Tongji University

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Thriving with the country for 110 years, and benefiting the society with science and education

In the 110 years since its founding in Shanghai as a German-style medical school, Tongji University has developed into a comprehensive research-oriented university with a formidable reputation in China and internationally. In 2013, it set out a formal goal to become a research-oriented world-class university with a strong focus on sustainability.

Sustainability permeates the research and education programmes of Tongji. With a remit of fostering creativity and excellence in young people, Tongji University has integrated knowledge and capability in its undergraduate and graduate education. It strives to make its students leaders of sustainable development, equipped with a strong knowledge base, hands-on skills, a mindset for innovation, a global perspective and a sense of social responsibility. Many of its graduates are already well-known scientists, educators, engineers, medical doctors, statesmen and entrepreneurs, including more than 140 members of the Chinese Academy of Engineering and the Chinese Academy of Sciences.

Home to the world's largest multi-function vibration test centre and the first urban rail transportation comprehensive test system and seafloor observation research base in China, Tongji University has taken charge of a series of key national science and technology projects and established many major research platforms. Its significant research achievements include key technologies for long-span bridges, intelligent transportation systems for urban areas, technologies for anti-seismic structures, urban wastewater control, development of new energy vehicles, intelligent greenhouse control systems, spatial information technologies for remote sensing, ocean drilling and breakthroughs in molecular genetics, along with other medical and life science research achievements.

With a focus on the application of basic research, Tongji University's research results are widely applied, contributing to national infrastructure and transportation construction, earthquake and natural disaster prevention, environmental protection and other social developments. The university is also keen to explore new approaches for social services and has created a new model for partnership by collaborating with the local government to promote the construction of a knowledge economic zone around the Tongji campus.

Tongji University is also enhancing its international collaboration. Built on its historic ties with Germany, its international network has spread across Europe and expanded to North America, Asia and Africa, with the establishment of 10 joint platforms for international collaboration, partnership agreements with more than 200 universities worldwide and multiple joint research centres with multinational companies, such as Siemens, Bayer and IBM. It is a global leader in worldwide university alliances for green campus and sustainable development and is the first Asia-Pacific university receiving the International Sustainable Campus Excellence Award.

With a strong faculty team and talented students, Tongji University has found a way to develop its own characteristics. Guided by the novel ideas of innovation and open-mindedness, it is living up to its commitment to sustainable education and is making big strides towards greater goals. ■

同濟大學
TONGJI UNIVERSITY

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1912

A merger led to the establishment of Deutsche Medizin- und Ingenieurschule (Tongji Medical and Engineering University)

1937-1945

Several relocations to the southwest of China, due to war

1995

Selected for the Project 211, the National Key University programme

2013

Set a goal to be a sustainability-oriented world-class university

1907

German doctor, Erich Paulun, founded Deutsche Medizinschule (Tongji German Medical School)

1927

Became National Tongji University

1949-1956

Many departments and programmes were merged with other universities during a nationwide restructuring

2002

Selected for the Project 985, a national scheme to promote world-class universities

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TONGJI 110TH ANNIVERSARY

The role of universities in a sustainable world

Tongji University is a renowned higher education institution in China and has the country's top-rated architecture and civil engineering programmes. With the platform of the UNEP-Tongji Institute of Environment for Sustainable Development (IESD), this comprehensive, research-oriented, internationalized university is leading the way.

Here, **Wu Jiang, Executive Vice President of Tongji University, Dean of IESD and Chair of the Global Universities Partnership on Environment and Sustainability (GUPES)**, talks about a university's role in sustainable higher education and Tongji's commitment to sustainable development.

How do you define sustainable development?

Sustainable development emphasizes considering needs of future generations while meeting the needs of a current generation. It is a scientific approach that coordinates economic growth, social progress, ecological balance and human development, and aims to maintain the harmony between humans and the environment, as well as amongst societies. The United Nations has now set up specific sustainable development goals and China is also committed to shifting its development model to a sustainable one. For a university with a social responsibility mission, our interpretation of this universal value is to promote the sustainable development of people and society via providing sustainable education, research and services.

What has led to Tongji's partnership with UNEP to establish IESD ?

In May, 2002, we signed an agreement with the United Nations Environment Programme (UNEP) to jointly establish the UNEP-Tongji Institute of Environment for Sustainable Development. The main motivation was to foster talents and boost scientific research on global environment and sustainable development. Now IESD has become a key platform at Tongji that promotes sustainable higher education, theoretical and applied research on sustainability science, and relevant international and domestic collaborations.

How does IESD integrate sustainable development in education?

I believe education is the basis of long-term social progress and the most essential function of a university. To serve society and contribute to sustainable development, fostering talents is our primary remit. We emphasize interdisciplinarity and have developed a series of sustainability-focused training courses and educational programmes to make education sustainable. Our arts and humanities students need to have some science and engineering knowledge, and vice versa. For instance, it's important to consider the environmental and social impacts when an engineer starts a new project.

In line with this, we have opened nearly 100 undergraduate courses and 10 master's minor programmes on sustainable development. Taught by an interdisciplinary group of experts in humanities, social sciences, architecture, new energy, transportation and engineering, as well as environmental sciences, these courses are taken by students in medicine, science and engineering, as well as arts and humanities. They encourage students to incorporate the

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concept of sustainability into their own areas of studies and cultivate their sense of social responsibility. Furthermore, we put great stock into transforming the traditional pedagogy into participatory learning to train students' higher-order thinking skills and enable their life-long learning, which is the essence of our sustainability-oriented education.

How does IESD contribute to sustainable development via research?

In our solution-driven approach to research, we have achieved a series of innovations in civil engineering, architecture, bridge and transportation, marine science, environmental science, new energy vehicles, surveying and mapping, and electronic information. We have supported the construction of magnetic levitation trains and an underwater tunnel. We developed technology that uses a combination of anaerobic microbes and micro-algae to treat water with a high concentration of organic pollutants, and helped to turn sewage into a usable resource. The fuel cell powered cars we designed represent a big step in the development of green vehicles that contribute to energy saving and air pollution control.

In social sciences, our public administration and policy studies have promoted green economics theories and contributed to improvement in urban development and public governance. Our investment in research on sustainability has also led to the establishment of several think tanks that bring in international experts from various fields to provide policy recommendations on sustainable development, as well as consultative services to enterprises. Our cross-disciplinary collaboration platforms help transform our research into industrial applications and policy implementations.

How does IESD enhance social service via international collaboration?

We are committed to research on climate change, disasters and conflicts, ecological conservation, environmental control, management of hazardous substances, efficiency of resource use and evaluation of environmental impacts, striving to become a think tank for UNEP. We participate in regional and global environmental projects organized or coordinated by UNEP and are leading the world in capacity building for environment and sustainable development.

Aiming to integrate environment and sustainable development into higher education to create a novel, internationally advanced educational model, we are actively engaged in international collaboration to foster high-quality researchers, technological backbones, industrial leaders and government administrators in the realm of environment and sustainable development for the world and particularly, developing countries. IESD is already becoming a centre for the research and education on environment and sustainable development in Asia-Pacific.

To promote research and technology innovation in global environmental issues and the application of environment-friendly technologies, we have made efforts to support South-South cooperation and facilitate technology transfers to developing countries. Particularly, we are dedicated to creating and promoting the dissemination of internationally advanced technologies that address global needs in environment and sustainable development.

Via various regional and global conferences and seminars, online news briefs and press releases, we are also becoming a hub for the advocacy of UNEP policies. Guided by the "Higher Education Sustainability Initiative" proposed at the Rio+20 summit in 2012, we are leading the organization of the Global Universities Partnership on Environment and Sustainability, which promotes international exchange on sustainability-oriented education among universities worldwide.

What are the challenges faced by Chinese universities to become sustainability-oriented?

We need to build a modern higher education system that integrates eastern and western cultures. Many Chinese universities are striving to become world-class through learning western systems, but I think we should note the cultural differences between western and eastern societies. In a traditionally top-down society like ours, some western systems may not work. We have power to mobilize the entire society to achieve our goals, but we should also leave some freedom for the university's own development. Based on the Chinese cultural context, we are exploring a middle way that integrates cultures, systems, and specific action approaches. I believe a sustainability-oriented strategy will guide our exploration. It will lead Tongji to become a world-class university with Chinese characteristics, living up to global responsibilities. ■

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A working model of sustainability science

Zhu Dajian, Han Chuanfeng, Zhang Chao (Institute of Sustainable Development and Management, Tongji University)

The establishment of a universally applied theoretical model is a hallmark of the maturity of a research field. Researchers of Tongji University have been developing such a model for sustainable development studies through years of exploration.

This proposed model is based on three key dimensions — the object, the subject, and the process.

The object dimension of sustainability science encompasses interrelated aspects of economy, society and environment. Studies on development should be shifted from a single economic perspective to the more comprehensive and integrated economic, social and environmental dimensions. Good development means socio-economic and welfare improvements made within the carrying capacity of the natural environment.

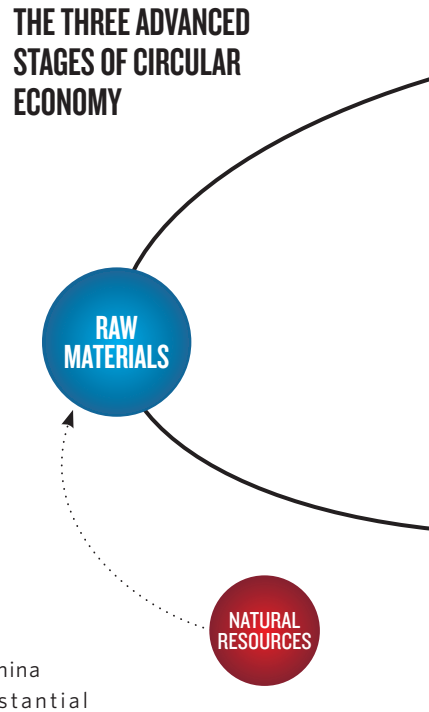
The subject dimension includes government, enterprises, society and their interrelationships. Governance and capacity-building for sustainable development require participation of all these stakeholders and its main driving force should be shifted from the government to a collaboration between government, enterprises, and social organizations. Sustainable development will be more effective under better management of communication between the three.

The process dimension focuses on end-of-pipe treatment and prevention of problems at the root. The process analysis of sustainable development should be an extension of the PSR method, where P (Pressure) indicates the cause of a problem, S (State) stands for the current state of a problem, and R (Response) represents the solution. Solutions are organizations' reactions to development, in response to either a state or outcome, or to pressure or causes. It is best to combine these factors to find a solution that addresses both causes and effects.

Object analysis and urban development

Given that the object dimension of sustainability science is defined as encompassing the economy, society, environment and their relationships, Tongji researchers proposed a two-hemisphere model of urban development, stressing that sustainable development can only be achieved when both human development and urban ecosystem are at a certain level. Based on the model, different types of development or transformation can be identified.

The model considers urban sustainability in two hemispheres: the human development hemisphere focusing on economic growth and social development, and the ecological input hemisphere, represented by resource consumption and pollutant emissions. The model emphasizes the separation of the two, positing that the key to sustainable urban development is to achieve high-quality development within the ecological carrying capacity. The model was developed over many years by Tongji scholars, who searched for potential answers different from traditional methods. For example, many studies based on weak sustainability suggest that cities with higher economic growth and human development are sustainable. But, our findings indicate otherwise, as those cities tend to have higher resource consumption and environmental losses. Contrary to previous findings suggesting that coastal cities generally have higher development efficiency, usually based on the weak sustainability paradigm, we find that both coastal and inland cities in China need substantial improvement in the efficiency of sustainable development, measured by ecological footprint (the input) and human development (the output). Of course, the two types of cities may take different paths.

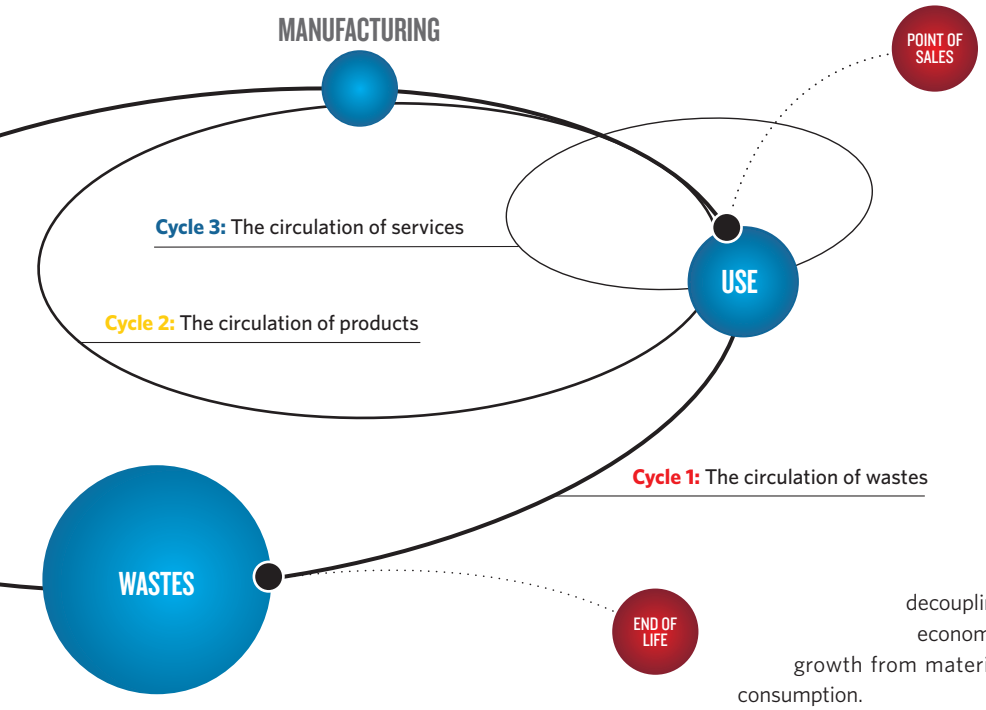


There are four transformation paths towards sustainable urban development, and different policy recommendations are pertinent for cities under different conditions. In general, we believe that China's most well-developed coastal cities are close to the limits of ecological carrying capacity, and must adopt a transformation model that emphasizes reducing ecological impacts while maintaining higher human development levels. For emerging cities in central and western China, a 'leapfrog' model of development might be more appropriate, that is, striving for improvement in human development within ecological constraints, so as to avoid the traditional development model of 'cleaning up after pollution'.

Process analysis and development strategy for circular economy

The process dimension of sustainability science emphasizes combining end-of-pipe treatment and prioritizing prevention over treatment. In line with this philosophy, we studied implications of replacing the traditional, linear economy with the circular economy.

The green development prioritized in a

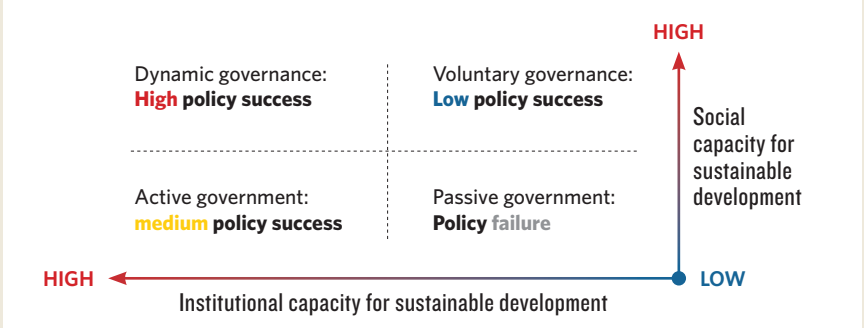


linear economy is defined by improved efficiency, either in mining, production, consumption, or processing. It requires working vertically and separately in all these aspects of material flows. It is an important aspect, but not sufficient as a standalone measure, because simply increasing efficiency alone is likely to stimulate more resource consumption and lead to greater environmental damages due to mass production and consumption in a scaled-up economy. This is the well-known 'rebound effect'. The circular economy differs because it works horizontally to close loops of material flows, turning them into multiple cyclic processes. This contributes to decoupling economic growth from material consumption.

There are three basic forms of circular economy, tracing from the end of the material flow to the source. The first is the circulation of wastes. The recycling of wastes can significantly reduce the burden of disposal by landfill and incineration and increase the proportion of wastes re-entering production and consumption. The second form is the circulation of products, including refurbishing and remanufacturing by businesses and sales of second-hand goods between consumers. This cuts the amount of goods being discarded after use. Finally, there is the circulation of service, including B2C product service systems and the C2C platform-based sharing economy, made vastly more effective and accessible by the advent of mobile internet.

The sharing economy represents the pinnacle of circular economy. Historically, people have largely believed that a rich and comfortable life requires the ownership of goods and that greater ownership equates to a better life. The sharing economy, on the contrary, prioritizes the right to use rather than ownership. As consumers can use an item without owning it, consumption can be made more convenient, and superfluous production and possession of goods can be avoided. Under this system, it is possible to achieve better socioeconomic welfare without much resource consumption and to delink the two, as sustainable development requires.

COLLABORATIVE GOVERNANCE AND SUSTAINABILITY



Subject analysis and inter-organizational interface management

The subject dimension of sustainability science promotes strengthening inter-organizational communication as the key to sustainable collaborative governance. Several processes and methods could be used by organizations to manage interactions.

Sustainable development depends on the diversification of various organizations and their capacity for collaboration. Without interface management and collaborative governance, separate organizations will not contribute to sustainable development, no matter how developed and diverse they are.

The general approach to improving interface management requires going beyond the traditional single-sector model and ensuring participation of both internal and external stakeholders. Stakeholders should be involved in discussion about issues important to organizations and society, focusing on finding the common ground. And priority issues should meet the "triple bottom line" of sustainable development from the common ground of internal and external stakeholders. These should form the basis of an integral management process including planning, implementation and evaluation.

On the road to sustainable development, government, enterprises, social organizations and the public generally have three levels of responsibilities according to their interrelations with one another: the core responsibility, cooperative responsibility, and volunteer responsibility. To achieve collaborative governance needed for sustainable development, any organization needs to adhere to its core responsibility and to cooperate with relevant organizations, while taking on volunteer responsibilities when there is spare capacity. ■

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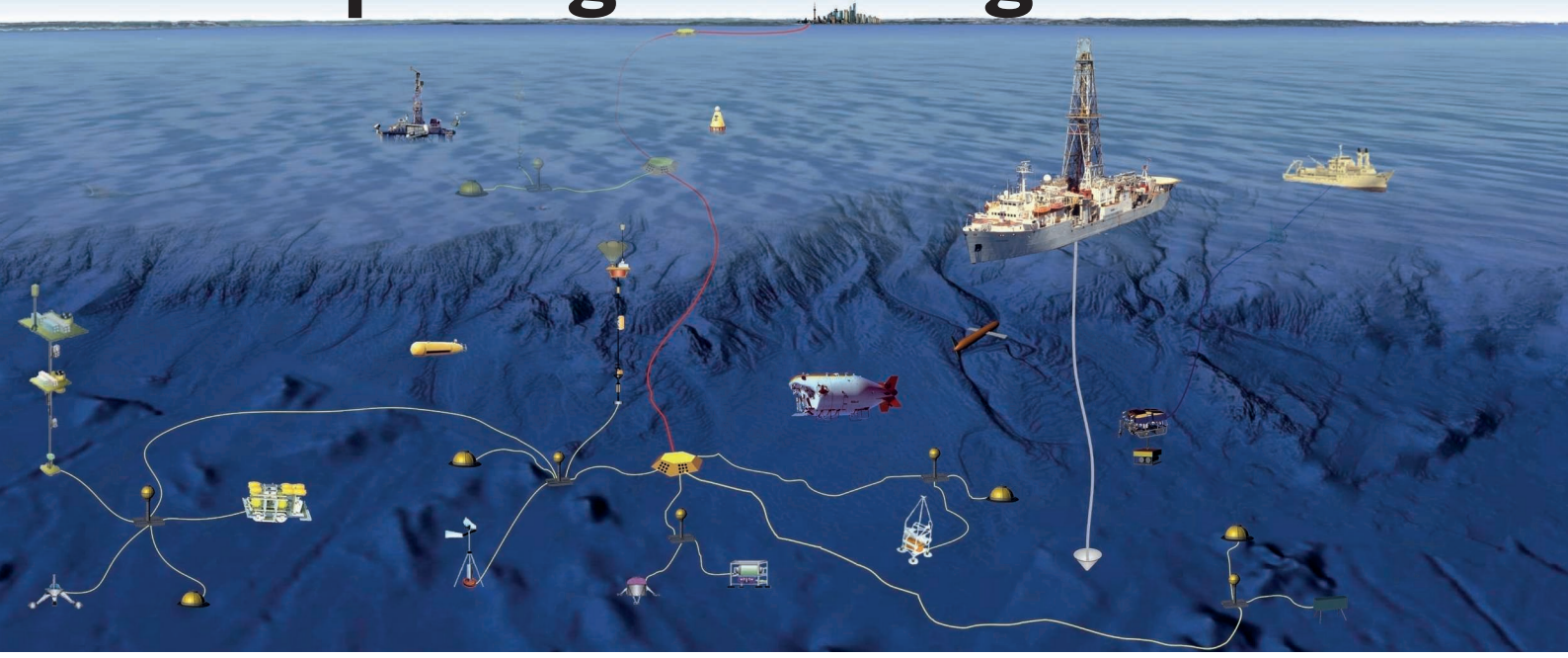
TONGJI 110TH ANNIVERSARY

MARINE SCIENCE

A deepening knowledge



Tongji University's Marine Geology department is an established leader in deep-sea research, combining marine science and technology. Since it began in 1972, the department has developed rapidly, making the most of its cutting-edge equipment and expert personnel. Its laboratory is equipped with advanced spectrometer systems, such as LA Neptune Plus and MAT 253 plus. It also has an X-ray fluorescence core scanner, and for field work uses a deep-water mooring observation system and tripod.

In recent years, the department has taken responsibility for several key projects sponsored by the National Basic Research Programme of China (973 programme) and the National Natural Science Foundation of China (NSFC). It boasts theoretical and methodological innovations in lithosphere and climate evolution, and interpretation of geophysical data. A hypothesis proposed by its researchers about the long-term cyclicity of ocean carbon reservoir was highly praised internationally.

The faculty is staffed by eminent scholars in the field, including Professor Wang Pinxian, member of the Chinese Academy of Sciences, three Chang Jiang Distinguished Professors, four recipients of the National Science Fund for Distinguished Young Scholars, and an innovative research group receiving NSFC's Science Fund for Creative Research Groups. The talented faculty members have published important works, such as The South China Sea: Palaeoceanography and Sedimentology (Springer) and Geology of the China Seas (Elsevier), as well as hundreds of papers in international journals, including *Nature* and *Nature Geoscience*.

With a focus on Earth system science, the department seeks to understand the effects of tropical forcing on climate change and the geological evolution of Western Pacific. Its major research directions include palaeoceanography and palaeoenvironment, marine sedimentology, marine biogeochemistry, evolution of ocean lithosphere, as well as submarine resources and exploration. By blending these basic deep-sea research areas, it has extended from studies of purely marine geology to sub-divisions of marine science and geophysics and has established a maritime base in Lingang, Shanghai. The department's international collaboration has helped forge a global reputation for China.

Tongji University's Marine Geology department has taken the lead in basic deep-sea research of the South China Sea (SCS). The department led the Evolution of Deep Sea Processes in the South China Sea (SCS Deep), a 190 million RMB NSFC project running from 2011 to 2018. It is the first large-scale basic research project in China's marine science history, aiming to reconstruct the marginal sea's life history, in terms of structure and magmatism, sedimentation and palaeoceanography, and biogeochemistry. The first foray into the sea in 2013 of China's manned submersible, Jiaolong, was part of the project.

Global cooperation in deep-sea research is demonstrated by the department's participation in international ocean drilling projects, such as the Deep-Sea Drilling Project (DSDP), Ocean Drilling Program (ODP) and Integrated Ocean Drilling Program (IODP). Aimed at better understanding of Earth history and dynamics, these are the world's longest and largest cooperative geoscience projects. The Marine Geology department of Tongji is home to the China IODP Office and Research Centre. With four voyages to the SCS — the ODP Leg 184 in 1999, IODP Expedition 349 in 2014, and IODP Expeditions 367/368 in 2017 to explore East Asian Monsoon, SCS seafloor spreading and SCS

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rifted margin, the department has made China a major force in ocean drilling and promoted development of China's seafloor observation sciences and technology.

The seafloor observation network marks outstanding progress in ocean science and technology. North America, Japan and many countries in Western Europe plan to construct cabled observatories deep in the ocean for prevention of disasters such as earthquakes and tsunamis. Tongji's marine science programme took the lead in putting the construction of a seafloor observation network into China's national 12th five-year plan. In January 2016, the National Development and Reform Commission appointed Tongji to be in charge of the construction of the National Seafloor Scientific Observation Network with funding of about 2.1 billion RMB. This will improve seafloor observation science and technology.

Tongji Marine Science has organized the integration of multiple parties for collective deep-sea exploration, establishing the Collaborative Innovation Centre of Seafloor Process Research, showing capacity for teamwork with marine research institutions. The department has set up the International Collaborative Laboratory for Deep Sea Science.

In 2014, in an evaluation by an global team led by Professor Nick McCave, the former head of the Earth Sciences Department at the University of Cambridge, the department was praised as a significant regional research institution and an emerging international research centre. ■

CIVIL ENGINEERING

Making things better from the ground up

Tongji's multi-functional shake table system supports seismic testing for bridge engineering.

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Since the economic reform in 1978, China has witnessed tremendous development in building and infrastructure construction, with rapid emergence of skyscrapers, long-span bridges and deep tunnels. Many of these mega projects have been achieved with the contribution of Tongji-trained engineers, who have a global perspective, strong leadership and deep insights into sustainability. Their contributions have won worldwide repute for Tongji.

The College of Civil Engineering at Tongji University originated in 1914 based on the German educational approach. During a restructuring in 1952, the college attracted excellent scholars and civil engineers, who helped to take Tongji civil engineering to the top ranks.

Resource scarcity and environmental degradation pose a huge challenge for the globe. It is time for the construction industry, which is closely related to human wellbeing, city development and economic growth, to broaden its objectives from being safe and economical to being comfortable, artistic, durable and sustainable. The College of Civil Engineering at Tongji University is training students in this vein.

After 30 years of massive city construction, buildings and infrastructures are degrading, in the worst cases, collapsing due to environmental changes and prolonged loading. In 2014 alone, corrosion-related losses and anti-corrosion measures for bridges, wharves and oceanic platforms cost 2.1 trillion RMB in China. By employing multi-scale methodologies and leveraging resources from other disciplines, such as chemistry, materials, mechanics and information technology, the college has been exploring the combined effects of environmental factors and loading on structures, the evolution mechanism of their performance and the time-variant reliability. These efforts help enhance the lifecycle performance of structures, and as a result, increasing their service life and reducing resource consumption.

China is prone to earthquakes, strong winds and other natural disasters. Aided by world-class multi-direction shaking tables and wind tunnel clusters, the college has made great achievement in the development of high performance, low damage, earthquake resistant structural systems and devices, which are

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widely applied. It has also made a significant theoretical breakthrough in aerodynamic flutter and buffeting of super long-span bridges. These have provided solid support to the construction of the 632-metre high Shanghai Tower, the Jiangyin Yangtze River Bridge and the Hong Kong–Zhuhai–Macau Bridge.

Moving beyond considering the effects of any single disaster, Tongji people have established a multi-hazard assessment framework. The college is planning to build an experimental centre to explore soil-structure interaction in a multi-hazard environment, aiming to gain an in-depth understanding of the failure mechanism and lifecycle management of engineering structures.

The traditional construction industry is still labour-intensive and demanding of resources. Powering buildings and producing building materials account for 46% of the total energy use in the entire country. The college is dedicated to developing smart buildings and infrastructure (Construction 4.0) to lead the industry along a green, low-carbon path. The research is supported by interdisciplinary technologies, including UAV (drone) photography, artificial intelligence aided planning and design, additive manufacturing, heavy load robotics, wireless sensing, self-healing material, building information modelling and the Internet of Things.

The new concept has been successfully applied to the 2010 EXPO Sunbeam building (Shanghai) and the low-carbon operation of the EXPO site, which have attracted worldwide attention.

The 21st century is the age for the development of the underground space. Taking account of the various rock-soil characteristics in different areas across China, the college has long been engaged in developing the geotechnical material evolution theory and the micro-disturbed construction control theory for tunnels. It has also developed a research platform on digital and smart underground space, as well as a risk evaluation-based operation platform for underground space. These platforms make it possible to exploit massive underground space, especially in large cities with complex geological environments, extensive underground pipelines and high-rise buildings.

The college is also working on the repair and reconstruction of abandoned mines, the development of deep-sea energy soil, and even the exploitation of lunar soil, for the benefit of mankind. ■

ARCHITECTURE AND URBAN PLANNING

A brilliant vision for China's built environment

China's urban landscape has been revitalized by the contributions of Tongji University's College of Architecture and Urban Planning. The college was the nation's first architecture school to offer a master's programme (1954), doctoral programme (1983) and postdoctoral programme (1988). It also created the first urban planning programme (1953), first landscape programme (1979) and first historic building protection engineering programme (2003) in China.

The college has been a leader of modernist architectural thought in China since the founding of its architecture department in 1952. Since 2000, eco-cities, green architecture, digital design and heritage protection have become the college's four main focuses. Continual efforts to excel underline its goals: to foster a distinctively Chinese contemporary, innovative spirit, to cultivate leading talents with a global perspective and social responsibility, to produce academic results with international impact, and to become

an acclaimed centre of architecture, planning, and landscape education. Academic diversity, innovation, wide application and global collaboration define the edges of the college.

Academic resources

The college is the largest of its kind nationally and has more than 230 full-time faculty members, including two members of the Chinese Academy of Sciences, one member of the Chinese Academy of Engineering, one Thousand Talents Plan professor, and nearly 2,500 students. Built on 33,560 square metres, the college has five teaching and research buildings, including a library, an archive centre, a museum of school history, a museum of art, and laboratories. Its annual total budget for discipline development, teaching and research exceeds 60 million RMB.

With an emphasis on interdisciplinary collaboration, the college works across 15 supporting platforms, respectively in research, education, practice, academic publication and international collaboration. The three academic journals it produces are *Time + Architecture*, *Urban Planning Forum*, and the brand-new *Architectural Heritage* (founded in February 2016).

Interdisciplinary innovation

In 2015, under Shanghai's Higher Education Peak Disciplines Plan, the college has founded nine interdisciplinary innovation teams: building technology and computational design; big data and urban spatial analytics lab; coordinated urban-rural development and rural planning; urban architecture theory & criticism; conservation and regeneration of urban/rural historic environment; intelligent city and transportation mobility; resilient city and sustainability of human settlement; just city and urban governance; and landscape interaction, heritage preservation and green infrastructure.

International collaboration

The college has formed comprehensive academic partnerships with leading institutions all over the world. In recent years, it has hosted almost 30 visiting international professors annually, and held more than 150 lectures by overseas lecturers. The college offers more than 70 lecture courses in English, and has double-degree programmes with 17 prestigious architecture schools around the world, including Milan Polytechnic University, Georgia Tech, Vienna University of Technology and The University of New South Wales. Many world-renowned scholars, such as David Harvey, John Friedmann and Pritzker Architecture Prize winners Tadao Ando, Glenn Murcutt, Robert Venturi, and I.M. Pei serve as honorary or consulting professors at the college. The college also hosts an international competition that attracts more than 20 domestic and international schools annually.

Social responsibility

Faculty and researchers at Tongji have always served the community and the nation. Tongji has provided a detailed planning service for many Chinese cities, and its expertise even extends to advice for cities in Africa and South America. It took part in the planning and architectural design of infrastructure for the Beijing 2008 Summer Olympics and the Shanghai 2010 World Expo, and played an important role in reconstruction after the Wenchuan earthquake in Sichuan. Professors at the college have also led the preservation and restoration of numerous historical cities, villages and architecture across China, such as Lijiang, Pingyao, Zhouzhuang, the Bund on Shanghai's waterfront, and the Putuo Zongcheng temple in Chengde, modelled after the Potala Palace in Tibet. The training centre of city construction leaders, a partnership with the Ministry of Housing and Urban-Rural Development, has nurtured many talents in the urban construction area nationwide.

Academic reputation

The college has made a significant contribution to introducing Chinese architecture, planning and landscape education to the world. It hosts two members of the French Academy of Architecture, four Honorary Fellows of the American Institute of Architects (HFAIA), as well as jury members for the Pritzker Prize, Mies van der Rohe Award and the Global Schindler Award, an academic advisor at Bauhaus Dessau Foundation, an honorary member of American Society of Landscape Architects (ASLA), and the Asia Pacific region president for the International Council on Monuments and Sites (ICOMOS).

Students of the college have won prizes of different competitions all around the world. Pritzker Prize winner Wang Shu graduated from the college.

After hosting the first World Planning School Congress in 2001, the college has since served as the secretariat of the Global Planning Network, and has assisted in the establishment and operation of the Association of African Planning Schools. The college has established the World Heritage Institute of Training and Research for the Asia and Pacific Region under the auspices of UNESCO, Shanghai Centre and Asian Development Bank-Tongji Urban Knowledge Hub, providing training for developing countries and spreading the Chinese experiences. In collaboration with UN-HABITAT, the college was commissioned to compile the book Urbanization in China Since 1978. In 2015, Tongji University ranked 16th in the QS World University Rankings in Architecture & Built Environment. ■

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MEDICAL AND BIOLOGICAL SCIENCES

Healthy reputation for excellence at home and abroad

In 1907, when German physician Erich Paulun founded the German Medical School in Shanghai, he laid down the foundations of what would become Tongji University. It also marked the beginning of Tongji Medicine, which would grow to become China's most renowned medical brand. Endeavour and experience spanning more than a hundred years has put Tongji University medicine and biological sciences in a position of great strength.

Tongji medicine concentrates on cultivating outstanding medical talents, conducting translational medical research and providing high-quality medical service. It seeks to enhance the integrations between medical and life sciences, clinical and basic medicine, the environment and public health, and health science and engineering, so as to push forward the sustainable development of health and medicine.

Tongji University School of Medicine

The strategy of Tongji University School of Medicine is to create a research platform integrating basic and clinical research undertaken by an exceptional pool of talent. The school houses a key laboratory of the Ministry of Education, eight national key clinical specialties and an array of municipal-level key disciplines (specialties) and clinical medical centres. Among its appointed faculty and staff include one member of the Chinese Academy of Sciences (CAS), eight experts recruited by the national 'Thousand Talents Plan', six chief scientists of the National Major Science and Technology Programmes, several Chang Jiang Scholars and recipients of the National Science Fund for Distinguished Young Scholars. It also has a National Innovation Research Group funded by the National Natural Science Foundation of China (NSFC).

The research of the school of medicine and its affiliated hospitals has gained international attention, publishing articles in *Nature, Science,* and *Cell,* with research on stem cells, tumours, neuroscience and vascular diseases. The school's achievements have also been nationally recognised. It has been awarded second prize in the National Natural Science Awards and the National Science and Technology Progress Awards, as well as first prize in the Natural Science Awards by the Ministry of Education and in the Chinese Medical Science and Technology Awards. In 2016, Tongji University School of Medicine and hospitals won 174 NSFC funding grants of 2 billion RMB.

The school cultivates high-calibre medical personnel and has the reputation of producing exceptional doctorates and postdocs. It is establishing an international medical education platform and strengthening its academic

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programmes of rehabilitation medicine and family medicine.

Tongji's school of medicine has six affiliated hospitals and many institutes that encourage collaboration between clinical and basic science research and from which have come many medical achievements. The affiliated Shanghai 10th People's Hospital, focusing on understanding the disease model and progression of colorectal cancer, has applied the model of precision medicine in the disease treatment. The affiliated Tongji Hospital, with the Tongji University Research Institute for Spine and Spinal Cord Injury, the International Research Centre of Stem Cell and Regenerative Medicine and the Sino-US Stem Cell Centre, aims to become the intersection between clinical and basic research. The Shanghai East Hospital is another site for translational stem cell research, aiming to remove bottlenecks that hinder progress in the field. Its research targets also address national priorities in health and medicine, such as cardiovascular disease. Furthermore, the Shanghai Pulmonary Hospital is responsible for the majority of pulmonary/respiratory surgeries performed in the country and was the site of one of China's first lung transplants. The Shanghai First Maternity and Infant Health Hospital has delivered more than 300,000 babies, the largest in the country, and is the regional clinical research and treatment centre for hereditary and rare diseases of infants.

The network of Tongji affiliated hospitals continues to expand.

Tongji University School of Life Sciences and Technology

In the 15 years since Tongji University School of Life Sciences and Technology was established, it has forged a reputation for its impact on the field of biological sciences. The school is defined by 'transformative medicine', and is seeking to develop its stem-cell research, epigenetics, bioinformatics, cytobiology and molecular biology.

Led by Pei Gang, a CAS member and chief editor of *Cell Research*, the school boasts rapid progress in stem cell research, publishing works in *Nature*, *Cell* and other internationally renowned scientific journals, bringing China onto the international spotlight. Results that originated in Tongji have already led to clinical trials to treat Alzheimer's disease.

The school has built up a strong faculty team with academic excellence in various sub-disciplines of life sciences. Among them there are two CAS members, three experts recruited by the national 'Thousand Talents Plan', three Chang Jiang Scholars, five chief scientists of the National Major Science and Technology Programmes, and 12 recruits of the national 'Thousand Young Talents Plan'.

The faculty members are actively engaged in translational research by collaborating with colleagues at affiliated hospitals because they recognise Tongji's core principle —connecting bench research to the bedside.

Pei Gang spearheads stem cell research in Tongji and beyond.

A Tongji team led by Chen Yihan, a CAS member, is dedicated to combating arrhythmia.

Tongji University School of Stomatology

Since 2011, Tongji University School of Stomatology has consistently been the top institute of its kind. Work has encompassed oral restoration and cosmetic surgery, osteogenesis, tooth transplants, bone growth, as well as repairing nerve damage.

The expertise of its researchers was key to landmark research that was published in *Cell* in early 2017. By using a mouse model, researchers were able to find a neural pathway that can result in predatory behaviour. A series of neurons were identified in the amygdala, a section of the brain involved with emotions, which controlled the muscles in the neck and jaw and influenced the level of biting force necessary to kill prey.

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TRANSPORTATION

Moving ever forward

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In its hundred-year history, Tongji University's transportation department has devoted its focus to road and railway engineering — the only place in China to cover both subjects for such a long period. Now, working on road, airport, rail, and Maglev trains for city and intercity transportation, as well as planning, design, management, operation and security of city transportation, the department is the country's most comprehensive institution for land transportation.

Tongji University's first foray into formal education in road and railway engineering adopted the German approach and incorporated the Civil Engineering Department from Qingdao Special Higher College in 1914. From the 1950s, the department reformed and looked to the education methods of the Soviet Union, and it was soon flooded with masters in engineering.

Since China's reform and opening-up, the department, inspired by American education ideas, pursued comprehensive and interdisciplinary development, which led to the establishment of China's first transportation engineering laboratory.

Tongji's transportation programme has had long-term integration with industry and close connection with relevant disciplines on campus, such as civil engineering, urban planning, environment science, telecommunications and surveying. The department has been a source of great support for national transportation development since its early days and is responsive to industry development by nurturing many pivotal and diverse industry figures, from engineers to business leaders.

Policy and design for sustainable transportation

Tongji University studies sustainable transportation policies and system designs, considering fairness, inclusivity, as well as socio-economic and environmental capacity. In building a multi-modal transportation system, Tongji researchers distinguished basic service (public transport, pedestrian transport, and bicycle transport), special public transport service (shared transport and custom transport) and advanced public transport service (individual automobile transport) and came up with an integrated method. Their discoveries and results, many published in quality international journals, guided the design of sustainable transportation policies and multi-modal transportation system for large and medium-sized cities including Shanghai, Shenzhen, and Wuhan.

Transformation to low carbon

Tongji researchers have performed an in-depth study on transforming China's transport system to one of lower carbon emissions on the basis of measurement of life-cycle greenhouse gas emissions. They proposed a policy framework of low carbon emission for transportation that combines structural, technological and policy transformations and defined the short-term and long-term goals. They calculated the road transportation carbon emissions at the city and national scales, built the emission quantitative model emphasizing the interconnections between life cycles of fuels and basic transportation facilities, and evaluated the potential of energy conservation and emissions reduction for the Chinese road transportation industry and for the Shanghai transportation system. They also proposed an Individual Carbon Transaction System targeting private car users which analyses consumers' purchases of new energy vehicles. The findings, published in international journals, provided important policy recommendations.

Rail transit discipline chain

The Chinese population enjoy high-speed rail and the convenience of the subway systems. These evolved from a rail transit discipline chain, which consists of network planning, route design, construction technology, dynamics analysis and maintenance of rail transit. Tongji University's Rail Transit Engineering programme has formed a complete discipline chain.

Investment is key to planning rail transit, whose high cost is one of its greatest challenges. Tongji researchers, leaning on rail transit financing experience from home and abroad, proposed a solution to return development benefits, and built a basic calculation model for value appreciation of nearby houses under the influence of urban rail transit.

They have also developed a tunnel boring approach to construct underground high speed railway beneath existing buildings with minimal disturbance to the surrounding ground, solving a key engineering problem in the sustainable development of rail transit construction.

High-density urban roads

Urban traffic congestion is one of the major challenges in urban expansion and development. High-density urban road networks boost urbanization and socio-economic development, but in the meantime, road congestion constrains urban socio-economic activities, and results in extra energy consumption and pollution.

With state funding support, Tongji transportation scholars introduced a way to identify high-density urban road network traffic congestion; created a theory of analysing such traffic congestion; built a comprehensive transportation design, control and coordination technology system for relieving traffic congestion; came up with improvement measures targeting multiple subjects in complicated mixed-use road network; and developed an analysis platform and design support system for the high-density urban road network congestion. These enabled integration of transportation planning, engineering construction, and transportation management.

Tongji scholars published some of China's earliest transportation technology standards, works and textbooks, which drove the emergence of China's transportation design industry.

Vehicle infrastructure integration: smart transportation

Technologies linking road vehicles and roadside infrastructure to improve road safety and efficiency are essential for the development of sustainable and intelligent transportation systems. Work by Tongji researchers has advanced technologies for vehicle infrastructure integration.

Aimed to resolve major issues in information and control of modern transportation, Tongji researchers built a precise analytic model for complicated urban multi-modal transportation systems, and developed an active transportation control approach that enables vehicle infrastructure integration.

Applying the research results, the team took charge of China's largest intelligent transport system planning — intelligent comprehensive transportation planning for the Suzhou Industrial Park.

They also built the intelligent monitoring system for transportation in Shanghai, Ningbo, Zhuhai and Foshan. The Shanghai Intelligent and Connected Vehicle project they designed was among 46 pilot demonstration projects in the Made in China 2025 scheme, for which up to 20,000 connected vehicles will be produced in 2019. ■

Made of a bamboo-aluminium composite, DuXing is much lighter than normal bicycles.

DESIGN AND INNOVATION

Reinventing the wheel

The Tongji University College of Design and Innovation has a reputation as one of China's leading design education institutions. It seeks to address global challenges by cultivating future leaders in sustainable design and innovation, who can contribute to social development while pursuing academic excellence. The college's vision is to establish an international benchmark for design education and research, which is grounded in China's socioeconomic context, while applicable to the design community worldwide.

The college focuses on improving smart, sustainable ways of living through product, service and system design. This idea is

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upheld by the college's various research teams: the SustainX Design Research Centre, Centre for Digital Innovation, Inclusive Design Research Centre, Design for Social Innovation and Sustainability (DESIS) Research Centre, Biomimetic Design Lab, Behaviour & Cognition Lab, Digital and Parametric Design Lab, Interaction Design Research Lab, and Intelligent Big Data Visualization Lab. This allows an expansive repertoire of techniques, tools, software, assembly and evaluation methods, and perspectives that can be invaluable when for problem solving. The college offers a competitive environment, opportunities, facilities and foresight to fulfil its transformation to an institution dedicated to sustainability.

Sustainable product design

By investigating how to apply the principles and methods of sustainable design, every aspect of design and production is evaluated. This encompasses materials, technology and arts of making, analysis of product life cycle, labour and decision-making. Design strategies are directed by either decreasing resource consumption or developing innovative products that tackle specific environmental issues.

Case 1: A sustainable bicycle

DuXing is a bicycle whose frame is made of a bamboo-aluminium composite that maximises strength and resilience, but also shock absorbance. Designed by Tongji professor, Yang Wenqing for Forever, China's traditional bicycle brand, DuXing is 30–40% lighter than current bicycle models and has already been awarded two innovation patents and three design patents. Innovative products like DuXing and others have helped to revitalize the old brand.

Sustainable service design

Since 2007, the Tongji University College of Design and Innovation has partnered with the Politecnico di Milano to establish the double-degree master's programme of 'Product-Service and System Design' (PSSD), the first of its kind in China. The core of PSSD is to provide quality service based on user experience, so as to achieve a "less consumption, better life" way of production and living. In the years since its founding, PSSD has been applied in the areas of transport, food distribution, health care, urban agriculture and education.

Case 2: Urban public transport design collaborated with VOLVO

Volvo and Tongji College of Design and Innovation collaborated to explore designs for public transport in the urban ecosystem. National policies to promote clean energy have brought a radical change to the public transport landscape, and new stakeholders are emerging. Employing the methodology of service design, the collaborative project studied the interactions, touch points, stakeholders and business models of public transportation systems. This has led to proposed strategies and solutions to the re-design of vehicles, infrastructure, service and system.

Sustainable system design

Extending product life cycle to reduce resource consumption is a cornerstone of sustainable

ENVIRONMENTAL SCIENCE

Leading the way in clean and safe solutions

Environmentally sustainable development requires knowledge and innovation brought by basic research, cutting-edge technology and major engineering applications. The College of Environmental Science and Engineering at Tongji University strives to conduct research on environment and sustainable development while providing a high education standard for students. It owns important technologies with proprietary intellectual property rights concerning wastewater treatment, solid waste treatment, and materials and environmental remediation. These technologies have been applied to some major national projects, such as those designed to control pollution of the Taihu Lake and the Chaohu Lake. The college is also cooperating with the World Wildlife Fund (WWF) on low-carbon city and ecological protection in the Yangtze River basin.

Moreover, the college has developed technologies that can be used to optimize drainage systems; control pollution caused by run-off in cities in the Chaohu Lake basin; upgrade the processes of urban sewage treatment works; and build land–lake eco-zones to intercept pollutants in rivers flowing through cities. With expertise in a range of key technologies such as aquatic biological-ecological remediation, pre-oxidization and biological pretreatment, as well as ozone-activated carbon-UF membrane treatment, the college has effectively used the technologies to control the pollution in

design. Too often products are bound for the rubbish heap shortly after they are manufactured. Therefore, we need a breakthrough that will allow maximum use of all resources with minimal environmental impact. The Tongji University College of Design and Innovation has established the 'Sustainable System Design' master's course. Its research initiative on 'Design for Circular Economy' was supported by the Ellen MacArthur Foundation.

In 2014, the college co-launched an initiative called 'DesignX', which focuses on a new, evidence-based design approach to address complex problems rising from socio-otechnical systems.

Case 3: China's first sustainable primary school

Xinjindai Primary School was damaged by the 2008 Wenchuan earthquake in Sichuan, and through the work of Tongji professor, Lou Yongqi, the school has been transformed into China's first sustainable primary school. The original hilly terrain was preserved, along with the 3,000 mu (around 494 acres) of agricultural fields, minimising disruption to the natural environment. A water recycling system was embedded and building locations were chosen to make best use of natural sunlight and reduce the dependency on electricity. Construction materials from the pre-fabricated houses built for temporary accommodation were repurposed as wall foundations for the new school. In addition, the school was designed not only to be an education institution, but also as a social hub for local people to strengthen interactions and improve the sense of community.

Design for social innovation

Social innovation supports the transformation into a sustainable way of living and production, and can be a powerful driver towards sustainability. Driving the processes of social innovation requires great visions, strategies and co-design tools to transform original ideas to mature solutions and viable programmes. Tongji University believes that design schools should play a crucial role in supporting and accelerating the processes.

In 2009, Tongji University established the Design for Social Innovation and Sustainability (DESIS) Research Centre and initiated a series of important design and research projects on social innovation. In 2015, the college entered the European Network of Living Labs and started experimenting innovative, sustainable strategies and solutions with local communities through close collaboration with them.

Case 4: Designing the community-in-place

In 2015, the Tongji University College of Design and Innovation initiated 'Open Your Space', a community-based project aimed to revitalise the old community of Si-Ping. With over 60 design interventions, the project transformed the community environment—from public facilities to retail stores. In collaboration with local stakeholders, the college has created vibrant cultural hotspots for the community, which led to the emergence of new economic and social relationships. The community has become a design laboratory where new ideas are generated, new tools are defined and tested, and new projects are initiated and supported. ■

rivers, treat sewage in urban areas, protect the safety of drinking water and improve rural environments. Treating underground and wastewater with nano zerovalent iron (nZVI) is at the frontier of research in ecological and environmental sciences.

The college has been an active player representing China in global environmental affairs. Since 2012, as the expert group leader on the China-UN-Africa Water Action programme, the college has been looking at problems facing the Nile, Lake Tanganyika and the Sahara. More than 100 teachers and students have gone to Africa to undertake projects to protect and improve drinking water in countries including Kenya, Ethiopia and Zimbabwe. They have built the Tongji University-Nairobi Lab for Safe Water Supply and provided training to more than 100 water treatment technicians in Africa.

In 2015, the college jointly released a white paper with the United Nations Environment Programme (UNEP). The paper, *UNEP-China-Africa Cooperation Programme: Enhancing the role of ecosystem management in climate change adaptation*, not only increases the college's influence, but helps China establish the trust of African countries, boosting cooperation significantly.

In 2013, the college's Professor Li Fengting was honoured with a UN prize in recognition of special contribution to South-South cooperation. At a variety of global events, including the United Nations Conference on Environment and Development, the college has been the only university representative from China. It attended the side meeting of the 21st Conference of the Parties (COP21) and delivered a report, highlighting the role of Chinese universities on the world environmental scene.

Initiated by Tongji University and the UNEP, the Global University Partnership on Environment and Sustainability (GUPES) was established in 2012. Every year for World Environment Day (June 5), Tongji invites more than 300 people from more than 30 countries to attend the International Student Conference on Environment and Sustainability, at which participants discuss environmental protection and sustainable development, expanding the impact of Chinese universities in the academic world. ■

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