Buildings against sustainability (in tropical climates)

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We need buildings to lead our lives – houses to live in, offices and factories to work in, schools and universities for education, hospitals for medical treatment, cinemas and theatres for relaxation, warehouses for storage…. Buildings protect us from adverse natural elements (e.g., intense sunlight, driving rain, strong winds) as well as "man-made" ones (e.g., break-ins) and provide us with comfort and privacy.

However, a building – more precisely, a built environment – is a threat to the environment (i.e., the natural environment) and to sustainability, especially if not properly planned, designed, constructed and used. A building consumes natural resources and energy, alters drainage paths and hydrological characteristics and adversely affects biodiversity in the area, contributes to air and water pollution, generates waste and promotes global warming.

Based on a discussion with Professor Thishan Jayasinghe (Professor of Civil Engineering, University of Moratuwa, Sri Lanka, www.mrt.ac.lk), this article looks into how buildings can adversely affect sustainability.

Buildings resist sustainability in three stages

Whether it is single-storey or multi-storey, big or small, a building can adversely affect sustainability in three stages:

- Construction
- Presence and use
- Changes, repairs and maintenance

Let's consider how each stage plays it anti-sustainability role.

Firstly, construction of a building and its access roads requires land clearing and leveling. Such actions will remove vegetation, alter drainage paths and hydrological characteristics in the area, and affect biodiversity.

Building construction consumes natural resources as building materials and energy. Emissions from plant, equipment and vehicles used during construction contribute to air pollution. Moreover, construction activities generate waste, which, if mismanaged, will cause environmental pollution. All these factors, together with adverse effects resulting from mining and quarrying of raw materials and production of building materials, contribute to environmental degradation.

A building's resistance to sustainability does not end with the completion of its construction. Its presence and how it is used can adversely affect sustainability. A building planned and designed with little or no regard to environmental friendliness and energy efficiency will require artificial means for creating a desirable indoor environment with acceptable thermal and visual comfort levels. Such a building will consume energy for this purpose in addition to other activities such as cooking.

Replacing vegetation (i.e., Nature's air conditioners) with a building raises the outdoor temperature in the neighborhood and contributes, to a certain extent, to the warming of local environment. The presence of a built environment instead of the original natural environment also interferes with groundwater recharge, disrupts the water cycle and increases the likelihood of flashfloods following heavy continuous rain.

The finishes of building elements such as walls and the coatings of certain equipment inside buildings can release toxic contaminants into air, causing air pollution – especially indoors. Another problem of building use is the generation of solid waste and wastewater.

Finally, changes to a building and its repairs and maintenance contribute to its "resistance to sustainability", in a similar fashion during construction but to a lesser degree.

Building construction against sustainability

Now let's consider in more detail how building construction can adversely affect sustainability, beginning with land clearing and levelling.

Suppose virgin land with rich soil is cleared and leveled for construction of a building and its access roads. Such clearing removes vegetation and topsoil, and alters natural drainage paths in the area.

Removal of vegetation causes significant adverse effects on the environment, both locally and, to a lesser degree, globally. Through a process termed photosynthesis, cells containing chlorophyll in green vegetation "produce food" (i.e., carbohydrates), consuming carbon dioxide in air, the energy in sunlight and water while releasing oxygen. By removing green vegetation, we eliminate a consumer of carbon dioxide, a major greenhouse gas, contributing to greenhouse effect and thereby promoting global warming, which is briefly described below.

The greenhouse effect is a natural phenomenon that is essential for the sustenance of life on the planet earth. The greenhouse gas layer in the atmosphere allows solar radiation to pass through because it is short wave. The solar radiation reaching the earth's surface heats up the earth as well as objects on it, including buildings. The heated earth's surface and the objects emit in turn thermal radiation (infrared radiation) to the surrounding bodies and to space. However, the greenhouse gas layer does not grant full access across it to this space-bound thermal radiation because it is long wave. Part of this radiation, therefore, returns to the earth's surface, trapping part of the heat received from the sun. The modern lifestyle of the humankind significantly releases greenhouse gasses, such as carbon dioxide, strengthening the greenhouse gas layer. The resulting increase in the layer's resistance to the space-bound thermal radiation contributes to warming of the earth's atmosphere. This phenomenon is known as Global Warming.

Land clearing and leveling removes topsoil, causes soil erosion and changes hydrological characteristics in the area. Soil erosion in turn causes infertile land and the eroded soil will block roadside drainage lines, lowering their capacity and thereby leading to flashfloods.

Removal of trees, plants and the undergrowth will eliminate the dwelling places of small species and their food sources, adversely affecting the prevailing food chains in the area. The consequent threats to biodiversity will not be limited to the building site and will invade nearby virgin land. Besides, by clearing virgin land for building construction, we restrict the terrain available for biodiversity.

Under building construction, a major contribution against sustainability comes from the consumption of natural resources as building materials. A typical building comprises a foundation, walls and columns, floor and slabs, roof and ceiling. For construction and fixing of these elements, we use a variety of materials such as concrete, bricks, lime, timber, steel, floor and a variety of tiles (wall, floor and roof). A major building material used up in buildings – especially in big or multistory buildings – is reinforced concrete, which is a combination of concrete and steel. Concrete making in turn uses up several building materials, namely, cement, crushed stone and sand. The last two are natural materials while cement consumes two natural materials as its primary raw materials, namely limestone and clay. Building construction therefore consumes a large amount of natural resources as building materials, significantly contributing to the world's natural resources depletion.

Building construction consumes energy in several ways. All building materials are either quarried or manufactured. For manufacturing building materials, raw materials are quarried. Energy is required for quarrying and manufacturing. In brick-making, for example, clay is mined and the clay units prepared are baked in kilns. Energy is also consumed in transporting building materials and construction equipment from the source to the construction site and within the site. Most construction activities themselves, such as concrete vibration, consume energy.

Building construction contributes to air pollution, directly and indirectly. Firstly, manufacturing of building materials releases emissions. Although these are usually controlled in major industries, primitive industries like brick-making burns clay in open air, releasing carbon dioxide freely. Emissions are also released by vehicles transporting building materials and a variety of construction equipment.

Construction activities generate waste, such as waste timber, leftover concrete and off-cut steel. If mismanaged, these wastes will lead to environmental pollution, in turn affecting human health in the long run.

Finally, building construction contributes to environmental degradation in several ways. Excessive mining for raw materials for

commonly used building materials has paved the way for adverse environmental effects. River sand mining, for example, is responsible for widespread riverbank collapses, flooding and saltwater intrusion into rivers while clay mining for brick making has led to infertile paddy land and mosquito breeding pits. Moreover, the contribution of building construction to the depletion of natural resources and non-renewable energy sources paves the way for long-term environmental degradation while greenhouse gas emissions during building materials manufacturing and construction promote global warming.

Building presence and use against sustainability

Suppose the construction of a building is over. However, its resistance to sustainability doesn't end there. Its use and even its mere presence can resist sustainability. Building presence and inappropriate use consumes energy, raises outdoor temperature, causes air pollution, generates waste and contributes to environmental degradation.

A major component of energy use in buildings in the form of electricity is for the creation of an indoor environment with desirable thermal and visual comfort levels. During building planning and design stage, widespread disregard of environment-friendly, passive concepts for achieving acceptable indoor thermal and visual comfort levels has forced occupants to seek energy intensive artificial means such as air conditioners and fans for thermal comfort and artificial lighting for visual comfort during daytime. Energy is also used by various energy-consuming activities in buildings (e.g., cooking and ironing clothes in houses and running machines in factories).

Mere presence of a building contributes to "local warming". Vegetation can be considered as natural air conditioners cooling the outdoor environment because of the phenomenon called transpiration. Transpiration is the process from which a plant growing on soil loses water, mainly from the leaves, to the air. Evaporation of such water uses the energy from sun's radiation, partly preventing the heating of some other surface. Replacing natural air conditioners (i.e., vegetation) with buildings contributes to "local" warming (i.e., rise of the air temperature in the neighborhood). The building surfaces absorb the solar energy and heat themselves up before radiating long wave thermal radiation to the exposed surfaces around it. These surfaces, too, heat themselves up, and radiate to more surfaces around them. The air in contact with these warm surfaces will also become warmer, resulting in a higher outdoor temperature in the neighborhood. In scientific terms, this local warming is called the "heat island effect", where the outdoor temperature of the built up areas can be higher than that of neighbourhoods with plenty of trees representing the natural environment.

Moreover, many finishing materials, such as paints on walls and coatings of furniture, emit various contaminants (e.g., Volatile Organic Compounds, or VOCs), adversely affecting the air quality – especially indoors. Exposure to these contaminants for prolonged periods can cause serious illnesses, sometimes fatal, such as cancer.

Building use generates solid waste and wastewater. Solid waste from buildings is either dumped in open dumpsites or burnt in uncontrolled manner, usually in open air, causing air, water and ground pollution. Such mere disposal of solid waste without recycling or recovery of minerals and embedded energy significantly promotes natural resources depletion.

Wastewater is of two types: black water and grey water. Grey water emerges from sinks, bath, laundry and kitchen while black water comes from toilets. Anaerobic digestion of black water in septic tanks releases methane, which is a greenhouse gas contributing to global warming.

The presence and use of a building contribute to environmental degradation. Buildings contribute to air pollution and raised outdoor temperatures, disrupt water cycle and cause flashfloods, and speed up natural resources depletion and global warming.

Contaminants emitted from the surfaces of building elements, furniture and equipment contribute to air pollution while waste heat dumped by air conditioners contributes to raise outdoor temperature.

Presence of a building robs rainwater of ground area for groundwater recharge, which is very important for effective functioning of the water cycle. This situation worsens if an impermeable pavement is around the building (e.g., tiles, paved area). Instead of contributing to groundwater recharge, rainwater collected on roof directly finds its way into roadside drains. Following heavy continuous rain, this

situation creates flashfloods because the drains network usually blocked due to eroded soil or waste is unable to cope with the resulting massive volume of storm water.

Consumption of electricity generated from fossil fuels contributes to the depletion of natural fossil fuel resources and using gas for cooking speeds up the exhaustion of natural gas resources.

Worse still is buildings' contribution to global warming. Commonly used equipments and day-to-day activities within buildings release greenhouse gases, which contribute to global warming. Among main culprits are carbon dioxide released from burning of waste in uncontrolled manner and methane given out from anaerobic digestion of black water in septic tanks.

Building changes, repair and maintenance against sustainability

After some time since construction – say after several years or several decades – the owner may decide to alter the building, usually an extension. Addition of a new room or changing cement rendered floor to a tiled one are examples. Or passage of time may require repairs to or maintenance of the building, such as replacing tiles of a leaking roof or repainting a wall. Another instance of requiring repair, or even reconstruction, is damage due to disasters – natural (e.g., cyclones, floods, earthquakes) or man-made (e.g., bomb blasts).

Like during construction, these activities will consume natural resources and energy, generate waste and contribute to environmental degradation, but to a lesser extent.

Buildings for sustainability

How buildings resist sustainability is now fairly clear. The next article will discuss how these problems can be mitigated and ways of making buildings to actively contribute towards sustainability. A variety of solutions will be discussed, including alternative building materials and passive concepts for planning and design of green buildings.

NOTE

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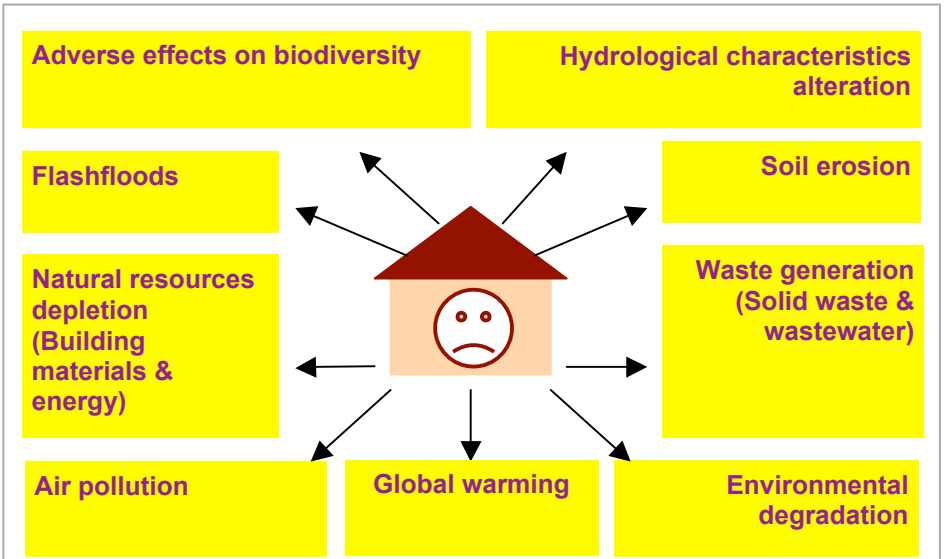

How buildings (in tropical climates) resist sustainability

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