake but requires discipline and regularity. Traditional farmers till date follow the ancient systems of crop rotation, multi-cropping, intercropping and polyculture which makes smart use of all inputs available to them, including soil, water and light. Ancient Americans traditionally followed classic mixed cropping: three sisters, terraces, floating bed, raised bed, back soil, slash and burn, etc. Famers in the rivers of the amazon basin were producing fertile soil on which to grow their crops for past 2000 years, the soils, known as "black earth," are still fertile after they were last made for 500 years. The soil contains high concentrations of humus, powdered charcoal, pieces of broken pottery, aquatic plant remains and sand. In china ancient agricultural techniques like row farming used to sow seeds in rows rather than broadcasting or scattering the seeds (http://www.ancientchinalife.com/ancient-chinese-farming.html). This technique facilitated the ancient Chinese farmers to irrigate the fields easily and derive maximum yield of crops using the "Dujjangyan irrigation system". Egypt also used effective planning of agriculture in the water limited areas (endorsed as being one of the first groups of people to practice agriculture on a large scale) growing crops on the black soil resulted from the flood of the Nile river.

Part of ancient Mexico City was formed over a lake, on which the Aztecs tribe built thousands of floating platforms (Chinampas) on which crops were grown. Other practices were directing rainfall into spiraling holes that led to underground storage chambers and many indigenous cultures constructed irrigation canals. Use of raised bed was the practice shared by all these farming societies covered with thick layers of organic matter or mulch (http://wastetoenergysystems.com/how-can-ancient-farming-methods-help-with-climate-change/). This technique holds the advantage in periods of excess rain, the beds hold part of the root system up in well-oxygenated soil, above the level of the standing water which prevents anaerobic decomposition of roots. Ancient agricultural practices hold promise for increasing food production worldwide. These techniques and their innovation can be easily implemented in ecovillages where the communities suffers from futile land, drought conditions, low water availability, high mountains coverings, etc. Going back to the ancient farming practices prudently facilitates environmental resilience with sustainable agriculture

### *5.3 Sustainable Waste Management*

Coherent waste management plays a key role in completing a sustainability model of a ecovillage. Ecovillage may even lead a 100% organic life, but that is bound to generate organic as well as inorganic – left over waste. Thus, ecovillage must be free of waste accumulation which necessitates in developing a systematic waste management system. Rural waste can be categorized into solid and liquid based on its physical form (Fig 2) and based on the pattern of use, it can be further classified into human waste (faces, urine, etc.), animal waste, agriculture/farm waste (crop harvesting material, weeds, straws, animal wastes, etc.), agro-industrial wastes (sugar cane, peals, etc.), household waste (garbage, food waste, etc.) and commercial waste (plastics, bottles, etc) (Waste to Resources Handbook., 2014). Inspite of the source and the origin, if managed properly, can generate income and livelihood simultaneously.

Ecosystems are usually stable in nature where the flow of materials and energy are balanced in a closed loop system. Waste products from one organism or process are used by another organism or processes considering, a zero-waste supply chain that completely reuses and recycles all materials. In a closed loop, waste is considered as unused resources. Sustainable waste management will recognize waste as a resource and find solutions for reuse, recycling, reduction, and energy recovery before disposal of waste. Employing nature's own system of recycling waste eventually becomes a resource. Segregation of solid waste (biodegradable and non-biodegradable) and liquid waste (gray water and black water) at source is an essential pre-requisite for proper management of waste. Conventionally, organic matter can be decomposed to form manure through composting under natural prevailing conditions. Black wastewater, organic solid wastes, animal waste (cattle dung), etc. can be treated anaerobically to generate biogas. Gobar gas plant facilitates anaerobic digestion of solid waste and generates biogas which can be used for heating and cooking purposes. The solid waste from anaerobic digester can be used as compost for agriculture purpose (Monnet, 2003). The disadvantages conventional gobar gas plants can be overcome by using advanced high rate biomethanation digester. Waste paper, cloth, metal and glass can be recycled and reused. Holistic waste management are best realized by building up closed-loop system where additional value will be generated through recycling and reuse of materials (Kumar and Malegeant, 2006; Venkata Mohan et al., 2016a,b,c).It improves the eco-efficiency by shifting the linear flow processes to a circular processes by combining environmental and economic issues (Wrinkler, 2011).

### *5.4 Sustainable Energy Management*

Energy is essential for sustainable development of village but it invariably adds to the carbon footprints of the community. Sustainability

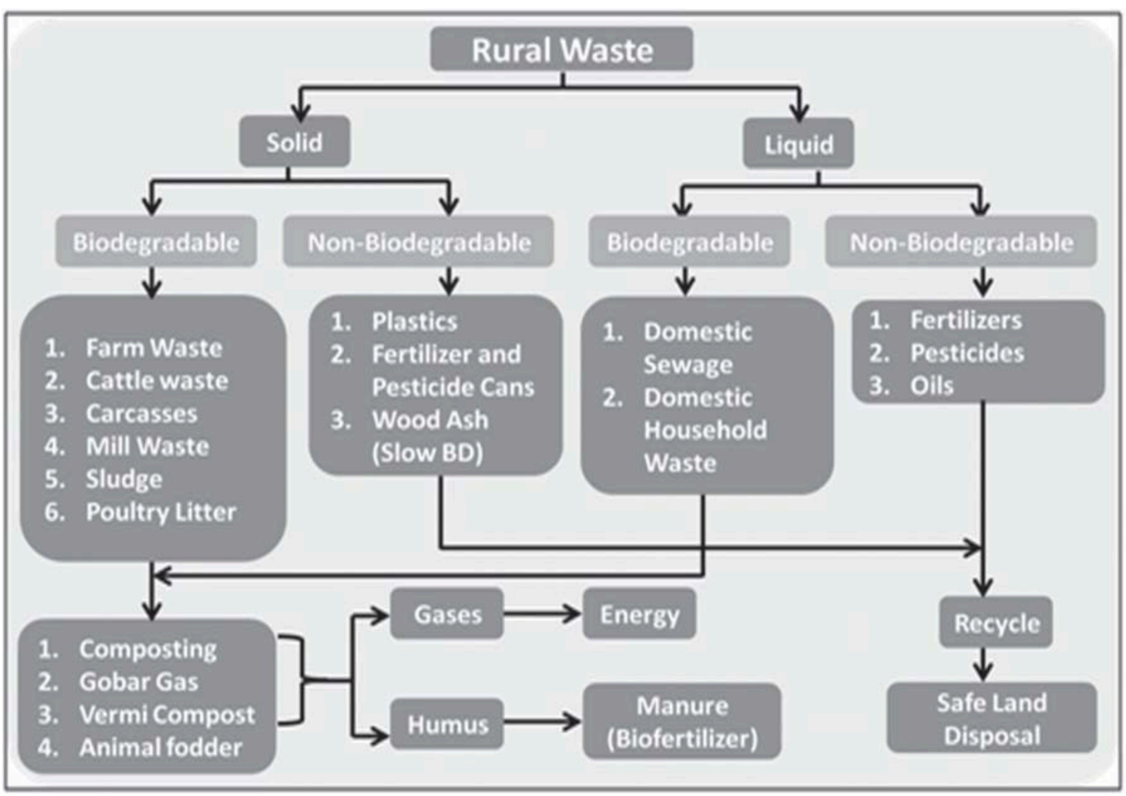


**Fig 2:** Types of wastes generated in rural areas and its management

basically addresses the issue of energy avoiding the fossil based sources and giving priority to the available renewable sources (Fig 3). The most commonly used renewable energy sources are solar, water, wind, and biomass/waste. The renewable energy potential of biomass/agriculture is attracting attention. India generates around 600 million tonnes of agricultural waste annually (Lourdes et al., 2013) with estimated power generation potential of 50,000 MW if fully utilised. Wind energy can be converted into useful forms of energy viz., wind turbines facilitate electrical power, windmills provide mechanical power required for pumping water for agriculture activities, etc (Premalatha et al., 2014). Solar energy, radiant light and heat from the sun can be used to harness energy by exploiting solar heaters, solar cookers, photo-voltaic cells, thermal electricity, etc. Solar panels can help meet several energy requirements of households and solar lamps can be used for mobility at nights. Solar heaters would be given priority for heating purposes to avoid fossil fuel usage. Solar powered water pumps can be used for drawing water for the agriculture activities. Street light with LED integrated solar panels can lighten up village streets (Sharma and Purohit., 2014).

Geothermal heat pumps, also referred to as ground source heat pumps or geo-exchange, refer to systems that use the ground, groundwater, or surface water as a heat source or sink (Omer, 2016). Geothermal heat pumps use 25% to 50% less electricity than conventional heating or cooling systems. Bioenergy produced by conventional anaerobic digesters or advanced high rate methanation digestors using solid waste from rural activities is important renewable source of energy which provides fuel for cooking purposes and organic manure (Dahiya et al., 2015). The advanced high rate methanation digestors can also be linked with sanitary toilets or animal husbandry effluents which can directly facilitate rural sanitation. This technique can arrests cutting of trees for firewood and thereby maintains ecological balance. Anaerobic digesters or biomethanation reactors plants requires successful community participation as well as sufficient animal husbandry activities to support the feed-stock requirement for functioning.

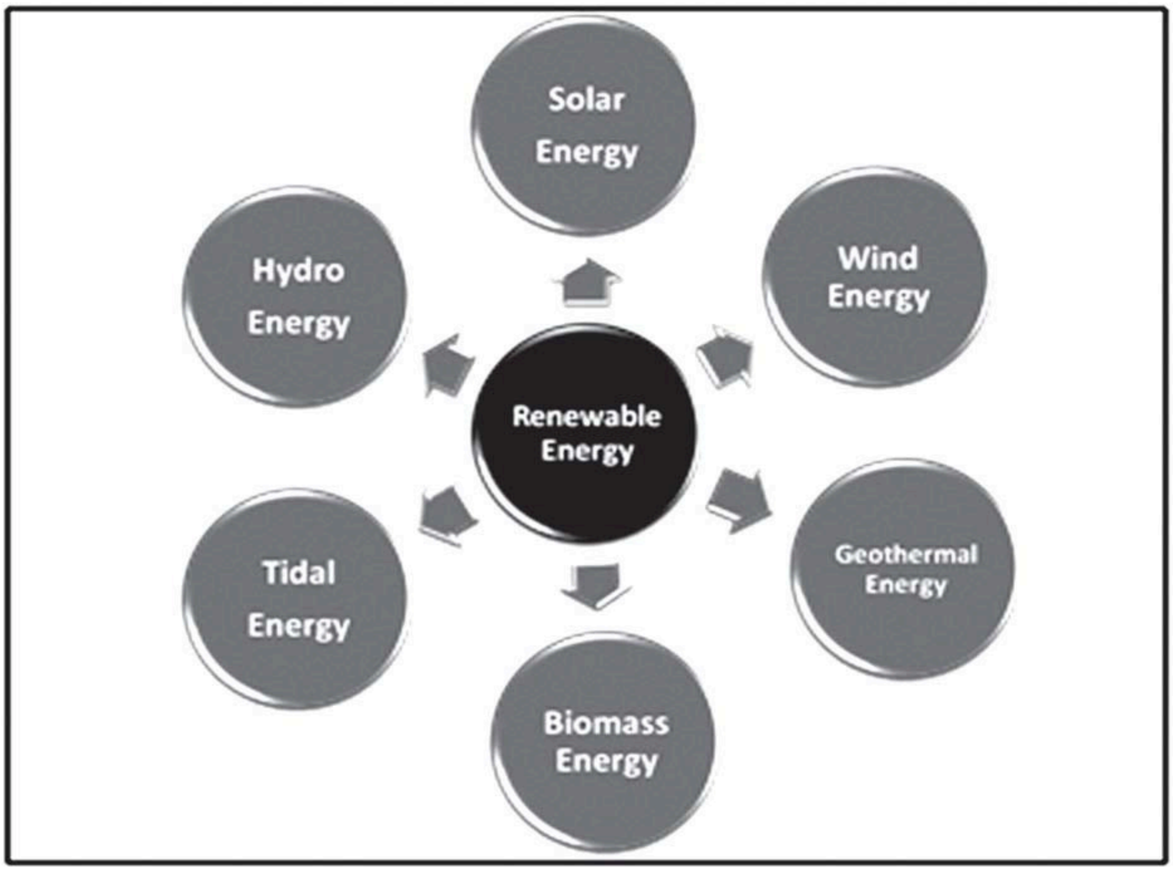


**Fig 3:** Various forms of renewable energies produced in rural areas

### *5.5 Sustainable Infrastructure*

Infrastructure forms the basic framework of a community and is a crucial aspect of sustainable development as it has ties with primary concern - human health, environmental systems, air and water quality, disaster management and economic viability. Sustainable infrastructure demands planning which is efficient, helps to support or create closer-knit neighborhoods and the sense of community with them, and preserves natural systems (ISA., 2016). Environmentally friendly processes and materials, which are sourced locally, reduce over consumption through insulation, renewable energy usage, good practices for air quality, water management, sanitation, waste management, land use, etc.. Green housing concept integrated with construction or maintenance of the infrastructure amalgamating with the surrounding ecosystem also plays major role (fig. 4). Architectural design based on the concepts of nature, planning designed based on the surroundings on the basis of natural features, resource availability, safety and environmental constraints are also important (Prakash et al., 2014). Adopting traditional techniques and using local materials with given priority and will reduce ecological foot prints significantly. The sustainable infrastructure should planned which can increase their resilience to future disaster.

### *5.6 Sustainable Health*

The main aim of sustainable villages is to reduce negative human impact and also make the forms of reorganizing the living conditions in a sustainable way. Most of the problems, which we face in our daily life, can be prevented and stopped by taking appropriate physical, mental and social measures. Making healthcare sustainable require focused interventions in the present system especially in rural areas. Rural unhygienic conditions due to lack of awareness in health aspects needs to be give key priority. Rural population majorly suffers from disease such as diarrhoea, amoebiasis, typhoid fever, infectious hepatitis, worm infestations and poliomyelitis, measles, tuberculosis (TB), whooping cough, pneumonia, malaria, etc. (Patil et al., 2002). It is estimated that around 37.7 million Indians are affected by waterborne diseases annually, 1.5 million children are affected by diarrhea alone and 73 million working days are lost due to waterborne disease each year (Report by Khurana and Sen; Water Aid).

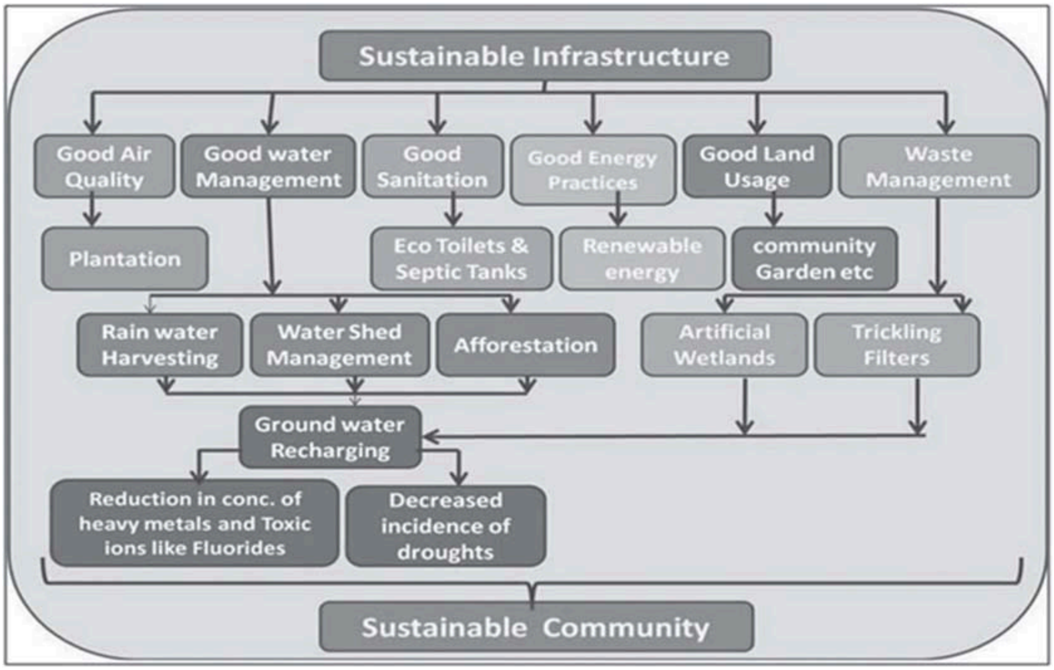


**Fig 4:** Sustainable infrastructure and community in rural context

About 80% of rural population lack access to safe drinking water. Access to safe and adequate drinking water or proper sanitation facilities is one of the main criteria in maintaining sustainable health. Thus, community sanitation has to be given priority to essentially eradicate most of the health hazardous associated with the regular human habitat activities. Safe waste disposal and management practices have healthy economic and aesthetic benefits.

### *5.7 Sustainable Empowerment*

Empowerment of women and youth in rural context is essential prerequisite for retaining the sustainable society intact. In the way of developing ecovillage, various self-employment models needs to be considered and designed in conjugation with the Government programs particularly refereeing to rural development, skill development, etc. Some of areas that can be considered in this dimension are listed below

- Agri-food Production
- Weaving
- Sericulture
- Horticulture
- Dairy and Husbandry
- Floriculture
- Fishery
- Kitchen gardens
- Community maintained biogas, water treatment plants, lighting, etc.
- Manure Production (composting)
- Organic farming

India with 15 Agro-climatic zones and 17000- 18000 species of flowering plants out of which 6000-7000 are estimated to have medicinal application

(Ayurveda, Siddha, Unani and Homoeopathy). About 960 species of medicinal plants are estimated to be in trade of which 178 species have annual consumption levels in excess of 100 metric tonnes. Tropical specific ayurvedic plants can be grown in different areas of the country which can provide livelihood to the rural population as these farmers. Farming of these crops will be the added advantage for enhancing the profit from the yield.

Freiamt village in Germany, with 4,300 inhabitants, uses different forms of renewable energy including a biogas plant, solar power, wind and water energy to produce about 14 million kwh energy annually (3 million kwh excess). Wildpoldsried, a municipality in Bavaria, produces 321% more energy than it needs and is generating 4.0 million Euro (US$5.7 million) in annual revenue by selling it back to the national grid. Maintaining a sustainable environment in addition also generates revenue with effective planning and management.

Cultivating azolla or algae can establish a new business opportunities in the area of aquatic farming since they are easily cultivable and harvestable. Algae such as spirulina can be used as SCP which have high nutritious value and good market. Azolla can be used as an ideal feed for cattle, fish, pigs and poultry, and also is of value as a bio-fertilizer for wetland paddy (Pillai et al., 2005). The azolla or algae cultivation on the effluents reduces the COD efficiently which in turns makes the water usable for agriculture. The biomass harvested from the azolla and algae can be again used as substrate for the fermentation process for biogas production (Venkata Mohan et al., 2016a).

Closed-loop systems promotes sustainability and also improves economic as well as environmental goals simultaneously (Fig 5). Close loop approach starts from the household activities. The infrastructure can be aligned to green building having solar panels, rain water harvesting system and well organized waste segregation system. The solar panels will provide green power and the segregated waste viz. inorganic and organic waste can be treated or recycled. Agricultural biomass or organic waste provides as feedstock for the anaerobic digester for the production of biogas and the untreated waste can be composted for organic farming. It can also be substituted to phosphate solubilising bio-fertilizers; ultimately achieving near to closed looping. The organic crop will be of high value leading to local economic stability.

Integration of various processes leads to the close the loop approach improves the eco-efficiency by shifting the linear flow processes to a circular processes by combining environmental and economic issues in circular economy mode (Venkata Mohan et al., 2006; Wrinkler, 2011).

## 6. Case studies

Ralegan Siddhi is one of the sustainable model village in India (Ahmednagar District, Maharashtra state). According to the World Bank report Group, Ralegan Siddhi transformed from a highly degraded village ecosystem in a semi-arid region of extreme poverty to one of the richest in the country. It also demonstrated the possibility to rebuild natural capital in partnership with the local economy. Anna Hazare, Sarpanch of the village and social activity, for his efforts in establishing this village as a model is recognized by the Government of India with Padma Bhushan award. The village is located in the rain-shadow area with low annual rainfall having barren and undulating land. It demonstrated the importance of watershed development and water management (http://www.annahazare.org/ralegan-siddhi.html). Water harvesting structures (nulla bunds, cement check dams and Gabion) have been constructed with people's participation helped in conserving each drop of rainwater and recharged the groundwater aquifers. Programs like tree planting, terracing to reduce soil erosion, digging canals for retaining rain

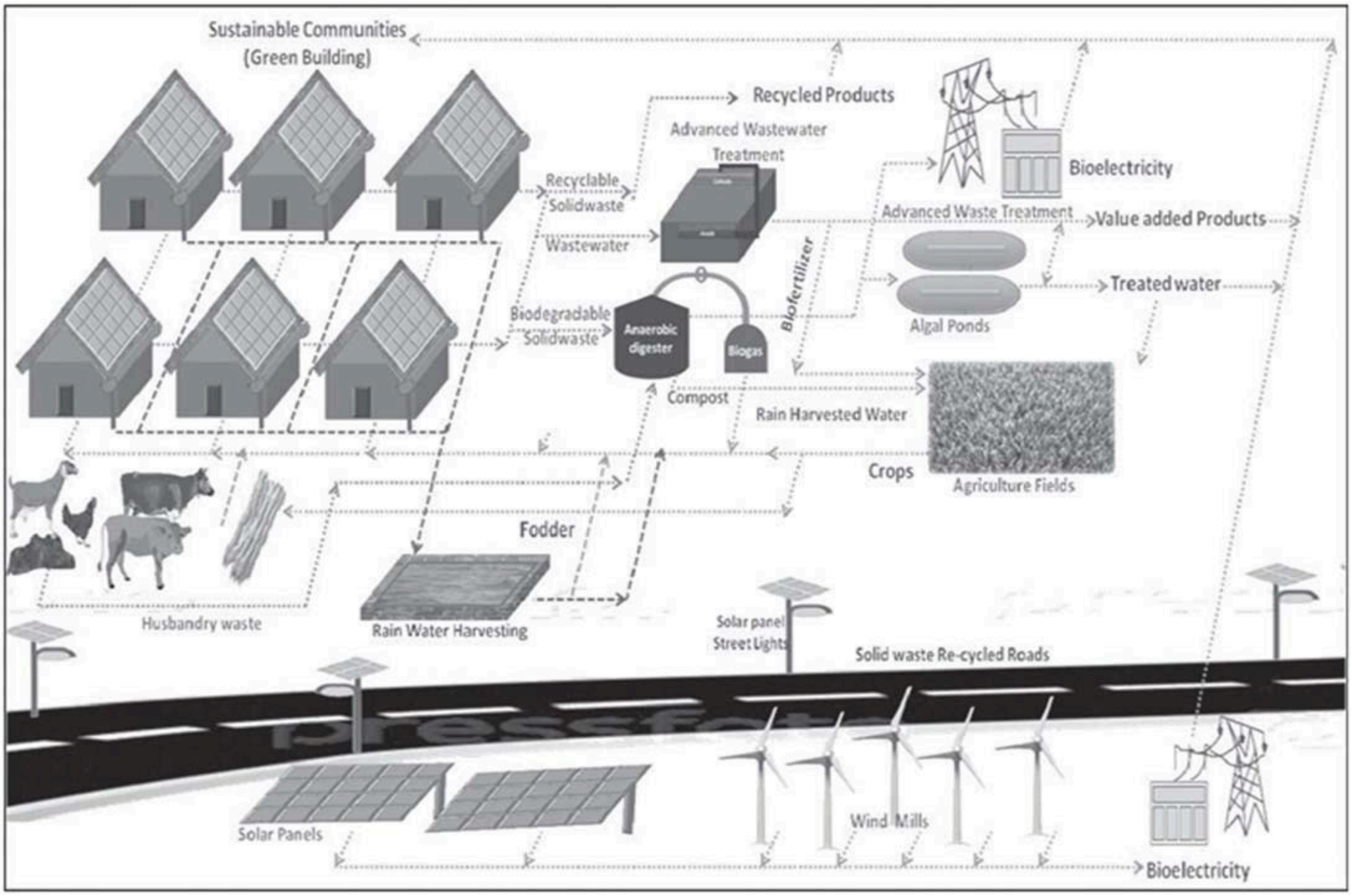


**Fig 5:** Overview of Eco-village in"closing the loop approach"

water (http://www.rainwaterharvesting.org/People/RuralJY.htm#anna). Due to the availability of water, the agricultural production has boosted up and created employment opportunities within the village itself which stopped migration. The per capita income of the villagers has increased several folds resulting in upgrading the economy of the village. The village also uses non-conventional source of energy viz., solar power, biogas (generated from the community toilet) and a windmill. It also showed the possibility to rebuild natural capital in partnership with the local economy.

Govardhan Ecovillage, developed by the International Society for Krishna Consciousness (ISKCON) is located at the foothills of the Sahyadri mountains, 108 km north of Mumbai (http://www.ecovillage.org.in/). This ecovillage is a model farming community and retreat center which highlights the need to live in harmony with the community, nature and the sacred. With the main focus to develop a 'spiritual ecology' this eco-community combines the technology of modern science with Vedic wisdom and provides the sustainable solutions. Practices viz. organic farming, animal care, green buildings, water conservation, alternative energy, soil biotechnology, waste management, rural empowerment, rural education, global outreach, art and handicrafts, plant nursery and research & training are being implemented in the village. This ecovillage also provides training in organic farming viz. Soil conservation, building up of humus, maintaining microbial population, water conservation and utilization, effective crop management and pest and disease management, etc.

## 7. Prospective and Scope of Ecovillage

A community is unsustainable if it consumes resources faster than they can be renewed and produces more wastes than the natural self-cleaning mechanism. Resilience is the ability of natural or man-made systems to respond dynamically to changes of ambient conditions with the aim to retain their inherent function, structure and feedbacks (Bloesch et al., 2005a,b). In ecosystems these cycles are self-regulated and characterized by recycling of materials and energy. A community that is sustainable can manage its resources to meet current needs while ensuring that adequate resources are equitably available for future generations. To meet the current challenges integrated solutions are needed rather than fragmented approaches that convene one of those goals at the expense of the others. Ecovillage concept helps to integrate several ecosystem services harmoniously with human activities leading to resilience with eventual goal to become self-reliant communities with minimal ecological impact. Implementation of closed loop systems broaden the conceptual reach of villages towards pragmatic applications, which will ecological integrates the nature facilitating the effective balance between the resource and the human needs.

India is gradually shifting to the concept of ecovillages. Considering India vast rural setting in volume and size, adopting ecovillage concept will play major role in sustaining the rural fragment of the society intact at its origin. Rural community strives for a better quality of life, healthy ecosystems, effective governance and economic security. The ecovillage design is very specific to the geographical location and depends on the exact characteristics of that area viz., climate, cultural practices of the inhabitants, local environmental issues, etc. The present state of activities ongoing in the area, social structures, local economy, agricultural practices, water resources, health issues, etc. will be influential factors in the design. The transformation scope should be laid on a defined goal with a well planned road map at macro and micro levels. The design should mainly intend to re-organizes the living conditions focusing on environment, society and economic sustainability. Such system shall empower the rural population and make them self-reliant socially, ecologically and economically.

Adopting to ecovillages facilities learning from the best elements in traditional and indigenous cultures, re-establish low-impact living, promotes micro-governance, encourage permaculture design, ecological technologies, localized energy generation, waste-management, organic and locally-based food production, etc. for a more ecologically sound and sustainable living (Dawson, 2010). The willingness to live within the limits posed by ecosystem with the available resource is vital requirement of an ecovillage. The initiatives, commitment and resources available will make the community healthier, safer, greener, more livable and more prosperous. These resilient-ecosystems embedded with the concept of adaptive capacity are generally non-linear and therefore, design should also encompass measures for the new and/or unpredicted vulnerabilities.

The Government programs that were specifically designed in this context since independence advocates ecovillage concept either directly or indirectly viz., Community Development Program (CDP), Rural Electrification Corporation, Accelerated Rural Water Supply Programme (ARWSP), Crash Scheme for Rural Employment, etc. Recently launched programs are National Livelihood Mission, Pradhanmantri Adarsh Gram Yojana (PMAGY), National Rural Livelihood Mission, Pradhan Mantri Ujjwala Yojana, National Rurban Mission, etc. Under these programs GOI tried to cover need and time based support for over-all development of rural areas with people's participation aiming toward sustainable living community. Swasthya Bharat (affordable health care), Samarth Bharat (specific area of advancement in science), Sashak Bharat (Self-Reliant), Swach Bharat (Clean and green/eco friendly technology), Smart cities/villages (Materials and technologies for farmers and infrastructure), Gram Jyothi, etc. are some of recent programs empowered to facilitate sustainable rural fabric. Ministry of skill development and enterprise is also promoting Skill Development programs with particular reference to the rural welfare.

Local skills (*In situ*) should be integrated into the development agenda that enable a community to function as a cohesive unit and engage with the modern economy. Proper training and skill development to the rural population can make them self-sufficient to establish their own independent business in the community. Capacity building in this regard plays a major role. Practical improvements with longer-term systemic changes should be anticipated for sustained benefits. Design of business models very specific to location will also benefit the local economy. The government machinery at local level and participation of community is highly essential for its long term success.

The Sustainable Development Goals (SDGs) with seventeen "Global Goals" with 169 targets covers critical sustainability aspects viz., water, sanitation, and hygiene, climate change, women and gender equality, economic growth, infrastructure, etc. The concept of ecovillage adequately follows SDGs individually and also interlinks majority of these goals. Moreover, the ecovillage concept addresses the sustainability issues at grass-root level which eventually cumulate at regional to global scale if applied and can effectively embrace the challenges faced by the mainstream society over next several decades. Incorporating sustainability to village invariably transforms the country sustainable, eventually makes world sustainable and thus ensure a better and safe future for the coming generations.

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