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# Application of a Metabolic Thinking Driven Sustainability Framework in Early-Stage Planning of Eco-City

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## Abstract

The fast urbanization rate together with increasing global population and consumption is challenging the long-term sustainability of our social systems and supporting ecosystems on earth. The signs of instability can be seen in environmental degradation, e.g., climate change and loss of biodiversity. Also, the increasing use of materials and energy creates competition and international conflicts. The success of international agreements to handle the global problems has been limited. This is because deeply entrenched economic and political interests are involved. Political leaders are locked up to promises of economic growth and increasing welfare. Through globalization, resources and products are transported long distances and it is becoming hard to distinguish between local and global effects. This makes people feel that the overall situation is so complicated, so they cannot affect it. Bringing things closer to people will create more awareness and can create enormous opportunities for new ideas and business to solve the existing problems. The United Nations 2030 Sustainable Development Goals are focused on reducing poverty in the world. China has succeeded in reducing poverty on a massive scale through fast economic growth but to the price of increased use of virgin resources and environmental degradation. It seems more and more urgent to develop support models for urban development on a local scale focusing on urban metabolism. As sustainable development involves many normative decisions, participatory planning and cross-sectoral planning will be needed to ensure that conflicts between goals can be resolved. The Swedish Green Building Council has, together with more than one thousand actors, developed a recent model for the support of sustainable urban planning called CITYLAB. This has been used in a case study in the city of Changzhou in China. The case study reveals several barriers in Chinese planning when it comes to implementing more of horizontal planning practices.

**Keywords:** urban metabolism, participatory planning, urban planning

## 1. Introduction

The fast urbanization rate together with increasing population and consumption is challenging the long-term sustainability of our social systems and supporting ecosystems on earth. Without healthy ecosystems, there can be no sustainable urban systems. The signs of instability can be seen in environmental degradation,

e.g., climate change and loss of biodiversity. Also, the increasing use of materials and energy creates competition and international conflicts. It is important to understand that there is a causal link between the increasing use of resources and negative effects on environment. This is valid both on local and global levels. With a growing population on earth, a central question is if urbanization is the solution or a threat to sustainable development? Although cities cover a small part of the world, their physical and ecological footprints are much larger. Cities produce more than 70% of the world's greenhouse gas (GHG) emissions and use 80% of the world's energy. On the other hand, cities are regarded as centers for innovation and they account for 82% of global GDP in 2014, and by 2025 this will rise to an estimated 88%. There will be 230 new cities by then, all in middle-income countries. One hundred cities in China alone may account for 30% of global GDP at that time [1]. From these figures, it is clear that new ways have to be found to plan cities in order to achieve a better balance between growth and resource consumption. This is especially important for developing countries where also population growth is high.

Different concepts and solutions for sustainable urban development have been presented, but the solutions seem inadequate. Emissions and loss of biodiversity continue to increase. Proposed solutions are mostly related to the idea of ecological modernization which essentially proposes that we can actually adapt our urban metabolism in line with sustainable development just by applying new technologies and new and smarter systems solutions. In this way it is assumed that we can keep the existing consumption patterns, and developing countries can go the same way the developed countries have done. The ideas of ecological modernization have been questioned in several papers [2], but it is an agenda which is favorable to use for politicians. It will raise no fundamental conflicts with their voters who are looking for a decent life with high living standard especially in the developing countries. The solution proposed is often to develop smarter cities. However, all ideas around this concept are vague and scattered [3].

The central argument, which will be developed in this chapter, is that sustainable urban development is a normative process and must involve local actors including people living in the area in order to go from awareness to action. We will also discuss role models and principles for doing this in order to reduce resource consumption in urban development.

## **2. Aims and objectives of this chapter**

The general aim of this chapter is to outline why we have ended up in a situation with fast urbanization and increasing resource consumption and to find a starting point for going from awareness to action toward more resource-efficient urban systems.

The objectives in the chapter are:

- Give a historical background for the growing resource consumption and related environmental impacts in urban development. How did we end up in the current situation?
- Discuss the main driving forces for increasing resource consumption and environmental effects linked to urban development.
- Discuss if we find a foothold for objective decisions on sustainable development based on environmental considerations.
- Outline support for planning of more resource-efficient urban systems based on a case study in China using a recent Swedish support system for urban planning.

### 3. The history of urban development and human resource use

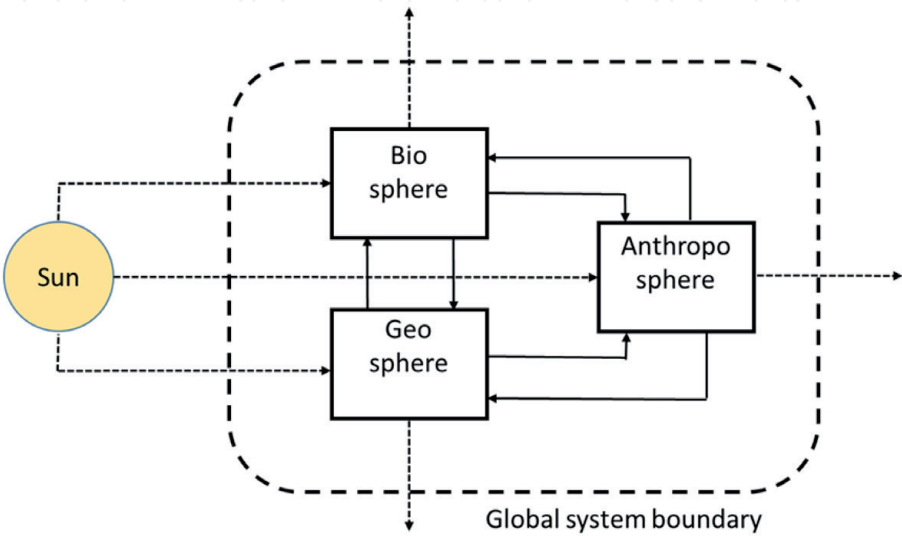
For thousands of years, human settlements existed within the biosphere without affecting it more than locally. The biosphere includes the regions of the surface, atmosphere, and hydrosphere of the earth occupied by living organisms. Most material and energy needed by humans came from local sources, and waste, mainly organic, was returned locally.

During the last couple of hundred years, a fundamental and dramatic change occurred. The large-scale exploitation of fossil energy and the technical inventions like heat engines allowed a rapid liberation from local energy sources with low intensities like renewable biomass, wind, and streaming water. Also new ways for transportation facilitated the exchange of goods and people on large distances. The starting point for this was the industrial revolution in England about 150 years ago. This resulted in a fast growth of urban settlements. Urbanization then started to form a global network of urban systems and also enabled a fast growth of the global population.

To illustrate this dramatic change, **Figure 1** shows the anthroposphere as a separate entity together with the biosphere and the geosphere. The reason for this is that the large-scale exploitation of energy-rich fossil fuels together with the fast development of technology has created a new situation in the biosphere. Humans are now affecting the environment on a global scale, and the new time periods have been named Anthropocene [2]. From being only local physical flows and stocks, energy and matter are now transported in complex patterns on a global level. The notion of metabolism is used to comprehend all physical flows and stocks of matter and energy within the anthroposphere. Human impact on the environment includes impacts on biophysical environments, biodiversity, and other resources. We here will refer to this as anthropogenic impacts on the environment.

The global metabolism on earth is driven by the energy from the sun. This global system is an open system for energy but a closed system for matter. Matter and energy are flowing between the biosphere, the geosphere, and the anthroposphere. For a long period of time, life has evolved through interactions between the biosphere and the geosphere driven by the energy from the sun.

The historically new situation is that humans have increased man-made flow of energy and materials on global level, so the anthroposphere now significantly interacts with the geosphere and the biosphere. This has created to a situation of high complexity, where it is easy to conclude that it is difficult for single nations to



**Figure 1.**  
*Schematic picture of metabolic processes on earth.*

change the pattern. Individuals can also feel that their behavior cannot affect the situation. This has led to something like a look-in situation where changing the metabolism is difficult to achieve. The essential question is how and on which level the change process can start. Is it through high-level political decisions or through the change of people's values and behavior on local level?

Starting from this perspective, we will look closer into the present and future situation of urban development.

#### 4. Urban development today and in the future

There are several driving forces for urban development and increasing resource consumption in the world today. The most important ones are:

1. A growing population especially in the developing countries.
2. Fast urbanization rate especially in the developing countries and also in the developed countries.
3. Increasing consumption/capita both in developed and developing countries.

A central force for the growing use of resources and environmental impacts is a growing population. The current world population of 7.6 billion is expected to reach 8.6 billion in 2030, 9.8 billion in 2050, and 11.2 billion in 2100, according to a United Nations report [4]. With roughly 83 million people being added to the world's population every year, the upward trend in population size is expected to continue, even assuming that fertility levels will continue to decline. One attempt to describe the role of multiple factors in determining resource consumption and environmental degradation was Equation [5]:

$$I = P * A * T \quad (1)$$

This equation describes the multiplicative contribution of different factors to environmental impact (I) which may be expressed in terms of resource depletion or waste accumulation. The factors are population (P) referring to the size of the human population, affluence (A) referring to the level of consumption by that population, and technology (T) referring to the processes used to obtain resources and transform them into useful goods and wastes. As stated above, P and A increase on the global level. The only way then to balance an increased impact is then to decrease T. This can be done by producing goods we consume using less energy and materials. The formula was originally used to emphasize the contribution of a growing global population on the environment, at a time when world population was roughly half of what it is now. It continues to be used with reference to population policy. One should not regard the equation as a simple multiplicative relationship among the main factors, but more as a qualitative visualization of the factors. Another way to express this relation is to use gross domestic product (GDP), a measure of industrial and economic activity.

$$\text{Environmental Impact} = \text{Population} \times \frac{\text{GDP}}{\text{Person}} \times \frac{\text{Environmental Impact}}{\text{Unit of GDP}} \quad (2)$$

In the United Nations Sustainable Development Goals, there are 17 goals [6] to handle this complex development, and several of the goals are conflicting. A basic



assumption in the UN agenda is that developing countries should have an economic growth of around 7% and that continuing urbanization is important for reducing poverty in the world. China can be a good role model for how economic development has reduced poverty. However, this has been coupled to an enormous increase in resource use and environmental degradation both on local and global levels. Even if we now can produce material goods using less energy and materials, the amount of goods consumed is increasing at a higher rate. Another conflict is that in the UN agenda, it is stated also that democracy is essential for sustainable development. Sustainable development, it is argued, can only be achieved with the involvement of people in a democratic way since the process involves value statements. At the same time, China is trying to export its growth model and also its political model with central control of one party. One argument put forward is that the developing countries should go through a state of increasing use of resources and environmental degradation before it can turn into a mature developed country. The problem is that the consumption of material goods and energy in developing countries is also increasing and that part of their environmental impacts has been moved to developing countries, e.g., China.

As we can see, the increasing use of resources in the world also increases environmental impacts, e.g., climate change and loss of biodiversity. A central question is if there is a limit for this development or we will reach a tipping point where no return is possible, and do we have time to create change before this tipping point is reached.

## **5. Is there a red line for our environmental impacts?**

The hope behind the UN 2030 SDGs is in line with ecological modernization, that is, economy and ecology can be favorably combined. Technological development and the shift to renewable energy sources can basically overcome the rebound effects. This brings us close to the concepts of weak and strong sustainability where strong sustainability indicates that natural materials and services cannot be duplicated [7]. Already since Thomas Robert Malthus in 1798 published his *An Essay on the Principle of Population*, it has been discussed if the increase in productivity can keep up with the increase of population on earth, thus avoiding starvation. It is obvious that up till today the increasing productivity in the food sector has kept up with population growth but to the price of larger inputs of nonrenewable sources and environmental degradation. The recent signs of global warming and loss of biodiversity challenge this development and the ideas of ecological modernization. Maybe it is time to realize that the sky is the limit.

The discussions around the future of urban development and solutions for sustainable development and ecological modernization are characterized through many buzzwords which seem to partly replace each other through time when new ones become popular. Examples of these buzzwords are clean technology, circular economy, artificial intelligence, information and communications technology (ICT), big data, etc. These concepts are included in general frameworks for sustainable urban development as low-carbon eco-cities, smart cities, etc. One of the difficulties in handling these buzzwords and concepts is that there is no general definition of sustainability which we can agree upon. Sustainability involves normative aspects, and the only solid boundary we could hope to find is the stability of natural ecosystems that is the fundamental support for all forms of life. In recent years, climate change has become an example of such a red line for non-acceptable environmental impact. The Intergovernmental Panel on Climate Change (IPCC) has formulated a general goal for maximum tolerated global warming to 1.5 degrees. However, there

is a high uncertainty in the consequences of what happens if we reach or exceed this goal. Another upcoming focus is the loss of biodiversity. The UN Scientific Expert Panel IPBES recently released the most comprehensive report on biodiversity globally since 2005 [8]. The report states that the protection of biodiversity is crucial for achieving global sustainability goals—and that one million species are threatened with extinction. Nature across most of the globe has now been significantly altered by multiple human drivers, with the great majority of indicators of ecosystems and biodiversity showing rapid decline. There are obviously many conflicts built into the UN 2030 SDGs. We need more energy to reduce poverty in the developing countries. We need then renewable energy sources as biomass and hydropower to decrease the use of fossil fuels, but this will have huge impacts on biodiversity.

A major question is if we can formulate objective and necessary conditions for sustainable development which all major actors can agree upon?. Is there a non-normative necessary condition? A necessary condition is a condition that must be present for an event to occur in this case sustainability. A sufficient condition is a condition or set of conditions that will produce the event. A necessary condition must be there, but it alone does not provide sufficient cause for the occurrence of the event. Sufficient conditions will inevitably include normative conditions since sustainable development is a normative process. As examples, continuing economic growth and infrastructure development, in some subregions, are required for achieving the sustainable development goals of eradicating poverty and hunger and ensuring energy, health, and water security but needs to be pursued in harmony with nature if they are to be sustained. It is clear that the ecosystems we live on are utterly complex and difficult to model. If we affect the systems, there will be changes but we have no way to assume that there is a specific red line for our impacts. The conclusion for this is that we just have to accept that the increasing use of resources will increase environmental impacts locally and globally. The only formed principle must be to apply the precautionary principle, that is, caution practiced in the context of uncertainty, or informed prudence. As the awareness of our impacts is increasing, it is now a matter how to apply this principle in practice and which political levels are to take the lead in this process.

## **6. How to go from awareness to action - Think Global – Act Local**

### **6.1 Action through international agreements**

Several international agreements have been signed in order to tackle some of the urgent goals and threats for humanity and to decrease global resource exploitation. One is the Paris Agreement with focus on climate change, and the other is the UN 2030 Sustainable Development Goals. However, it becomes more and more obvious that there are serious conflicting goals in the UN 2030 Sustainable Development Goals. The most important focus in the goals is to end poverty in all forms and at the same time conserve ecosystem services. These goals should be met through economic growth (minimum 7% annual growth) with the minimum use of resources and development of renewable energy sources. It is clear that political leaders have identified the necessity to handle sustainable development in practice. This process has been going on for many years and already at the United Nations Conference on Environment and Development in Rio 1992. It was stated there that the right to development must be fulfilled so as to equitably meet the developmental and environmental needs of the present and future generations. However, there are serious limitations for going from awareness to action in practice on the highest political

levels. Two years before the Rio meeting, Caldwell [9] formulated the problems which hinder political solutions for sustainable development on global level:

The prospect of worldwide cooperation to forestall a disaster seems likely where deeply entrenched economic and political interests are involved. Many contemporary values, attitudes, and institutions militate against international altruism. As widely interpreted today, human rights, economic interests, and national sovereignty would be factors in opposition. The cooperative task would require behavior that humans find most difficult: collective self-discipline in a common effort.

Sustainable development thus involves many conflicting goals where actors have different values. A conclusion from this is that sustainable development in practice has to be brought down to local levels where actors can participate in formulating the normative solutions and where support for conflicting actions can be developed. National policies have to be formulated so that support from local levels is obtained. At the same time, the local development has to ensure that global environmental restrictions can be handled in stepwise solutions.

## **6.2 Action through local initiatives**

On the local level, urban planning is still very much characterized through sectorial planning where different experts solve problems without a more integrated view of the problems related to sustainable development. This is partly due to how we educate experts in different fields at the university. Architects and urban planners have limited knowledge of energy systems, and energy engineers have limited knowledge in urban planning. The idea is to divide the very complex issue of planning urban development by reductionist thinking.

Many of the problems with today's situation in cities are related to the way we produce and use resources, and that this industrial system has been built up during only around 150 years using cheap fossil fuels. We are addicted to the idea that we can extract unlimited amounts of resources from nature and let it end up as wastes to air, water, and landfills. The problems show up in different sectors and are a result of our lack of methods to plan cities in an integrated way. We are used to plan in a sectoral way without taking the whole picture into account.

The city is a complex system so that it resembles more of a chaotic system than a deterministic one. Because of the chaotic nature of the city, it is difficult to describe causal relations even if we have access to a lot of data. This indicates the inherent difficulties in modeling urban systems using big data, a research field developing fast in the area of smart urban development. Several papers have discussed this issue and indicate that a qualitative approach might be more fruitful [10]. A lot of work is done to model subsystems in a quantitative way, but still the problem is to go from a set of quantitative models to practical solutions in the complex urban system. We collect data but cannot use them for action plans. This was once described as "Humans may well become the first species to document in exquisite detail the factors leading to its own demise (without acting to prevent it)" [11].

The city consists of many subsystems which interplay in a complex way. This complexity has also led to the division of urban planning into several city planning departments. There is now a need for more cooperation between these in order to achieve more of cross-sectoral planning which will be discussed more in detail below. When looking at these systems, which often are managed by different units in the city, it is obvious that they are linked in many ways in an unpredictable manner. Actions in one system will produce effects in another system. It is not possible to understand in detail the whole complexity, so we still also need traditional sectoral planning methods. It is, however, necessary, when developing the

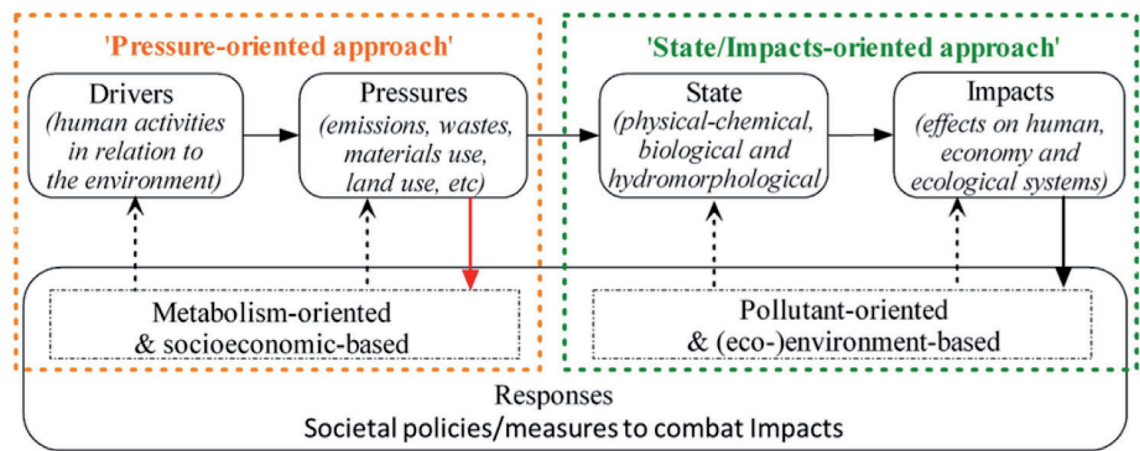


comprehensive plan, to consider the cross-sector effects. This can be done by using different working methods described later on.

Tracking resource consumption in urban development inevitably at the end leads to the consumers, which are people and the source for consuming resources. It is true that industry and the public sector also consume resources, but this is all for satisfying the needs of people. Cities attract people because they offer potential for the development of their life, material, and culture. A strong force here for increasing consumption is modernity. We identify modernity with a new better life and often the old things with something we want to escape from. Changing people's behavior in order to change consumption pattern toward more resource-efficient patterns has been debated extensively in the field of sustainable consumption [12]. One conclusion is that values and behavior is interlinked in a complex way [13]. Experiences from this research show that it seems change of values precedes the change of behavior. Urban planning can here play an important role in developing urban areas which affects people's values.

To develop our understanding of resource use in urban development, we have to understand the relation between resource use and different impacts. The Driver-Pressure-State-Impact-Response (DPSIR) framework (**Figure 2**), to a large extent, intends to aid in describing environmental problems by identifying the cause-effect relationships between the environment and various anthropogenic activities in a wider socioeconomic context.

In terms of this framework, socioeconomic development and sociocultural forces function as drivers (D) of human activities that increase or mitigate pressures (P) on the environment. Environmental pressures then change the state of the environment (S) and result in impacts (I) on human health, ecosystems, and the economy. Those may lead to societal responses (R) to the corresponding drivers, pressures, state of the environment, or impacts via various mitigation, prevention, or adaptation measures with regard to the environmental problems identified. Today focus is very much on impacts and responses, but more and more we identify consumption as an important driver for environmental impacts. It is, however, easy to fall down into passivity and frustration when facing the huge environmental problems we are facing on a global level. It might be easy to say "I have not created the problems and I cannot solve them." However, today we must consider that everyone is part of the problem as well as of the solution. The expression "Think globally—Act locally" urges people to consider the health of the entire planet and to take action in their own communities and cities. Long before governments began enforcing environmental laws, individuals were coming together to protect habitats and the organisms that



**Figure 2.**  
The DPSIR model.

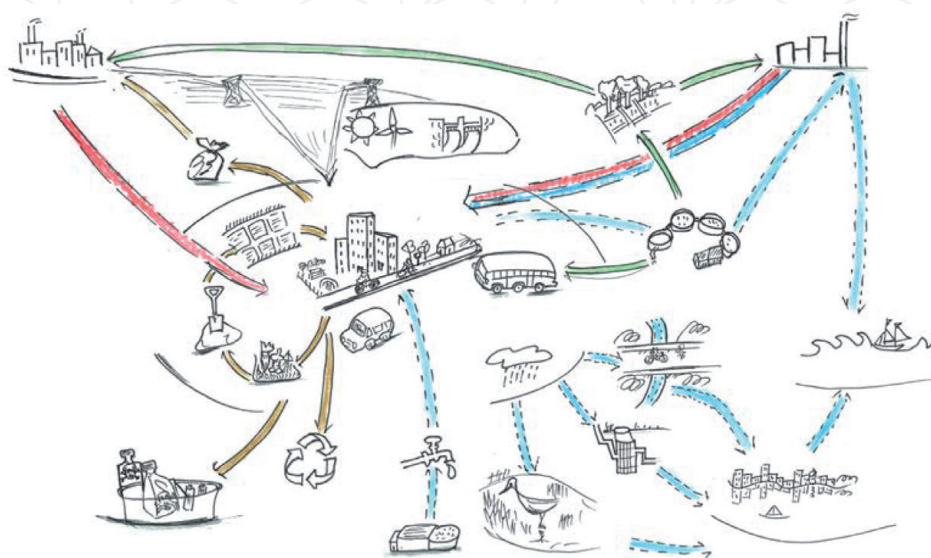
live within them. These efforts are referred to as grassroots efforts. They occur on a local level and are primarily run by volunteers and helpers. We have to become more proactive in the way that we avoid creating problems instead of trying to solve them once we have created them. To do so people have to get knowledge about causal effects to develop an action-oriented approach. Many of the actions are complex in that they often move the problem. The electric car is an example of this. Mobility in a city is essential for developing a liveable city, but electricity is not a primary energy source but just a carrier of energy. If electricity is produced in coal power plants, we have just moved the emissions when introducing electric cars. Looking at the whole energy system, it might also turn out that a modern diesel car is more energy efficient than an electric car. By moving the emissions away from the city, there is also a risk that people's awareness is changed so that they believe that the problem is solved.

The development of more sustainable cities must involve actors at local level including the people who are inhabitants in the city. Human activities are the central source for resource use and impacts. This means that we have to develop not only awareness but also new methods for integrated action plans. New methods and tools are needed for urban planning; different methods must be combined to offer explanation models for the system. The single largest limitation for this to happen is the sectoral planning system.

In the next section, we will describe such a support for planning which has been developed in Sweden by thousands of actors and which is built on gradual experience development.

## 7. Swedish experiences of sustainable urban planning

Sweden has a long tradition of participative urban development on local level, and several city areas have been internationally renowned [14]. In several cases comprehensive planning has started using a simple metabolic model as a platform for discussion between city planners, architects, developers, construction companies, and companies in the energy and water sector. In order to understand and visualize the urban metabolic system for a city, an eco-cycle model (as can be seen in **Figure 3**) can serve as a platform for visualizing cross-sectoral links between urban systems, thus stimulating discussions and creating new ideas.



**Figure 3.**  
*Example of an illustration of an eco-cycle model.*

The idea behind eco-cycle planning is that what comes out of the city or city area in the form of waste (domestic or industrial waste or wastewater) should be returned to the city or city area as recycled or reused material or in the form of energy (electricity, district heating and cooling, and transport fuel). The difference between resource and waste is a matter of order (entropy) and quality. This applies both for materials and energy. In the same way as for energy, the quality of materials is gradually reduced in the city metabolism. Eco-cycles can be created at different spatial levels. Using the eco-cycle model for a systems approach permits discussions on:

- Reusing and recycling materials, e.g., construction material.
- Minimizing the use of energy from finite resources, e.g., fossil fuels.
- Using less energy through higher efficiency, passive systems, etc.
- Recovering energy through exergy ladders, downcycling of organic matter from, e.g., waste.
- Producing and storing energy through local sources, e.g., solar energy, heat pumps, and developing systems integration.

We here again emphasize the need to approach a system such as urban planning with interdisciplinary methods. Urban planning is not a system which is limited to a specific science. Urban planning is an incredibly complex system in constant change. This fact demands that different stakeholders together form an image of the system to improve their understanding of the system. It is no longer sufficient that one stakeholder alone, for example, researchers, offers solutions to problems in urban planning.

The long tradition of participative urban development on local level in Sweden has now been accumulated into a support system for sustainable urban planning called CITYLAB, which will be described below.

## **8. CITYLAB: a model for stakeholder cooperation in developing sustainable city areas**

Based on the historical experiences from sustainable urban development, the Sweden Green Building Council (SGBC, a membership NGO) has developed CITYLAB, a tool and certification guide for the support in the development of more sustainable city areas.

### **8.1 The background of CITYLAB**

The Swedish industry wanted a flexible methodology for sustainable urban development that would work for big and small projects with different prerequisites. Work started in 2010, and the first part CITYLAB GUIDE for the development of sustainability programs was launched in early 2018. The development process involved thousands of people from governmental agencies, municipalities, construction companies, consultants, architects, and researchers.

Compared with other existing sustainable city evaluation and certification systems, such as LEED in the United States and BREEAM in the United Kingdom, CITYLAB pays attention to the dynamic development process of the project and supports the cooperation and experience exchange between different participants and projects. CITYLAB is a supporting tool for participative planning more than



a template for certification according to standards. Early in the development of CITYLAB, four value words were established, namely that the CITYLAB certification system should *make a difference, be adaptable, be credible, and be usable*.

The CITYLAB GUIDE has an open structure that can be adapted to meet new demands and conditions. This flexibility recognizes that urban development projects take place over extended periods, often involve ambitious goals, and at times require new development measures, strategies, and solutions to be formulated in order to meet emerging local challenges. CITYLAB has specified 10 *Overall Sustainability Goals* for sustainable urban development. These goals have been developed based on the UN Global Goals for Sustainable Development, the Delegation for Sustainable Cities’ document “Fifteen Obstacles to Sustainable Urban Development,” and Sweden’s national environmental quality objectives, public health policy objectives, and Vision for Sweden 2025.

CITYLAB Action Guide specifies 17 *Focus Areas* that are to guide the work in addressing sustainability within an urban development project. The Guide’s Focus Areas are complex and partially overlap one another; as such, they are to be read and applied in parallel, in support of the work undertaken in relation to sustainability within a project. The 10 goals and 17 focus areas are illustrated in **Figure 4**.

### 8.2 Integrated metabolic thinking with CITYLAB

CITYLAB proposes 10 overall sustainability goals for urban development. Projects can choose to use all goals or focus on some of them.

The 17 focus areas proposed in the guidelines are covering all the elements of the city which will, in a complex way, affect sustainability goals. On the left side in **Figure 4** we can see focus areas which are directly related to resources and on the right side, areas which are more related to the function of the city. In the indicator system, the CITYLAB GUIDE explicitly proposes to pay attention to the synergy and conflict between these elements and manage the coordination and conflict on the basis of fully understanding the status quo and establishing a “vision” in order to achieve the project’s objectives. This completely greets the logic and thinking



**Figure 4.**  
*Ten overall sustainability goals and 17 focus areas in CITYLAB guide.*



of metabolism in the design method. In the indicator system, CITYLAB has more specific focus points, including mixed functions, affordable housing, overall development structure, public space, social issues, circular economy, green travel, biodiversity, ecosystem services, green space elements, and low-carbon energy system. These areas have a certain integration of the previous simple elements, corresponding to the city's functional services and attributes of themselves. These comprehensive level elements indicate that CITYLAB's guidelines have transferred the metabolic theory logic in the ecological context to urban design methods and have achieved new developments in theoretical construction.

CITYLAB is a result of a long development phase in Sweden and is built on the idea of participative local planning which is typical for Swedish planning. However, the global challenges for sustainable urban planning takes place in the fast-developing countries like China where planning traditions are more hierarchical in structure. Much of eco-city planning in China is top-down starting from governmental policies [14]. In order to evaluate if the principles of participative processes in CITYLAB could be used in a Chinese context, a case study was developed, which is described below.

## 9. Application of CITYLAB in a Chinese case

In order to evaluate CITYLAB in a Chinese planning context, a research project was carried out in 2018 in Changzhou, China, in cooperation with the Swedish Green Building Council, Southeast University School of Architecture, Urbanization, and Urban Rural Planning Research Center of Jiangsu and the local government of Changzhou [15].

### 9.1 The objectives of the study

Changzhou is one of the most developed cities in China. Rapid economic growth and rapid urbanization have changed the scale and appearance of the city. The conflict between safeguarding ecological system services and economic development has become increasingly prominent. With an analysis of the problems of the development of eco-cities in Changzhou, the project wanted to explore sustainable urban planning methods adaptive to China and many other developing countries.

The study mainly consisted of the following aspects:

- To analyze and discuss the recent approaches and barriers for sustainable urban development in China.
- To make a comparison between sustainable urban models in China and Sweden.
- To conduct a case study in a Chinese context based on a comprehensive comparison with new sustainable urban development models in Sweden.
- To evaluate the Swedish planning model CITYLAB and to discuss in principle role models for sustainable urban planning in developing countries.

### 9.2 The Changzhou case

As a case of this study, Changzhou Tianning District was chosen for the following considerations:

- Changzhou has a good economic foundation as a relatively developed city in China. The local government's willingness to build a sustainable city is also strong, which lays a good foundation for the sustainable development of the city.
- The urban attributes and development context of Changzhou are similar to most of China's current well-developed cities. It can be regarded as a typical example, and the research results have strong reference significance for other cities. This is important for scale up of demo examples.
- Changzhou not only has a long history and culture but also has unique water resources and railway resources in terms of geographical conditions. The resources that urban development can rely on are abundant, and the contradictions and conflicts facing sustainable development are also concentrated. Therefore, at the level of method exploration, Changzhou can be regarded as a typical example of sustainable urban planning practice in developing countries and has a strong representative significance.

The case selected by the study is located in Changzhou City, and is an important city on the extension axis of the Shanghai-Nanjing Railway, the Beijing-Hangzhou Canal, and the Shanghai-Nanjing Expressway. Changzhou has a long history and charming river city culture and is one of the most developed cities in China. The city is historically the absolute center of the Yangtze River Delta and has experienced an era of development along the canal and along the railway. It consists of six urban districts, Tianning, Zhonglou, Xinbei, Wujin, Jintan, and Liyang, with a population of 4.72 million in 2017. As a part of it, Tianning District is located in the northeast of Changzhou City, near the junction between Changzhou and Wuxi. It covers 154 km<sup>2</sup>. The Grand Canal passes through the district which covers some historical and cultural blocks such as Qingguo tunnel and Qian Hou Bei An. There are many water networks in Tianning District. There are seven main rivers and eight branch rivers with a total length of 52.5 km. The main functions of rivers are water diversion, drainage, flood discharge, and ecological landscape.

### 9.3 Development modes

There are two main urban development models in China. One is the unrestricted development of satellite towns in the radiation zone of the central city which is called suburban sprawl which results in a chaotic state of the city or a machine-made urban appearance; the other is the vast towns that are far from the city and are currently experiencing the complex pattern of decline and revitalization, transformation, and restructuring. With the urbanization of China going deep into the water, unbalanced, uncoordinated, unattractive, and unsustainable development remains a big problem. A number of new cities almost have no features and lack vitality. Therefore, the positive impact of an independent building or micro-urban design should be given special attention which can be regarded as singularities of urban development.

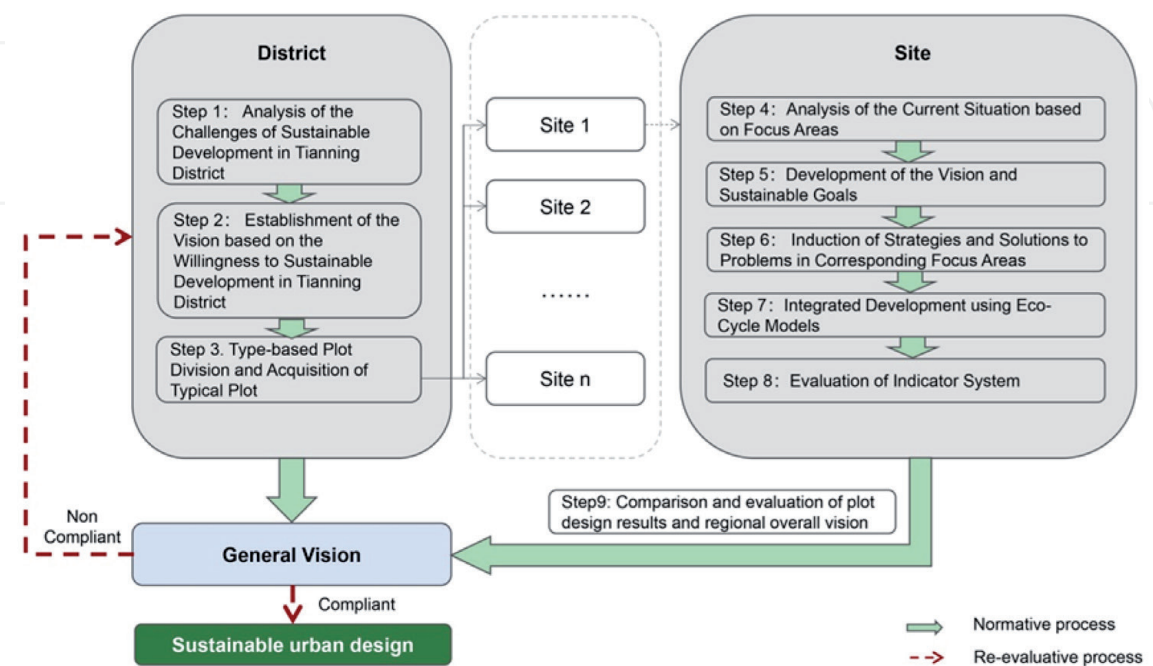
The Tianning District of Changzhou City has a great potential to generate urban singularities by using its own characteristics because of the "Three Rivers and Four Cities" urban form which may be a booming district on the basis of the ecological network background and heavy breath of life. In terms of the urban catalysts, the construction of urban events should follow the principle of urban story theory; pay attention to the integration of people and nature, the integration of people and history and culture, and the integration of people's interactions, in

order to pursue the overall ecological value of the city and the fair values of the environment; and finally make the city maintains long-term vitality. Secondly, the concrete strategy of “city marketing” should be put forward to shape the positive public opinion. Thirdly, a sound and scientific policy evaluation and evaluation system should be established for the influencing factors of urban events. In addition, the enthusiasm of urban residents for participating in major events and the shaping of the city image should be combined to enhance urban culture and the interaction between cities and major events. As the “urban singularity” becomes the indispensable component of urban rejuvenation, it cannot be operated in isolation and painstakingly. To achieve a healthy and sustainable development of the city, the key lies in finding comparative advantages, creating competitive advantages, and building industrial advantages [16]. In order to avoid the homogenization competition between cities and achieve differentiated development, the road of urban development and revival should pay close attention to the characteristics of the city itself.

9.4 The case study

A framework was developed as shown in **Figure 5**. The framework covers eco-city development guidelines for district and smaller plots. Forming several representative plot types, each plot type is typical of a piece of land. Next, consider the development method of a specific type of typical plot. The overall workflow is shown in **Figure 5**.

Starting from the idea of urban metabolism, the CITYLAB framework analyzes the macroscopic urban development context and the microscopic composition of urban organisms to construct a “two-way complementary” design research process. It is mainly divided into three parts: district, plot, and integration. First of all, by analysing the city’s environment at the district level including social factors, government composition, economic development, etc., one can develop a general vision for the current district development. In order to further implement the general vision and provide higher practicality, based on the “bottom-up” thinking



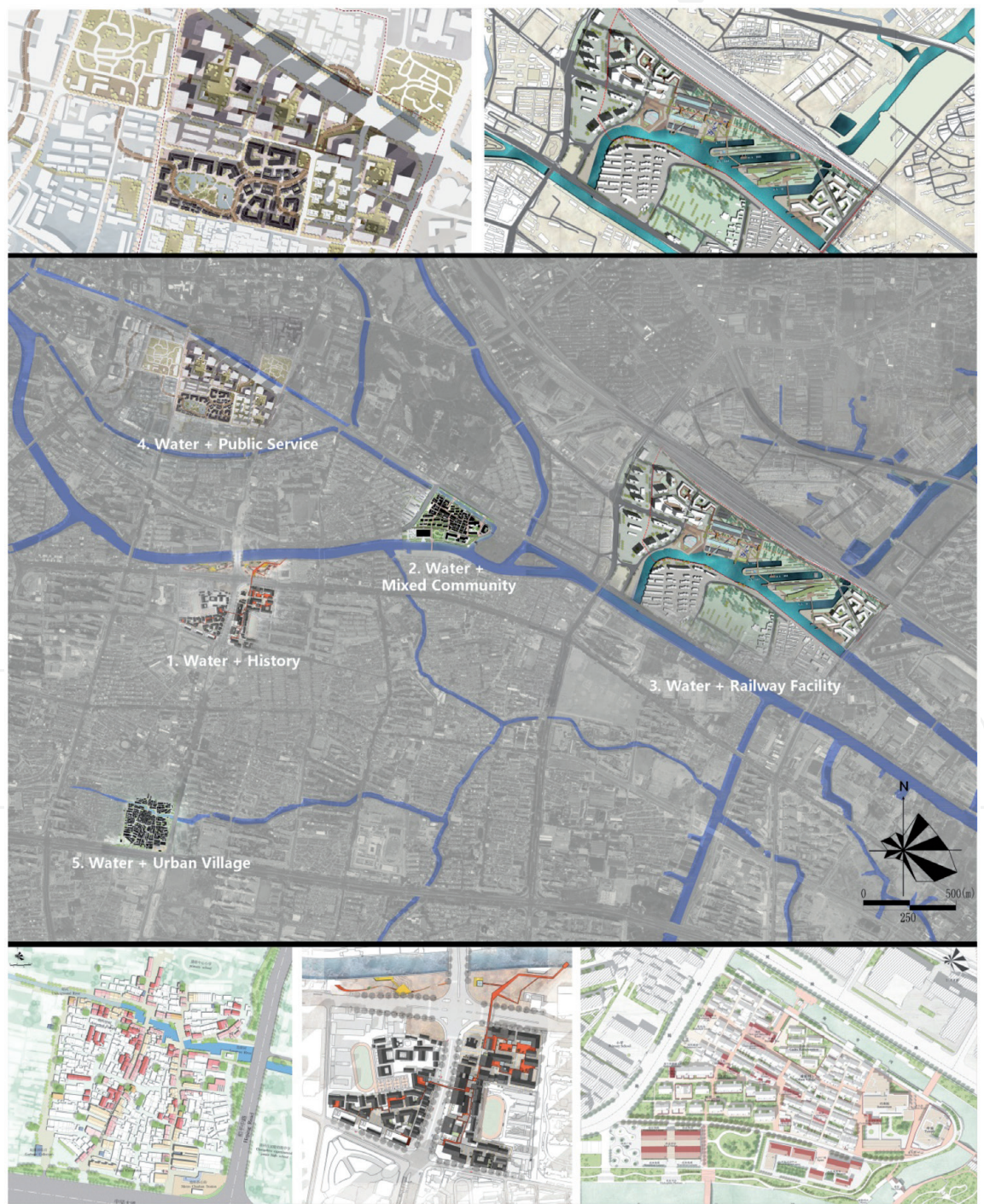
**Figure 5.**  
*Sustainable urban planning workflow in Tianning District.*



of geography, we divide the whole district by comparing the similarity and particularity of the geographical and economic patterns of the site.

For the treatment of typical plots, it is more convenient and direct to deal with the city's metabolism problem, that is, by organizing the local planning process to achieve the established cross-disciplinary sustainable development goals and using these small-scale plots as the singularity of regional planning development, based on the similarity and continuity between the plots, form a series of urban renewal chemical reaction sources and activate the overall district sustainable development plan.

In this series of processes, the results of the master plan design of the plot need to be further compared and reassessed with the overall development vision of the district. This method of backtracking reverifies the overall deductive logic. If the outcome is compatible with the general vision of the district and can play a role in



**Figure 6.**  
*General plan design for sustainable planning of typical plots in Tianning District.*



promoting it, then the method of analysis and derivation is effective, and the design results are in line with the needs of sustainable development. If the design result of the plot is not compatible with the general vision of the district, it is necessary to re-analyse the relevant influencing factors from the district perspective. Also, the presentation of the general vision and the division of the plot type will also be adjusted accordingly. The process covers the normative process and the reevaluative process. It has a strong correspondence and complementary relationship with China's current sustainable city development focusing on policy guidance, lack of attention to local issues, and lack of system integration.

Based on the above method, the workshop carried out relevant sustainable urban planning on five typical plots in Tianning District, forming the results as shown in **Figure 6**. These five plots serve as demonstrations of the district, "from point to face" to activate the renewal of the surrounding plots and eventually form a comprehensive coverage of sustainable urban planning. Based on the above methods and results, we conducted an interview with the local government of Changzhou. The relevant feedback is as follows. The local government of Changzhou believes that the planning of ecological cities should first analyze the internal causes of urban ecological problems and clarify the relationship between them and the urban development mechanisms. Secondly, new sustainable development models and mechanisms should be established on the basis of the original development of the city, and they should be coordinated with the original model and at the same time promote public participation and form a long-term development model of the ecological city. CITYLAB principles can be gradually applied in the construction of Changzhou eco-city, and in the actual planning and construction. The 10 sustainable development goals should be adjusted according to the actual situation in Changzhou. The five ecological urban planning experiment of typical plots is a strong testament to the applicability of sustainable urban development planning based on the CITYLAB GUIDE.

## 9.5 Case study results

Based on the current situation of sustainable urban construction in China and the sustainable urban planning and design in Sweden, the main problems and challenges of sustainable urban planning and design in China are summarized. On the basis of these problems and challenges, we choose the guidelines of CITYLAB eco-city construction developed and implemented by the Sweden Green Building Council as the guidance basis and take Changzhou Tianning District as an example to carry out practical exploration, which proves the operability of the method at the practical level. Based on these guidelines, we establish a basic model for sustainable urban development planning in developing countries and lay the tone of the study.

Nevertheless, in the practice of sustainable urban planning in Changzhou Tianning District, we can realize that there are still some points that are difficult to integrate with CITYLAB and there are difficulties in the implementation process:

1. As a planning support system, how CITYLAB proposals for urban project planning integrate with the existing urban and rural planning system in Changzhou, and how to participate in the urban decision-making system?
2. In addition to cooperating with local government and local professional planning agencies, how can CITYLAB platform attract more local public participation and promote the local "bottom-up" urban mechanism in Changzhou?
3. As a system platform covering the whole process of urban planning, construction, use, and maintenance, CITYLAB has a certain difficulty in intervening in

the local urban and rural construction in Changzhou in a short period of time and providing corresponding technical support in planning, construction, and management.

## 10. Conclusions and discussions

Though 60–70% of people in developing countries still live in rural areas, half the total world population now lives in urban areas. Rural people continue to move to cities attracted by the promise of work, higher salaries, and a better social life. The fast urbanization rate together with the increasing population and consumption is challenging the long-term sustainability of our social systems and supporting ecosystems on earth. The urbanization leads to the increasing use of resources and environmental degradation on global and local levels, and many signs show that we have reached a point where the stability of the global ecosystems is in danger.

The United Nations 2030 Sustainable Development Goals are focused on reducing poverty in the world. This will require economic growth, and the big issue is if this growth can be decoupled from the increased use of virgin resources and environmental degradation.

Through globalization, resources and products are transported long distances, and it is becoming hard to distinguish between local and global effects. This increases the environmental impacts, but it also makes people feel that the overall situation is so complicated so they cannot affect it. Bringing things closer to people will create more awareness and can create enormous opportunities for new ideas and business to solve the existing problems.

The success of international agreements to handle the global problems has been limited. This is because deeply entrenched economic and political interests are involved. Political leaders are locked up to promises of economic growth and increasing welfare.

China has succeeded in reducing poverty on a massive scale through fast economic growth but to the price of environmental degradation both on local and global levels. China is trying to become a role model for sustainable urban development, but the backside of this model is obvious. China has developed several top-down strategies for sustainable urban development through the concept of low-carbon eco-city development, but with limited success.

It seems more and more urgent to develop support models for urban development on a local scale. As sustainable development involves many normative decisions, participatory planning and cross-sectoral planning will be needed to ensure that conflicts between goals can be resolved. Cross-sectoral planning means in practice bringing competences from different urban sectors together physically in workshops, in order to discuss how integration between the urban systems affects the comprehensive plan in an early stage of conceptual planning of the city.

Sweden Green Building Council has developed a recent model for the support of sustainable urban planning called CITYLAB. This has been used in a case study in the city of Changzhou in China. Participatory and cross-sectoral planning is a challenge in China where there are barriers between different city departments and between the urban planning department and state-owned companies. Planning of energy solutions when developing a plan is especially difficult since the state-owned energy companies are usually not taking part in the city planning process.

The case study in China was carried out during a very short period of time, and more experiences of integrating the new method with existing planning routines in China will be needed.

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