



SUSTAINABLE INNOVATIVE SOLUTIONS – A PROGNOSTIC APPROACH TO CLIMATE CHANGE

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ABSTRACT: Climate change is an all-pervading phenomenon impinging upon earth's natural equilibrium. Although once a natural phenomenon, it has now evolved as an anthropogenically induced phenomenon driven by accentuated greenhouse effect as a result of increased fossil fuel burning due to rapid industrialization and urbanization disturbing the environmental sustainability of earth's ecosystems. The present paper highlights the sustainability issues that are intricately linked to climate change through models like **DPSIR** and suggests a solution-oriented approach wherein smart sustainable strategies and innovative concepts like **Principle of Prevention / Precaution**, responsible consumption and recycling, sustainable transportation, **Stakeholder analysis**, **Technology Assessment** etc. have been discussed to deal with the problem in hand.

Keywords: Climate change, greenhouse effect, Green energy use, sustainable urban planning, green transition.

INTRODUCTION: Climate change is an all-pervading phenomenon changing the face of the earth irreversibly. Climate change includes global warming as well as changes to Earth's climatic and weather patterns. Global warming is likely to be the greatest threat of the 21st century. Global warming is the most conspicuous phenomenon of climate change characterized by a general increase in average temperatures of the Earth, which modifies the weather balances and ecosystems for a long time. It is directly linked to the increase of greenhouse gases in our atmosphere, worsening the greenhouse effect. The causes of Global warming are linked to anthropogenic activities, which is a direct consequence of excessive usage of fossil fuels used to satisfy the modern day needs of industries and urban areas (**Drake, 2000**). Other activities that also lead to climate change are deforestation, intensive farming, waste disposal, mining and overconsumption. As mentioned above, climate change not only includes global warming but also extensive changes in the weather patterns such as changes in precipitation regimes leading to floods, droughts and even desertification including impacting soil and growing seasons of the world. Climate change is an integral feature of earth since time immemorial as it alternatively experiences **Ice Phase** characterized by lowering of temperatures leading to formation of glaciers and ice caps and ice sheets and **Hot Phase** leading to warming of the Earth where there is melting of ice and rise in sea levels (**IPCC, 2001**). However, due to the advent of human civilization, climate change has involved as an anthropogenic element as a result of rapid industrialization, increase in population growth and pollution. On account of anthropogenic interference, the speed at which the climate is changing is most alarming as the earth is unable to cope with these human induced changes and there is permanent alteration of Earth's natural balances. The anthropogenically occurring climate change thereby gets superimposed over the already occurring natural climate change producing disastrous impacts such as rise in average surface temperatures

ranging between 1 to 3°C, melting of the cryosphere, abnormal sea level rise, changing agricultural patterns, interference to the different Biomes and ecosystems of the world and an overall disturbance to the Biosphere itself. Due to this, the ecological balance also gets disturbed resulting in famine, floods, cyclones, and other related issues.

Anthropogenic acts for over thousands of years have not only affected biodiversity but has also left hectares of barren land unused. An appalling rise in human population has a direct correlation with climate change. According to the IPCC Working Group I report, Climate Change (2021): The Physical Science Basis, scientists have come across climate change observations in every region across the whole climate system of the Earth. Many of these changes as noted by IPCC are unprecedented in thousands and even hundreds of thousands of years in the Earth's history (IPCC, 2021).



Figure 1: Sustainable Urban housing

Earth's resources are finite, but the population growth is infinite and therefore even though resources may be developed for human usage that is in arithmetic ratio, the rise in population is always in geometric ratio. As a result, the availability of resources is never commensurate with the population explosion that the Earth is experiencing at present. Thus, this ever-growing population puts undue pressure to exploit Earth's resources that produces externalities like greenhouse effect and pollution and ultimately climate change and unsustainability (Bigio, 2001). Therefore, any efforts to tackle climate change must include policy initiatives aimed at reduction of population gradually in the long run. Along with this, there is also a serious requirement to cut down use of non-renewable resources that is not only depleting the earth's resource base but is also causing environmental degradation. The deep ecology serves as a guiding tool for the actions of humans. Even though the world is going towards materialism, but if it causes degradation of the environment, then it should be stalled. The views and the mindsets of the society must change in a way that they start adopting a Nature-centric viewpoint in order to preserve the disturbed equilibrium. One such policy is to improve resource productivity that can aid in ensuring sustainable resources and material management building on the principles of 3Rs (reduce, reuse and recycle) that can be a central element of Green Growth Policies. According to an OECD report (2015), this will not only help in improving the environment but can also help in sustaining

economic growth by securing adequate supplies of materials and improving competitiveness (OECD, 2015).

This present research paper apart from discussing the issues intricately linked to climate change prescribes a 'prognostic approach' to deal with the problem. In simple words, prognosis means treatment and therefore a prognostic approach involves prescribing smart and innovative solutions that would be inherently sustainable and capable in addressing the problem of climate change and would be beneficial to all stakeholders in the long run.

The Problem of Climate Change – A DPSIR Analysis

A Driver-Pressure-State-Impact-Response Framework is a tool to analyse the causal relationship between the society and environment. It essentially provides a structure where indicators that represent the problem as well as the needed enabling feedback to policy makers on environmental quality and the resulting impact of the political choices made, or to be made in the future can be represented in a systematic way.

In the present research work, once it has been discussed that what are the issues involved in Climate Change at a mega scale, the application of the DPSIR model provides an in-depth understanding of the problem of climate change at meso & micro levels. These are the two levels where one finds interplay of both societal and environmental factors at spatial levels that play their individual roles in the causation as well as aggravation of the problem of climate change.

If this Model is interpreted analytically, it may be seen that forces resulting in climate change such as use of fossil fuels resulting in accentuated CO₂ concentration and enhanced greenhouse effect, environmental degrading agriculture such as slash and burn agriculture, soil, water and air pollution etc. represent the ***Driving Forces-Pressure-State*** indicators of the model.

The impact is represented by depletion of earth's natural resource base as well as the deterioration of the quality of air and water. Restriction and regulations, promotion of people's awareness on the issues involved and implementation of Sustainable Resilient Solutions or strategies to tackle the problem defines the ***Response*** part of the model. These sustainable solutions have been discussed in the next section.

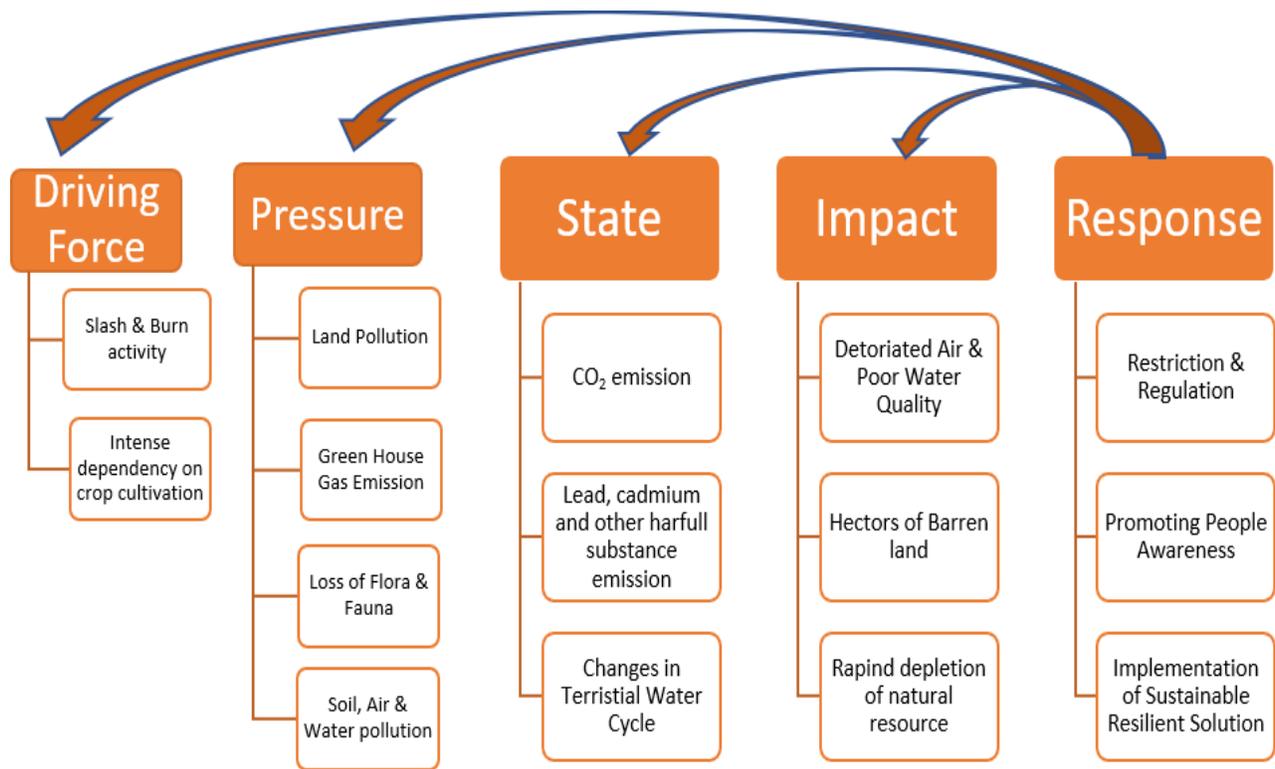


Figure 2: Illustrated DPSIR Model

STUDY AREA: This is a comprehensive research analysis or a commentary that adopts a solution-oriented approach to the problem of climate change. It is therefore not restricted to any study area.

MATERIALS & METHODS: The research work in this paper is original and the solutions put forth are self-prescribed. However, for explanation of concepts and examples cited, secondary sources have been used. For this purpose, books, journal articles, internet sources, newspapers, etc. have been use.

RESULTS:

Sustainable Innovative Solutions to Tackle Climate Change: Substantial literature exists on the theory of what is climate change and global warming, however the situation is such that there is an emergent need to focus upon the solution side that are sustainable and innovative and will be smart enough to either restrict or stall the damage arising out of climate change at the earliest. It is thus the following sections discuss such sustainable innovative solutions that can be adopted as a prognostic approach to prevent the harmful impacts emanating from climate change including the advantages and disadvantages of those strategies:

1. Use of Renewable Energy Sources

The first way to prevent climate change is to move away from fossil fuel usage. The alternative fuels that can replace coal and petroleum could be renewable energies like solar energy, wind energy, hydroelectricity, biomass and geothermal energy.

Benefits of renewable energies are that it doesn't produce any greenhouse gas emissions as is produced by fossil fuels and will thus be a boon in tackling the air pollution scenario as well. It also reduces the dependence on the imported fuels. The renewable fuel supply will have a continuous supply and never run out and it's a

cheaper form of electricity unlike fossil fuels. But the disadvantage is that renewable energy has high upfront costs. It has limited storage capabilities i.e., the electricity generated is not large enough. It needs a lot of space to install and has very expensive storage costs. The above diagram is a depiction of how natural equilibrium of an urban system has suffered a serious imbalance resulting in a tilt that has led to the weakening of the entire system. It is also seen that Sustainable Urban Planning shares a synergistic relationship with Technological Assessment & Government Regulation. In other words, in order to achieve sustainability in an urban scenario, there needs to be a fair collaboration between the above two aspects. The three main aspects that are integral to Sustainable Urban Planning are (1) Architecture and Sustainable Design (2) Urban Air & Water Quality Regulation and Management and (3) Green Infrastructure Design with Availability of Open Space. All these three would ensure not only an environment friendly planning but would also guarantee a resilient and disaster free urban space that would naturally have a positive ring on the climate change scenario.

The other side is represented by Technological Assessment & Government Regulation that includes factors such as Energy Use Practice, Strategic Urban Governance, Urban Waste Management and Promotion of Biodiversity in the city. Each of these aspects have a direct correlative role in diminishing the impacts created by climate change and environmental degradation. It is presumed that once more weightage or importance is assigned to these four aspects, the tilt can be taken care of and the natural balance can be restored once again. However, it is believed that out of these, Energy usage practice holds the key to the achievement of the restorative balance. For this, switching to renewable sources of energy can prove to be a game-changer as this would not only lead to a diminishing greenhouse effect but would also save the earth from resource depletion as is the case with fossil fuel usage.

Energy and Water Efficiency

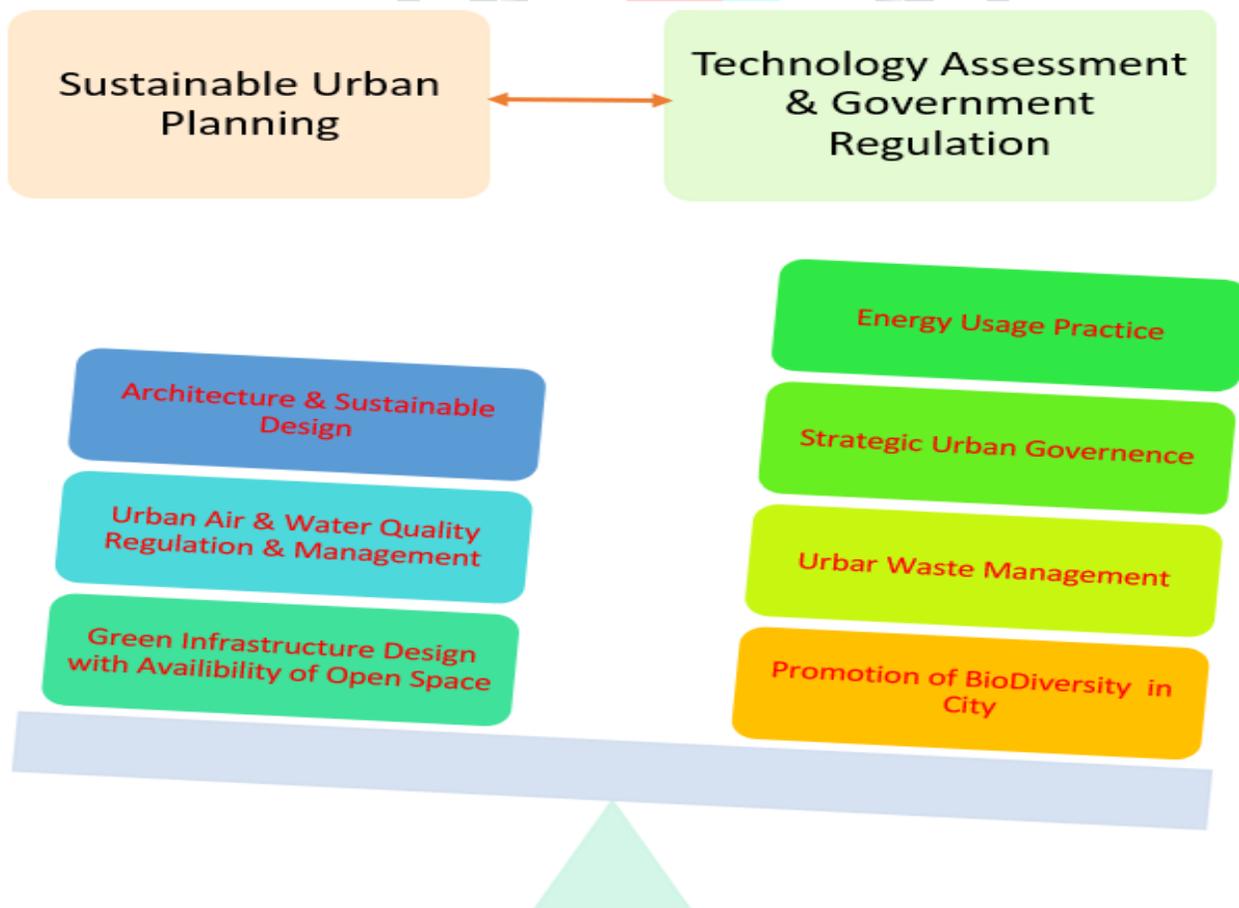


Figure 3: Balancing Act in Sustainable Urban Development

Producing clean energy is essential but reducing our consumption of energy and water by using more efficient devices (e.g., LED light bulbs, innovative shower systems) is less costly and equally important. It also helps conserve and protect the environment. Furthermore, with the growing average of households that produce air pollution and other harmful chemicals, the use of energy efficient appliances is indeed one of the best ways to help fight the climate change (IHDP, 2002). It can be a simple way to save Mother Earth for the next generations to come.

3. Sustainable Transportation

Promoting public transportation, carpooling, and focusing upon electric and hydrogen mobility will lead to fewer cars on roads. This will help reduce CO₂ emissions and thus fight global warming. There will be less pollute on and clearer skies. As there will be lesser concentration of harmful chemicals, there will be healthier communities. But the major drawback of this strategy would be the high cost attached to it. Electric vehicles include high prices, charging infrastructure, limited range will only be covered and there are only limited available options.

4. Sustainable Agriculture and Forest Management

Encouraging better use of natural resources, stopping massive deforestation as well as making agriculture greener and more efficient should also be a priority. The benefits are cost reduction, promotion of biodiversity, social equality, control of air pollution, and soil erosion and it advocates better treatment of animals as well. There are also some disadvantages such as limited use of land, lowered income, bigger consumption of time and effort and shorter shelf life of products.

5. Responsible Consumption Pattern and Recycling

Adopting responsible consumption habits is crucial, be it regarding food (particularly meat), clothing, cosmetics or cleaning products. Last but not least, recycling is an absolute necessity for dealing with waste. Recycling is converting waste product into reusable material. They are useful as it leads to reduced energy consumption, decreased pollution, etc. Recycling is considered as very environment friendly, slows the rate of resource depletion, decreases landfill waste and lastly fights global warming. But recycling is not always cost effective and has high upfront costs, and they are often of lesser quality. The recycling sites are commonly unsafe.

To *sum up* the above discussion on sustainable solutions, it may be seen that among the solutions, renewable energy would be the best one. With renewable energy and appropriate infrastructure, the world can have a better and sustainable future. Further, every other strategy would fall into its place with the adoption of renewable alternatives. Different kinds of Voluntary Environmental programmes include public voluntary schemes, negotiated agreements, unilateral commitments and private agreements could be implemented to bring about a change in the energy regime.

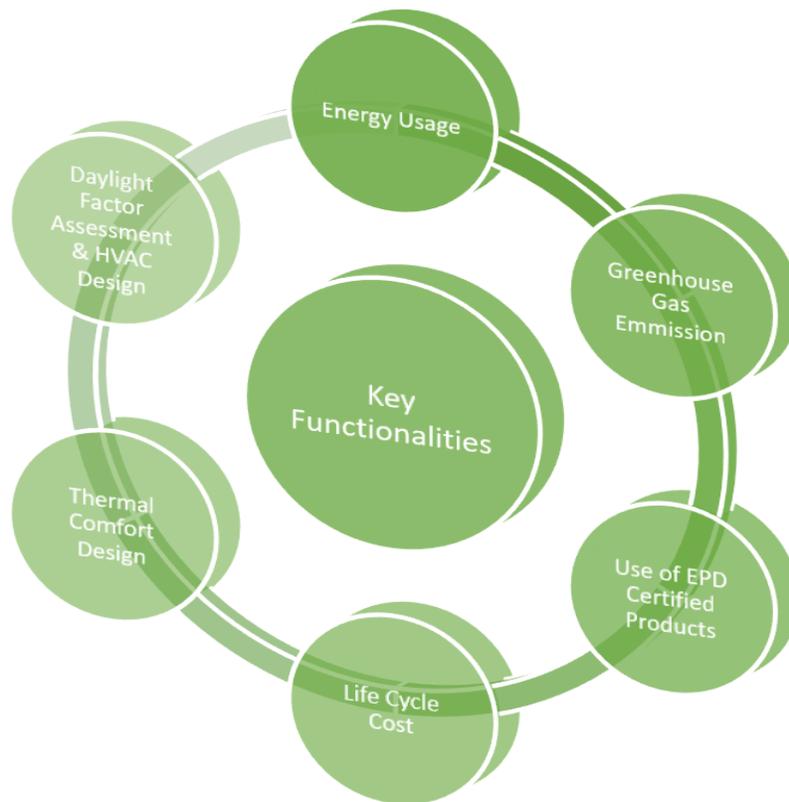


Figure 4: Key Functionality in Sustainable Urban Planning

DISCUSSIONS

Assessment and Analysis of Other Issues: Any sustainably innovative solution to be adopted to tackle this problem of climate change needs to consider a wide array of issues involved. To discuss a few, every strategy includes a cost benefit analysis as it involves huge monetary inputs in addition to physical ones. Similarly, in present times, most schemes and solutions are technologically driven and therefore must consider a technological assessment as well. Any prognostic approach thus requires a large scale investment of huge extension effort from policymaker and funds. Thus, careful consideration of all issues involved can however, create sustainable environmental, social, and economic returns in the long run.

The circular diagram is a representation of key functionalities which when adhered to or violated, whichever the case may be result in betterment/impingement over the environment including climate change. The major functionalities are as under:

Energy usage – Excessive usage of fossil fuels has led to the worsening global warming. Thus, there is an emergent need to switch over to cleaner fuels, that are renewable in nature such as solar power, wind energy hydroelectricity

Greenhouse gas emissions – Climate change is primarily caused by increase Radiative forcings leading accentuated greenhouse emission rate that has caused this alarming climate change scenario. Thus, we must all aim towards reduction of greenhouse gases in the atmosphere.

Use of EPD Certified Products - An Environmental Product Declaration (EPD) is a transparent, objective report that communicates what a product is made of and how it impacts the environment across its entire life cycle. Therefore, such certification would not only act as a deterrent in the climate worsening products but would also help in Environmental Impact Assessment (EIA).

Life Cycle Cost – This involves exact estimation of life cycle of an asset. This would help in cost benefit analysis viz-a-viz infrastructure development.

Thermal comfort design – This design guarantees a person satisfaction regarding the thermal environment. In other words, a person enjoys an optimum thermal environment that is neither too hot nor too cold. This concept can be directly linked to the green urban design that is ecofriendly and reduces global warming.

Daylight Factor Assessment and HVAC Design – Daylight Factor Assessment is now integral to any climate modeling and is a challenge for architects and urban planners. Heating, Ventilation and Air Conditioning (HVAC) is also a key element of environmentally controlled urban designing that has a direct bearing on the climate of an area by reducing emission rates of greenhouse gases.

Internal Insulation through Polyurethane fiber filaments as an insulating material

One of the major game changers in the power industry viz-a-viz HVAC component can be the intelligent use of polyurethane fiber filaments as an insulating material with thermal conductivity factor of $0.03 \text{ W}\cdot\text{m}^{-1}\cdot\text{k}^{-1}$ in the brick walls so as to prevent greater absorption of both heat and cold from the outside environment that will naturally diminish the energy usage of the heating and cooling equipment's in the buildings.

For any brick wall, internal wall cement plaster is generally used with 13 mm thickness and sometimes it can be of 19 mm thickness also. 19 mm plaster is done in two parts. First layer is of 13 mm and 2nd is of 6 mm thickness.

In this study we propose an innovative affordable solution which will lead to generation of carbon offset and gaining of carbon credit. Here we propose an innovative affordable technique of thermal insulation for internal wall for better air-conditioning and energy saving. For any brick wall, internal wall cement plaster is generally used with 13 mm thickness and sometimes it can be of 19 mm thickness also. 19 mm plaster is done in two parts. First layer is of 13 mm and 2nd is of 6 mm thickness.

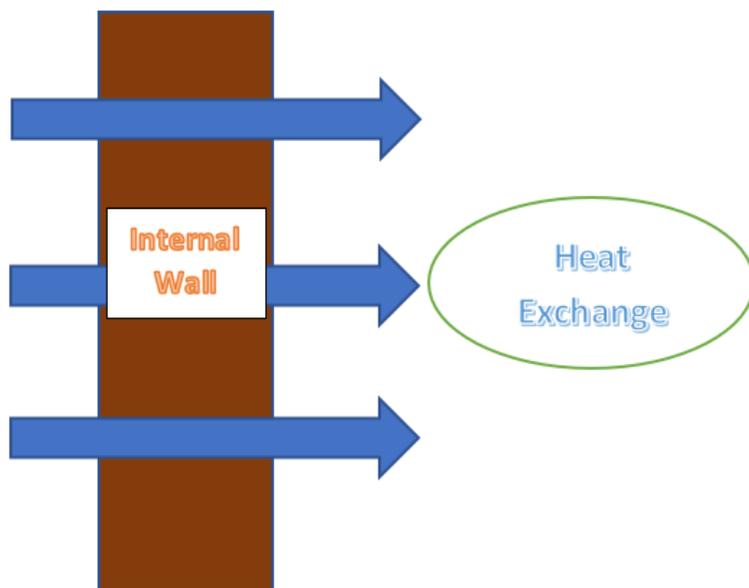


Figure 5: Illustrating heat transfer through the wall

Figure shows normal condition of heat transfer and resulting in continuous air conditioning.

In our approach, we lay a layer of mix comprising of coconut fiber, fly ash as binding agent, micro silica gel to provide better viscosity, along with mix of polyurethane and styrene. This composite is layed in layers. First layer is being a mulch mix of coconut fiber, fly ash and micro silica, once it is hardened, a second layer of polyurethane spray for final finish.

This combination provides, better heat insulation for internal room Air conditioning. In this approach, we retain the room temperature as desired for longer duration as the thermal conductivity of this layer ranges between 0.03 to $0.04 \text{ W}/\text{m}\cdot\text{K}$ (watt per meter kelvin) with a very

low diffusivity of 0.003×10^{-6} . This composite layer improves performance and durability of the wall forming an airtight seal to prevent thermodynamic transfusions, thus lesser energy is required for air conditioning.

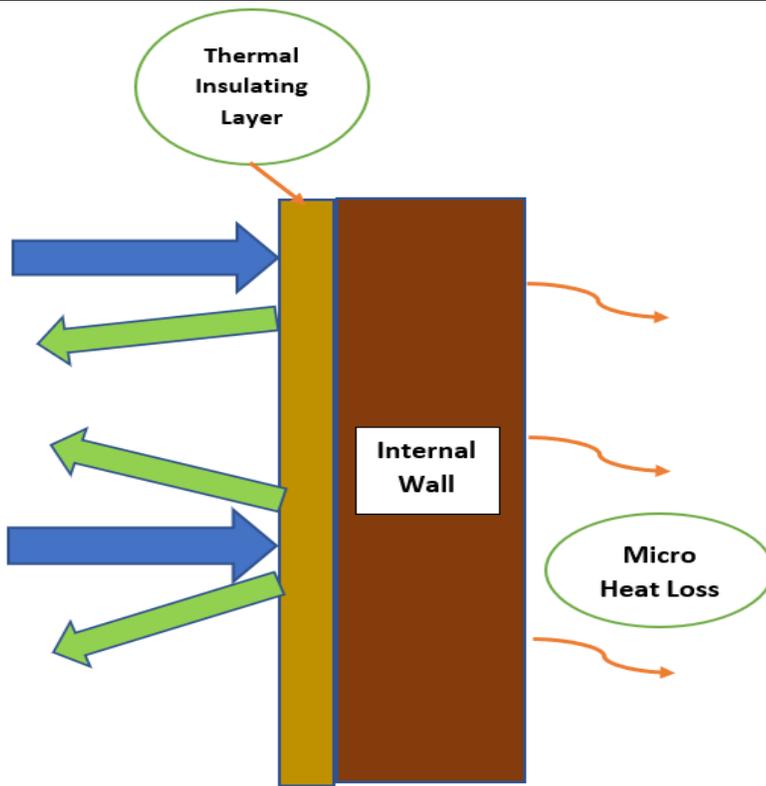
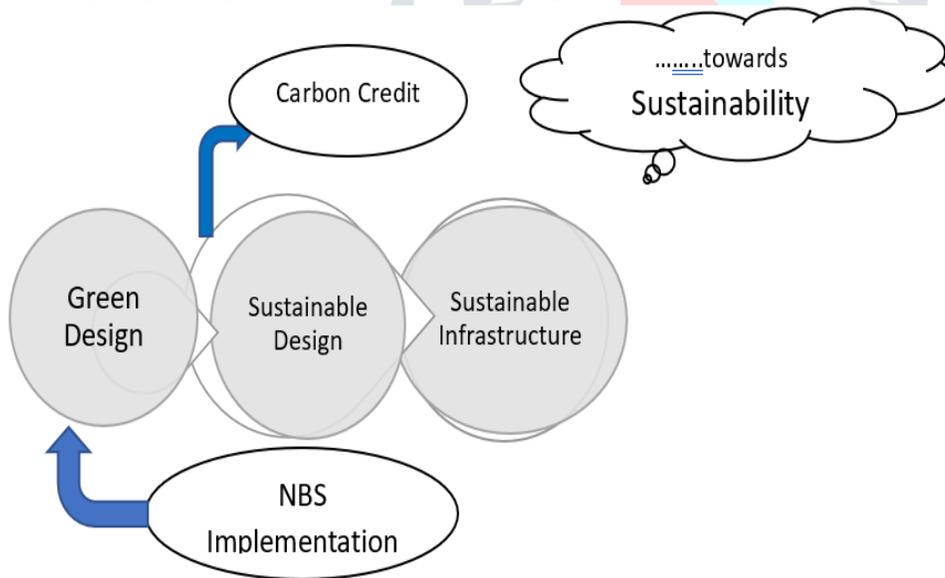


Figure 6: Heat insulation through wall post treatment

The figure shows the mechanism of temperature trapping by the sustainable layer by creating the wall thermodynamic transmission proof leading to lesser energy requirement for airconditioning.

As from the graph of balancing act of Sustainable urban planning it can be concluded that, Energy usage practice plays a great role in defining urban sustainability. So, with this innovative approach using natural fiber and fly ash which is an industrial waste, we are creating carbon offset and when we replace cement plastering activity we are saving roughly 1:4 to 1:6 volume of cement used for construction work, so during course of construction work we are gaining carbon credit as lesser quantity cement consumed results into lesser responsible emission of greenhouse gas. Again, during operation of a building as a part LCA of sustainable construction we propose for lesser energy consumption in air-conditioning,

resulting in gaining carbon credit and leading towards better sustainability.



Thus, with this innovative design which is can be termed as green design for urban development, which with implementation of sustainable development goals in the design aspect and its subsequent implementation resulting into a green construction and ultimately to a sustainable LCA is depicted in the figure above.

Figure 7:Sustainable Infrastructure Model

Cost-Benefit Analysis (CBA)

A cost benefit analysis (CBA) of any scheme or solution typically involves the following:

- A. This involves Identification of all benefits
- B. This refers Definitive with quick realization, futuristic realization, sustainable benefits and cost
- C.This is the expenses for new strategy formulation and implementation. Now post comparison of all benefits in terms of monetary value with respect to cost, if $\{B-C\} > 0$, it is viable

Stakeholders Analysis: Here the Stakeholders are Government, policy makers, with their prime interest is to ensure vote bank entertaining policy and keeping the major followers happy. In a country like India, politicians have millions of blind followers, and they play a very important role as an influencer being stakeholders. Any strategic plan or long-term policy these stakeholders undertakes aims mainly at short term policies and virtual long-term strategy, but with increased awareness drive across the world dealing with environmental ethical dilemmas with sustainable solution, stakeholders portraying liberal approach towards drafting new strategic plans for future resilience

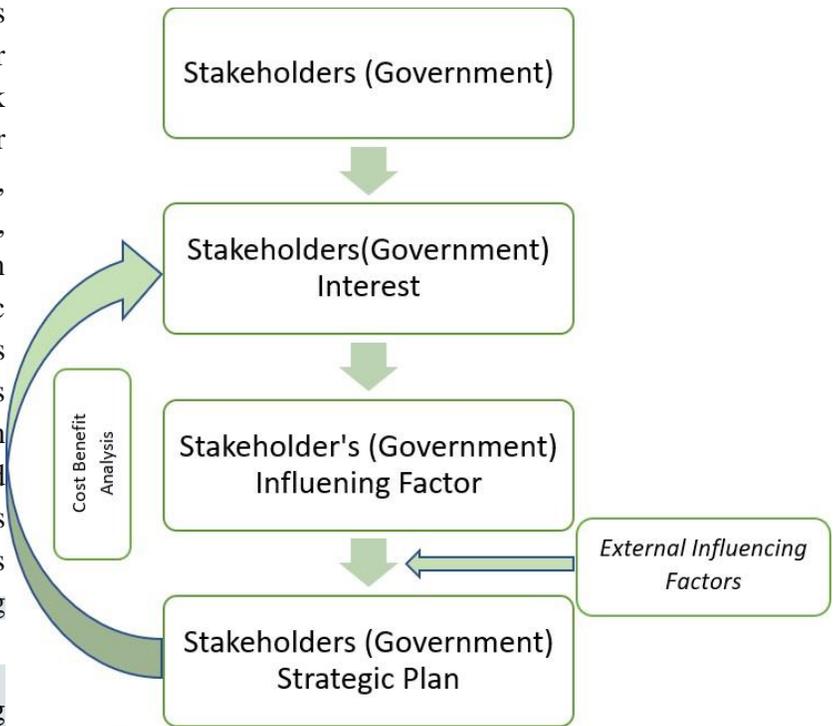


Figure 8: Stakeholders Role in Sustainable Development

Technology Assessment (TA): Post designing of plan, new technology assessment, evaluation of new

technology in terms of socio-economic factor with political influence is called technology assessment. Now the steps of this Technology Assessment could be as under:

Step 1 Identification of nature of new technology, location of implementation of new technology, identification of major goals, which will be achieved post implementation of new technology.

Step 2 This involves listing of inventories, associated supportive technologies, involvement of human resource, identification of any other environmental aspects associated with the new technology intervention.

Step 3 This involves assessment of the impact on Human health, wealth, local natural environment, global environmental impact, sustainability of resource usage etc.

Step 4 This involves comparative assessment of existing practice and alternative proposed technology.

Step 5 This involves decision making phase wherein consensus decision can be made analyzing all the factors influencing the TA, gaps, and uncertainty assessment and the resultant benefits suppressing the cost involved and long-term sustainability.

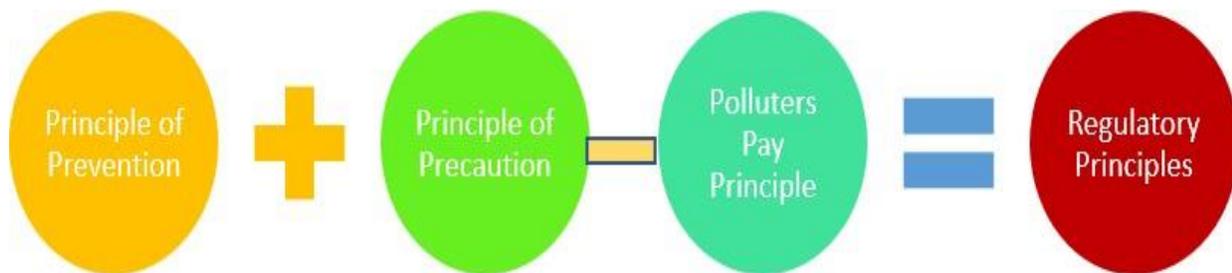


Figure 9: Innovative Regulatory Principle for Sustainable Development

Principle of Prevention / Precaution: The issue with slash & burning, its probabilistic impact, result and consequences are definitive. Also, there are Undefined futuristic consequences, unknown probability impact factor and undefined effects are likely to occurring in near future owing to this practice in Himalayan region.

In this region, Polluters pay principle cannot be implemented as majority of the population is involved in this process and imposition of any such regulation will bring into huge socio-demographic resistance. Instead of polluters pay principle, in Indian context several beneficiary schemes can be promoted along with generating awareness among the people living there towards the benefit of adaptation of new technology and future sustainability.

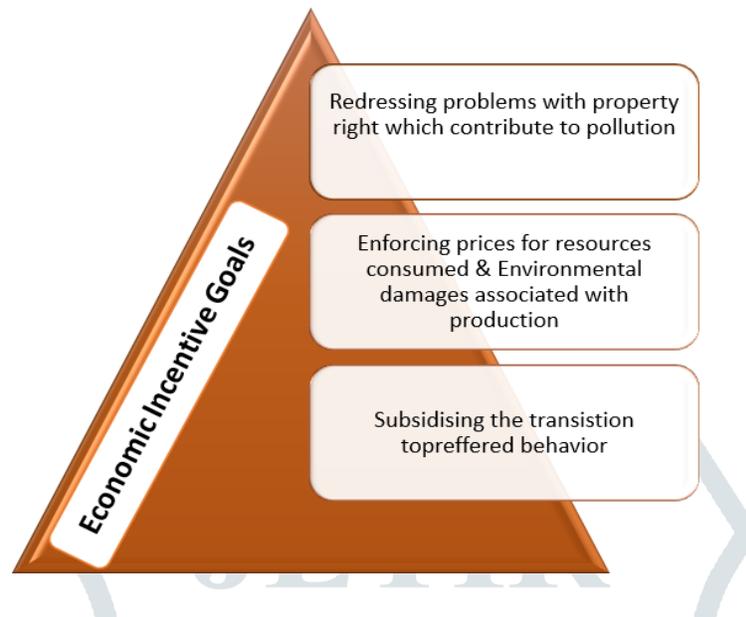


Figure 10:Graph Showing Economic Incentives and Sustainability

Now in terms of implementation of these regulatory principles, stakeholders, policymakers, or government can't enforce strict command and control regulation, but it can be rather implemented effectively with adapting benefit strategies through Economic Incentives as implementation and enforcement of legislation many a time seems to be incapable of achieving an acceptable degree of compliance. For instance, a Public Private Partnership (PPP) Model is an important illustration of such implementation, where the villagers as well the local administration has equal rights over the village common land usually referred to as the *gauchar*. This not only ensures equal rights but also guarantees conservation of the land in use. Climate change is such an issue that must involve local people as environment in most cases is better understood and managed by native people who have a better understanding of local issues (Aggarwal, 2003).

CONCLUSION: To *conclude*, it would be pertinent to say that a step in the right direction has been initiated as after years of hard negotiations and efforts of all countries, the world has reached a common understanding with respect to global environmental protection that social progress and economic development must be in coordination with environmental protection and ecological equilibrium. The *Rio Summit*, *Kyoto Protocol*, etc. are all forging international cooperation to achieve the same. In order to improve the standard and quality of living of human societies and to promote their prosperity and better thriving of the entire human society, accomplishment of global sustainable development is most imperative (Asian Development Bank, 2004).

To tide over this burgeoning issue of climate change, collective international effort is thus the need of the hour. Therefore, to solve issues like global ecological environment destruction and climate warming up, governments must show wisdom and sensibility to shatter the narrow concept of bondage plagued by national interests and work towards international cooperation, collective security, common benefit and rational negotiation. Only through such mutual efforts of the international community, sustainable development objectives can be realized with harmony between economic development on one side and population, resource and environment on the other. Global climate change, perhaps, will provide great prospect for strengthened cooperation and mutual benefits for the entire international community. At the same time, it is also noteworthy

that this problem is also region-specific owing to geographical, social and economic anomalies. Thus, apart from international efforts, countries need to devise sustainable innovative solutions at grass-root levels to achieve a local level prognosis of the issues involved as has been discussed in this paper. Some **specific recommendations to policy makers are as follows:**

1. Educate and generate awareness among people that needs to be region as well as strategy specific
2. Economical beneficiary schemes need better advocacy for usage of new technology.
3. Provision of subsidized allocation of land and materials that are environmentally sustainable and non-polluting such as rock phosphate to those whoever practices new technology to save the environment
4. Shifting the pollution act responsibility on to the polluter if the new technology is not implemented.

ACKNOWLEDGEMENT

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