

# **Eco-Urban Planning & Design for a futuristic vision of Shanghai**

*Sustainable strategies enable a much cleaner & efficient Neighbourhood*

Subhajit Das, Florinna Dutt,  
subhajit.design@gmail.com, scorpio.rina@gmail.com  
University of Pennsylvania

*Keywords: Sustainable Planning; Infrastructure Design; Bio-Responsive Built environment.*

## **Overview**

The research project delineates the present urban settings of Shanghai with respect to the major ecological factors. The paper investigates the problems related to changing environmental conditions in rapidly urbanizing Shanghai, and how these conditions might pose certain major problems in urban living conditions of the City. According to the United Nations (UN), between now and 2025, the world population will increase by 20 % to reach 8 billion inhabitants (6.5 today). 97 % of the growth will occur in the developing nations (of Asia and Africa). The cities in developing countries will account for 95 % of urban growth in the next twenty years and will shelter almost 4 billion inhabitants in 2025 (Baer 2009). With the increasing industrialization and prosperity of Asia, Shanghai will function as a major metropolitan and economic Capital, with rising energy demands. The issues that directly relates to the urban energy use would largely include transportation, building and housing, public health and safety and increasing living standards of people inhabiting. Thus, the research addresses these issues in brief and tries to substantiate the alternate technological innovations that would aim to provide a sustainable solution to the increasing urban sprawl of Shanghai. The proposal for urban design focuses on the factors that would fundamentally make use of urban wastes that would otherwise pollute the ecology in both micro and macro level. Consequently this new proposed development would intend to curtail the carbon footprint of the city and in turn reuses, reclaims and reduces existing resource consumption.

## **Introduction**

From late 1970 China has been undergoing a major economic reform, accompanied by rapid and extensive Urbanization. However Urbanization in China led to significant environmental and ecological problems esp. in mega cities such as Shanghai. The issues principally include increased air and water pollution, local climate alteration and major reduction in natural vegetation cover and production. The City has been experiencing huge urban sprawl, with 23million residents and 14.2 permanent million residents living in the urban area. Some of the major impact and ecological concern of Shanghai Due to the increased urban sprawl has been described as follows:

Urban Heat Island (UHI): The urban heat Island (characterized by increased temperature in urban area compared to surrounding suburban areas) has direct correlation with the population density. UHI results in the increasing demand for cooling leading to an increased demand for electricity and thus leads to amplified production Greenhouse gases such as carbon dioxide and other pollutants produced due to the usage of fossil fuels (Tan 2009). Analyzing the meteorological Data in Shanghai and its surrounding suburban area it has been found the difference in mean annual temperature (MAT) increased from 0.1° C in late 1970 to 0.7° C between (2000 -2004), with a growth rate of about 0.26 ° C in each decade (Zhao 2006).

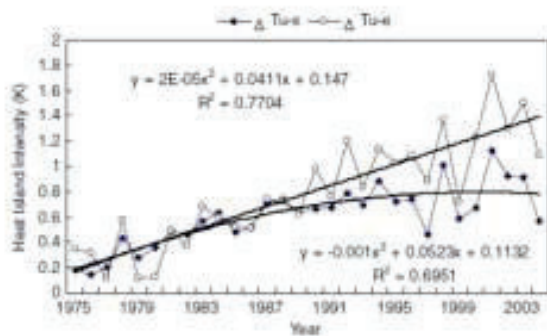


Figure 1 : The variation of urban heat island intensity [in terms of the difference of daily maximum temperature between the urban centre and suburban sites ( $\Delta Tu-s$ ), and that between urban and exurban ( $\Delta Tu-e$ ) sites] from 1975 to 2004

## Air and water Quality

Urbanization also can be associated as a heavy encumbrance on local air and water quality of Shanghai. Air quality monitoring data observed from various sources showed that concentration of Sulphur dioxide (SO<sub>2</sub>), Nitrogen Dioxide (NO<sub>2</sub>)/ Nitrous Oxide, Carbon Dioxide (CO<sub>2</sub>) and total suspended particles in air has subsequently increased since 1983 and varied considerably. The air pollutants highest in the central urban areas compared to the suburban areas. The sources of such pollution are urban transport, generation of electricity, heat from non-renewable energy sources (such as coal) and various industrial actions. In Shanghai, fuel structure is heavily dependent on coal. Water pollution pattern also show similar pattern with increasing severity in the central area though certain variation in pattern has been observed from 1990 to 2001, that shows that the water pollution concentration decreased in urban areas where as deteriorated in the suburban and rural areas due to transfer in the factories from the city to the suburban areas. (Zhao 2006)

Changes in Biodiversity: Shanghai is rich in biodiversity. However due to urban expansion and related human actions taken, there is considerable and continuous loss in the biodiversity. The number of native plant species had fallen rapidly. At the same time studies, reflect that the native crops were increasingly replaced by non- native species of greatly due to introduction of managed parks and green spaces in contrary to the natural

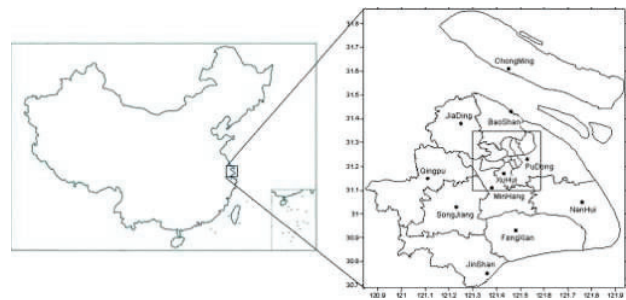


Figure 2 : Shanghai within China and the spatial distribution of 11 weather stations across the city.

vegetation and landform. “About 300 alien plant species have been planted in Shanghai from 1980 – 2005”. The Yanzhong Greenland consists of 26 native woody plants out of 142. (Zhao 2006)

The major environmental concern that are studied above and associated with increased urban sprawl in Shanghai could be an index to propose further ecological reform in urban design and policymaking. As stated by EeroPalaheimo “the first eco- city will not change the world, but it would provide a seed of change. This is why we need one eco-city radically different from the already existing ones. It would demonstrate that environmental problems could be solved with the help of modern technology”(Kinnunen 2008). The investigation of the paper would further lead us to the modern technological interventions that could possibly reduce the environmental impact of urban sprawl in Shanghai and it would further function as a design prototype and inspiration for further green design and sustainable development in the city.

## Site & Existing Conditions

The site selected for the model ecological development is located beside the Suzhou Creek, Shanghai. Suzhou Creek also known as Wusong River in China flows through the City Centre with a total stretch of 125 Km. The creek was functioning as the city’s trade route since 1930, and facilitated transportation of the goods. There were plenty of warehouses and factories located alongside the creek consequently polluting it with industrial wastes as well as domestic wastewater and most polluted river in Shanghai. Since 1998 with the launch of Suzhou Creek Rehabilitation Project, a 12 year redevelopment program to improve the water quality, flood mitigation, wastewater management and a drive for urban



*Figure 3 : Showing the existing urban neighbourhood of the selected site. The top panoramic view shows the interconnected bridge over the narrow river. The bottom panoramic view highlights the overall site density & skyline.*

revitalization along the river led to the Clean and revitalized Suzhou creek. The warehouses and factories are relocated. The factories and warehouses in the site are conserved following adaptive reuse strategies to develop as a Art centre as well as substantial mixed use development.

The specific location of the site selected is between the subway stop of Qufu Road and Tiantong Road, line 10 along the Suzhou creek. The site is at the both end of the river and spans 385 000 sq.m.in area (approx.). The design problem is visualized more as an urban Neighbourhood remodelling, which would impact Shanghai and act as a paradigm for eco-city due to the embedded green strategies employed and projected to be developed in future. The site taken is a conglomeration of 10-12 blocks of urban space in the Suzhou Creek belt. The Site currently is in development phase, and some mild demolition of small-scale buildings is going on, for large scale mixed use, residential projects.

In-depth survey of the site revealed the following urban micro and macro scale problems:

1. No organised green space or scattered incoherent landscaping, lacking continuity.
2. In efficient usage of water front, no planned urban space near the river.
3. Extremely close spacing of building blocks at low scale, thereby disabling possibility of adequate ventilation and delighting.
4. In organized block sizes which is inefficient to enable proper value to the properties.
5. Proper bus routes are missing. Small un-organized shuttle services available, but they are highly unorganized and create urban chaos.
6. Unorganized scattered retail units, which is uneconomical to generate enough revenue from the projects.

### **Green Strategy**

After Studying the Urban Scenario in Shanghai and the various ecological problems associated with its fast growth, the methods to deal with the issues of ecological stress were identified. The paper investigates the futuristic technology. The strategies chosen through the process of technology research would help battle the problem of exhausting abundant natural resource and emission of Greenhouse Gases. The industrialized world is constrained by interests that are short-sighted and rigidity of the existing infrastructure. The idea of an

# GREEN RE-construction

Sustainable Strategy Diagram

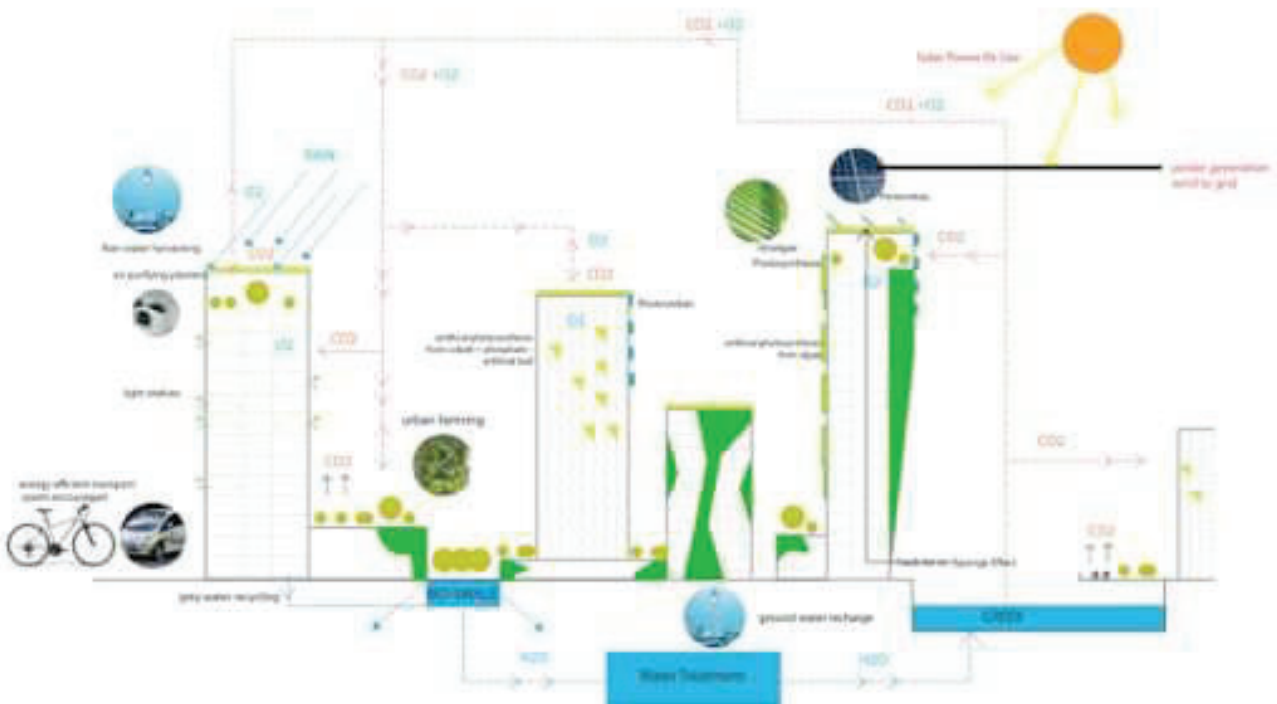


Figure 4 : Visual flow diagram showing the envisaged eco city model adapted for the neighbourhood, which successfully re channelizes, green patches & oxygen network in the environment. In the process it enables fast depletion of environmental carbon footprint of Shanghai.

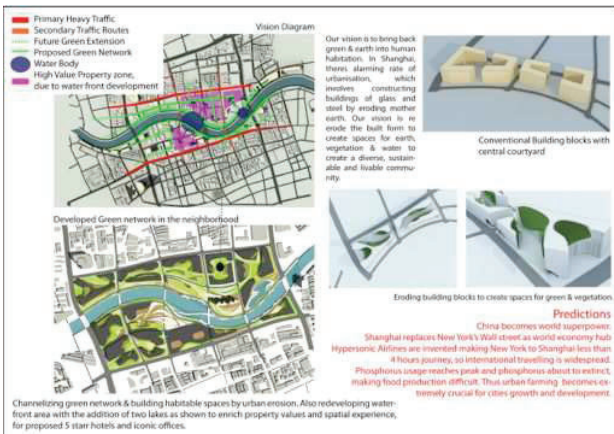


Figure 5 : It shows the transformation of current conditions to proposed visionary green networks. Showing the vision of the project, highlighting the key concept of urban erosion adapted in the neighbourhood.

Eco city prototype established shall not pollute the surroundings and minimize the use of non – renewable natural resources. The residents will be able to produce their own requirement of food and energy as well as a closed water circulation system with means water is supplied from neither outside the city or wastewater exported out. Since we cannot stop construction, as shelter is one of the primitive needs of humankind, and with the growing need of industrialization, we can always try to reduce or optimize it. More importantly, we can pledge to give back to the mother earth from whom we have always been taking resources to live, sustain and flourish. The idea expressed in this paper of a Green Conclave is to “Re- Erode” the built form created by Man and adds the mother earth back into the site in form of Water feature, Green vegetation and urban farming to maintain the indigenous qualities of landform that existed before extensive mega scale construction. Alongside the unique design initiative, the built form is also projected to be integrated with features that would help to utilize the wasted resources (like wastewater or greenhouse gas emitted)



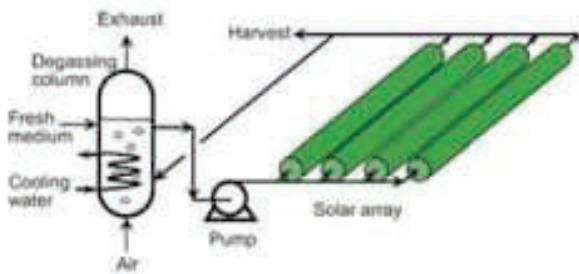


Figure 8 : Top left diagram explaining the tubular design of the algae photo-bio reactor. Top right image shows an exemplary algae photo-bio reactors used over the building facade

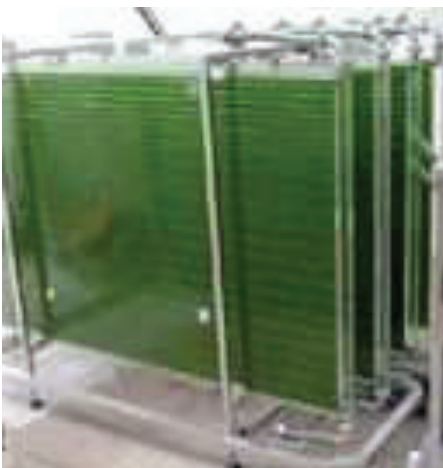


Figure 9 : Schematic image of flat panel algae photo bio reactors.

alternate source of energy. Artificial Photosynthesis is a way to mimic the photosynthesis of Plants in artificial environment. The energy derived from the process would be used to create fuel source such as hydrogen. It could use plain water and captured sunlight as its raw material. This technique of artificial photosynthesis could be used integrating it with the built environment. However, the Process could be a complicated one but with the advent of new innovations such as the “Artificial leaf”(Nocera April 4, 2012)by It is a cobalt- and phosphate-coated silicon device. These devices can be embedded in the façade or roof top to instantiate artificial photosynthesis successfully to produce Hydrogen as an alternative fuel source at substantially cost effective way.(Science Daily 2012)

## Algae as a source of Bio fuel production

Micro Algae are microscopic biological organisms grows in aquatic environments uses lights and Carbon Dioxide to create algal biomass that is rich in three main components , carbohydrates proteins and lipid oils. The natural oil made by micro-algae is in the form of tricylglycerol, which can be employed for the production of bio-diesel(Wen 2012). Some species of Algae are also capable of producing hydrogen gas under specialized condition. The biomass from algae can be burned to produce methane biogas useful for generating electricity. Micro – algae are strictly photosynthetic. They need light, carbon dioxide as its energy and carbon source respectively. They are also known as photoautotrophic capable of producing its own food from inorganic substances using light energy. The micro algae require light Carbon Dioxide, water and inorganic salts to grow. The temperature of the growing medium should be between 20°C

and 30°C . The growth medium shall contain inorganic elements such as nitrogen, phosphorus, iron and silicon (Grobelaar 2004). As such algae live in high concentration of Green House Gas such as carbon dioxide and Nitrogen dioxide abundant from car exhaust and industrial waste . Open Ponds or Enclosed Photo bioreactors are the two principal ways to grow algae, this system faces major disadvantage, which includes contamination of the produced biomass, productivity affected by the lighting conditions as optimal lighting requirement is difficult to maintain for an open pond. Enclosed Photo bioreactors could be Flat plate or tubular reactors (Norsker 2011). These systems are made of transparent materials generally placed outdoor for illumination by natural lights having large surface to volume ratio. The advantages of using enclosed Photo-bioreactors are manifold with reduced risk of contamination, greater productivity which can be higher ( 13times) than that obtained from open ponds. For the enclosed photo bio-reactor that yield can be close to 2- 3 grams /Lperday .(Dasgupta Nag 2010)

### **Urban Agriculture (UA)**

The widely used definition of Urban Agriculture come from Mougeot (2000). It states that urban agriculture is an industry located within a city or metropolis, which grows raises, process and distributes a diversity of food and non-food products, reusing human and material resources products and services found in and around the urban area and in turn supplying human and material resources, products and services largely to that urban area (Redwood 2009). With the rising urbanization food, supply to the urban population with an optimized budget becomes an important issue regarding sustainable urban development and Daniel Nocera may actually see widespread deployment of the technique in near future. The artificial leaf has a sunlight collector sandwiched between two films that generate oxygen and hydrogen gas when dropped into a jar of water in the sunlight; it bubbles away, releasing hydrogen that can be used in fuel cells to make electricity. Nocera replaced the platinum catalyst that produces hydrogen gas with a less-expensive nickel-molybdenum-zinc compound. On the other side of the leaf, a cobalt film generates oxygen gas. The metals used are cheap and easily obtainable in abundance, which earlier was only possible through platinum catalyst.

This replacement of the catalyst material makes it possible for extensive use. management. A sustainable city should be able to be self-sufficient both in terms of energy and food supplies. Shanghai can be cited as an example of how mega cities can be organized in terms of food production, due to the production, distribution and marketing of food from many diverse operating units to the Shanghai municipal government and by increased mechanization, electrification and water conservation system. However, with the growth in migrations and increased demand of food and considering the positive ecological significance of urban agriculture/ farming a unique model of the same is being researched. The prototype for the proposed urban farming would give rise to a model that would not only increase the food supply to the urban population but also function in favor of bio-diversity management, providing pleasurable urban environment. It might not be directly related to energy production but it could definitely play an active role in the air pollution, Green House gas emission, reduction in urban heat island through photosynthesis and providing increased green shield over steel and concrete built form.

### **Applications of Technological Interventions in Future Planning**

The vision of the planning reform was to utilize the primary site resource that is the Suzhou creek water feature. The design takes into account the existing site condition as explained above and proposes an optimised mixed-use development in the site yet taking care of the ecological notions. The river belt is redesigned with a copious green belt extension that would not only solve the purpose of a green recreation belt for the residents and workers but also reclaim the lost biodiversity of Shanghai. This would also help in the reduction of urban heat Island effect by minimizing the hard cover in the site.

Besides the shape of the built form, our strategy is to craft conditions for artificial photosynthesis. The “artificial leaf” devices for photosynthesis can be embedded in the building façade and rooftop attachments at an optimised angle to trap the solar energy as well as CO<sub>2</sub> supply to these artificial photosynthetic devices. Carbon dioxide could be supplemented from the high percentage of airborne CO<sub>2</sub> entrapped from the surroundings

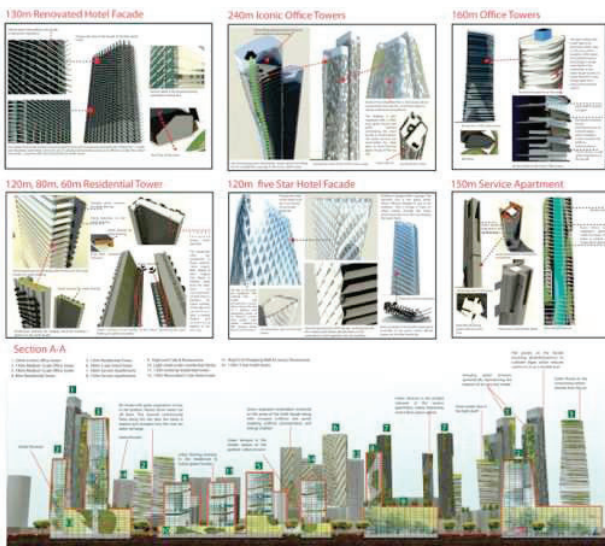


Figure 10 : Section through the main cross section, showing the building use and density. In the top of the image different building design typologies and grammars are explained which aids in sustainable neighbourhood design plummeting carbon production.

thus converting environmental carbon into storage fuel with the help of solar power. Another plausible method to initiate artificial photosynthesis is by cultivating algae in photo bioreactors panels especially flat plate reactors. The algae when cultivated on the facade in manifold ways such as shading devices, or attached building ribs, in places where there is optimised lighting conditions available starts to initiate photosynthesis. They provide certain aesthetic quality to the building façade. As such the entire façade of the buildings acts as an interface to absorb the greenhouse gases through artificial photosynthesis as well as in the production of algal biomass and effectively creates and alternate source of energy that would substitute the quantity of fossil fuel consumption.

The idea to re-erode built form and adding mother earth back into the site in the form of water bodies, green vegetation, and urban farmlands for food productions or natural

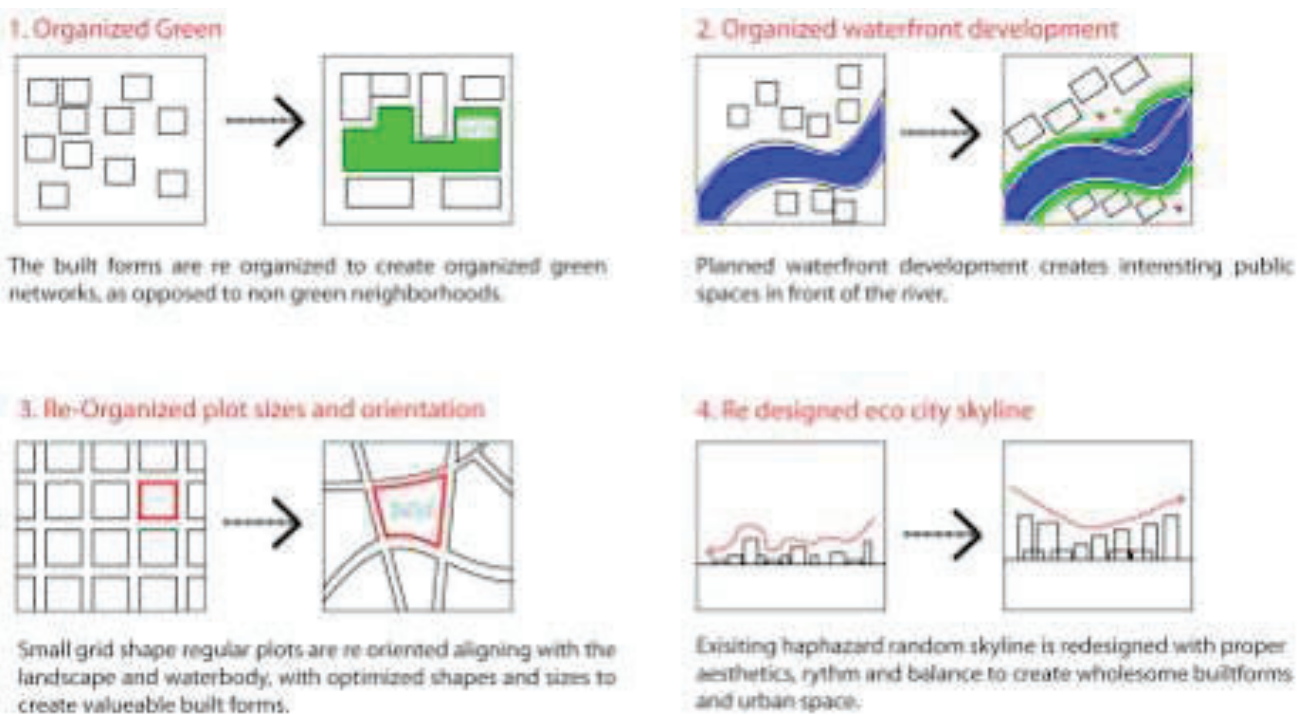


Figure 11 : Diagram showing the change proposed and the summarized account of the benefits confirmed from the designed urban intervention in the neighbourhood.

sanctuary, creates sustainable mini eco-systems like natural vegetation as in forests or grasslands or farmlands. Thus, buildings are eroded or scooped out in three dimensions to create 3D networks of green vegetation. This added green flora can be in the form of roof terracing or soft semi porous covering, not only significantly plummet urban heat island effects, but also substantially reduce carbon footprint of



the eco-town by photosynthesis. At the same time, employed green concepts like bio swales & algae cultivation shall purify air and water drastically. This paradigm of ecological intervention at the city scale shall be a seamless synthesis of built form & green eco-system

The above are functional strategies of green urban design. We aspired to create an exemplary project for Shanghai symbolically flaunting the new green image of the skyline by showcasing vertical vegetation on the built form.

## Pros and Cons of Futuristic Ecological Planning Proposals

Based on our research proposal and current exploration the possibilities of changes and urban reform presented could create a desirable urban reform based on the extent of ecological impacts produced. The design principle is to avoid wasting energy while at the same time minimizing waste generation as a target. At the same time, pioneering design ideas of using the waste and otherwise detrimental by-products of Urbanization, such as greenhouse gas emission, production strategies of alternate fuel sources have been examined. Although the research elucidates the requirement and importance of using such methods, the technologies described have not still been developed as fully functioning working prototypes. Some of the processes such as production of alternate Fuel sources could still be deemed expensive and challenging when considered in the scale of an Eco-city. However technological innovation had always been an optimistic solution yet with time and advancement of knowhow of a process, the goals could be achieved as projected in past.

## Conclusions

The project proposal is to create a sustainable neighbourhood in the site under consideration (developed as a phased construction), which currently is in extremely under developed and grimy condition. The project envisaged a mini eco-city model, exemplifying optimized usage of existing resources to accommodate the growing need of urban residents in the city in the wake of rapid economization and urbanization of Shanghai. It is aspired to drastically reduce travel times for the future residents to economize fuel costs and thus a

mixed-use urban model was formed which comprised of office, hotels, commercials, residential & mixed-use spaces. Such kind of program would encourage people to live work & play at the same location plummeting the energy needs. The basic design concept while incepting such a model was urban erosion, wherein the idea was to re erode built spaces, just as built spaces when raised erodes mother earth. Idea was to add vegetation and green cover over these eroded built forms to diminish net carbon footprint of the city.

As a new city hub, major eco adaptable architectural interventions were instantiated, some of them largely based on the principles minimising surrounding pollution, and redefining methods to minimize the use of non-renewable natural resource.

## References

- Baer, J.M. *The World In 2015 , Rising Asia and Socio Ecological Trabsition. Luxembourg: European Communities , 2009.*
- Dasgupta Nag, C. and et al. "Recent trends on the development of photobiological processes and photobioreactors for the improvement of hydrogenproduction." *International Journal of Hydrogen Energy , 2010: 1-21.*
- Devan, J. and et al. "Meeting The Challenges of China's Growing Cities." *McKinsey Quaterly , 3 November 2008: 107-116.*
- Grobbelaar, J.U. "Algal nutrition." *In Handbook of Microalgal Culture: Biotechnology and Applied Phycology , by A Richmond, 97-115. Blackwell Publishing, 2004.*
- Kinnunmen, L. "From Finland to China Eco-City." *Kemia-Kemi, 2008.*
- Nocera, D.G. "The Artificial Leaf." *American Chemical Society, April 4, 2012: 767-776.*
- Norsker, N.H. and et al. "Microalgal Production- A close look at the economics." *Biotechnology Advances 29, 2011: 24-27.*
- Redwood, M. *Agriculture in urban Planning. Sterling, Virginia, USA: Earthscan and International Development Research Centre (IDRC), 2009.*
- Science Daily. 9 May 2012. <http://www.sciencedaily.com/releases/2012/05/120509123900.htm>.*