Measuring Sustainable Development in China

Theoretical and Methodological Background of the Sustainable Well-being Index (SWI)

Chinese Academy of Science and Technology for Development
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Foreword

This report documents the theoretical and conceptual approaches and the methodological techniques applied in the development of the Sustainable Well-Being Index for China (SWI). The index is a result of a four years project to develop an indicator system to assess sustainability implications related to rapid economic growth, with particular focus on so-called "emerging economies", and the SWI for China can be considered as a pilot system in this respect.

The original objective of the project was to develop a set of Sustainable Development Indicators (SDIs) for China and emerging economies, with special attention to how growing economic power is converted into increased social well-being and longer-term prosperity. Due to the ambiguity of the term "Sustainable Development" we decided to use the term "Sustainable Well-being" for the index in order to better reflect the sustainability focus of the finally compiled indicator set. However, the SWI should be seen - and is referred to – as a Sustainable Development Index in this report.

The results from the pilot project for China are published via a newly developed web site at www.chinaswi.org. This web site also contains survey data collected particularly for this project, including data that are not included in the index. It also contains a blog on which comments that may help us in improving the index are particularly welcome.

The project has been carried out by a team from the *Chinese Academy of Science and Technology for Development (CASTED)* and *Fafo Institute for Applied International Studies (Fafo)*, complemented by experts on well-being and sustainability indicators from Statistics Norway and Professor Jørgen Randers from the Norwegian Business School BI. In addition to Professor Randers, the team has consisted of: Wang Yuan, Wang Fenyu, Zhao Yandong, Shi Changhui, Zhang Huanzhao, Chen Zhi, Zuo Xiaoli and Ying Ying (CASTED); Svein Erik Stave, Jon Pedersen, Zhang Huafeng, Hedda Flatø, Liu Jing and Kristin Dalen (Fafo); and Per Arild Garnåsjordet and Anders Barstad (Statistics Norway)

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1.1 The emergence of Sustainable Development Indicators

The "modern" debate on environmental and social sustainability has been going on since the 1960s,[1] but the term Sustainable Development was not commonly in use before the launch of the WCED's report "Our Common Future" (The Brundtland Report) in 1987. Both the WCED report and the earlier debates and publications related to sustainability aimed at influencing decision-makers to incorporate environmental and social development aspects into policies and governance. However, the question of monitoring the state of Sustainable Development and the actual effects of Sustainable Development policies and strategies did not come on the agenda before the 2nd UN conference on the Environment and Development in Rio de Janeiro in 1992, the launch of the Rio Declaration, Agenda 21, and the establishment of the Commission on Sustainable Development (CSD).

Chapter 40 of Agenda 21 called on countries and the international community to develop indicators of sustainable development, based on the argument that such indicators are needed to increase focus on sustainable development and assist decision-makers at all levels to adopt sound national sustainable development policies. The call led to the development of a large number of national sets of Sustainable Development Indicators (SDIs), particularly for nations in the western world, as well as a number of universal sets developed by major international institutions dealing with international development, including the United Nations, the World Bank, OECD, and the European Union.

The focus of Sustainable Development, and hence the indicators, has varied substantially since the the 1960s, and also since the initiation of SDIs in the 1990s. The debate associated with Sustainable Development prior to the Brundtland Report had a general focus on environmental issues and the negative effects of economic growth and activities. The first SDIs were developed on basis of the Brundtland report's paradigm of Sustainable Development, which was seeking a balance between economic, social and environmental development. In the 3rd World Summit on Sustainable Development in Johannesburg in 2002, the focus shifted to socio-economic development and poverty alleviation, although concerns were also raised about the potential negative environmental effects caused by the rapid economic growth in the so-called BRIC countries. The focus of the 4th UN conference on Sustainable Development in Rio (Rio+20) in 2012 was "greening of the economy" and institutional frameworks for Sustainable Development, which will set new premises for selection of SDIs.

[1] See e.g. R. Carson's book "Silent Spring" in 1962; D:L. Meadows et al. report to "The Limits to Growth" in 1972; the 1st UN conference on the Human Environment in Stockholm in 1972; and IUCN's World Conservation Strategy, 1980

1.2 SDI frameworks

As already mentioned, most countries in the "western world" have developed national sets of SDIs in the period after the Rio conference in 1992, primarily as part of their national Sustainable Development Strategies. The vast majority of these sets are based on frameworks and guidelines given by the UN and the Commission on Sustainable Development, who published indicator sets in 1996, 2001 and 2006.

The purpose of indicator frameworks – or conceptual frameworks – is to provide a structure in which individual indicators can be organized in order to ensure focus in the indicator selection process (clarify what to measure), and to ensure analytical and aggregation opportunities (how to analyze). All conceptual frameworks are based on certain underlying worldviews or narratives, which are more or less political in nature. These underlying narratives (assumptions about how the world functions or how it should be) are rarely discussed or challenged by indicator measurements. Hence the selection or development of conceptual frameworks determines to a large degree the overall results and knowledge you gain from indicator measurements, and considerations around the construction of frameworks should therefore be given high priority when developing new sets of indicators. Without a strong and well founded conceptual framework as basis for indicators selection, most participatory selection methods, such as public consultations, are likely to fail due to lack of focus and unclear and divergent narratives between the actors involved in the selection process.

Since theories of Sustainable Development, core values, world perspectives, interest, etc., varies considerably between various actors involved in developing SDI sets,

different conceptual frameworks are used by different actors. Among the most common ones are:

- Sustainable Development pillars-based frameworks
- Theme-based frameworks
- Pressure-State-Response (PSR) frameworks
- Capital frameworks
- Index frameworks

Sustainable Development pillars-based frameworks

Most SDI frameworks are based on the conventional dimensions, or pillars, of Sustainable Development derived from the Brundtland report's definition of the concept: the social; the economic; and the environmental dimension, normally complemented with a fourth dimension: the institutional/ governance dimension. These dimensions, also termed sectors or pillars, may serve as a framework structure alone, but in most SDI sets they are combined with other frameworks (see below). When the four dimensions of Sustainable Development are used alone to organize SDIs, they serve as a theme-based framework (see below) where individual indicators are selected to cover key sustainability aspect in the respective sectors. Using the four dimensions of Sustainable Development as the sole and only framework for selecting SDIs generally leads to problems such as lack of focus.

Theme-based frameworks

Theme-based frameworks are the most widely used type of frameworks internationally, especially in official national indicator sets. Typical examples of theme-based frameworks are the third set of indicators developed by CSD/UN (see table 1) and the SDIs for the European Union, which are organized according to 11 main themes (level 1 indicators) sub-divided in two more levels (EU 2009). The main themes are:

- Socioeconomic development
- Climate change and energy
- Transport
- Consumption and production
- Natural resources
- Public health
- Social inclusion
- Demographic change
- Global partnership
- Good governance

As with Sustainable Development pillars-based frameworks, a weakness of theme-based frameworks is that they may lead to fragmented SDI sets, incorporating "all good intentions" but also lacking focus and the ability to provide aggregate views of Sustainable Development in general. An advantage of theme-based frameworks, and a main reason for their popularity, is that they are easily adaptable to monitor the effects of national Sustainable Development Strategies, and hence are policy-relevant.

Pressure-State-Response (PSR) frameworks

Pressure-State-Response (PSR) frameworks are process models where each indicator is classified as a pressure, a state, or a response. Pressure indicators describe processes or activities that have a positive or negative effect on Sustainable Development (e.g. pollution). State indicators describe the current situation (e.g. the health status of children exposed to the pollution), whereas response indicators reflect societal actions aimed at moving toward Sustainability (e.g. pollution control measures). The initial set of 134 CSD/UN indicators, published in 1996, was organized in a PSR framework. Whereas variations of the PSR continue to be used in more environmentally oriented indicator sets, the revision of the CSD/UN indicators in 2001 discontinued the PSR framework mainly because "it was not suited to addressing the complex interrelationships among issues; the classification of indicators into pressure, state or response was often ambiguous; there were uncertainties over causal linkages; and it did not adequately highlight the relationship between indicators and policy themes" (UN 2007). Nevertheless, it can be argued that the PSR framework has a stronger theoretical basis than for example theme-based frameworks, and hence promotes clearer focus and more analytical coherence, but also that these strict theoretical boundaries are difficult to handle politically.

Capital frameworks

Capital frameworks[2] provides a basis for calculation national wealth as a function of the sum of and interaction among different types of capital, including not only financial capital and produce

[2] See: United Nations, 2009: Measuring Sustainable Development; United Nations, New York and Geneva. http://www.unece.org/fileadmin/DAM/stats/publications/Measuring_sustainable_development.pdf

capital goods, but also natural, human, social and institutional capital. This requires in general that all types of capital must be expressed in common terms, usually, in monetary terms. In a Sustainable Development perspective this implies a focus on "what resources we have at our disposal today, and whether we manage these in ways that make it possible to maintain and further develop the resource base over time"[3]. Explicit in Capital frameworks is the notion of substitutability between different types of capital, which is a complex and debated issue particularly in relation to elements that are difficult to quantify (or - should not be quantified) in monetary terms, such as climate and biodiversity.

Other challenges attributed to Capital frameworks are: disagreements about how to express all types of capital in monetary terms; problems of data availability; and the integration of intra-generations equity concern within and across countries. An advantage of the framework is however that it may provide a powerful tool for decision-making due to its close link to the standard system of National Accounts, and that it allows aggregation through the accounting system. Another framework based on the Capital approach and linked to the system of National Accounts, is the System of Integrated Environmental and Economic Accounting (SEEA)[4], which includes accounts expressed in monetary terms as well as in physical terms.

National Accounts based frameworks, such as the SEEA, were not set up specifically to address Sustainable Development and therefore do not take into account two of the four dimensions of Sustainable Development – the social and the institutional pillars. Some of these concerns are addressed through efforts to expand the system by incorporation human capital and to explore the possibility of linking the frameworks with social accounting matrices.

Index frameworks

Index frameworks, or in more general terms – aggregated or composite indicators, have generally been developed to capture certain aspects of Sustainable Development, in particular environmental aspects (e.g. the Ecological Footprint; the Environmental Sustainability Index; and the Environmental Performance Index). The Ecological Footprint[5] translates human resource consumption and waste generation in a country or any other entity into a measure of biological productive land and water and relates it to a measure of biological capacity. The Environmental Sustainability Index[6] integrates 76 data sets—tracking natural resource endowments, past and present pollution levels, environmental management efforts and the capacity of a society to improve its environmental performance—into 21 indicators and finally into a single index. The Environmental Performance Index[7] aggregates 16 indicators related to resource depletion, pollution, environmental impact and energy efficiency into an index aimed at measuring policy impact.

More comprehensive aggregated indicators on sustainable development include the Adjusted Net Saving, developed by the World Bank, and the Genuine Progress Indicator (GPI). The Adjusted Net Savings[8] indicator is calculated by subtracting monetary values for resource depletion and damage caused by air pollution from traditional net savings derived from national accounts, and adding expenditures on education. This indicator is also included in the set of CSD indicators in the economic development theme. The GPI[9] modifies GDP by adding economic contributions of household and volunteer work, but subtracting factors such as crime, pollution, and family breakdown in order to arrive at a measure of well-being.

Aggregated indicators face significant challenges to aggregation related to data availability; methodologies; selection of variables; and in the case of indexes – the weighting of the relative importance of variables. The main advantage of the frameworks is that they promote consistency and relationship between indicators and scales in the SDI sets. Construction of hierarchical structures if SDIs provides good opportunities for analyses of relationships between indicators; aggregations of different parts of the SDI set – or the whole set; and flexibility in the way SDI results can be presented (e.g. by presenting aggregate results through public media for creating attention, and more detailed results for decision-makers and experts).

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[3] See: Alfsen, K. and Moe, T., 2005: An International Framework for Constructing National Indicators for Policies to Enhance Sustainable Development. Background paper prepared for the UN Experts Group meeting on Indicators of Sustainable Development, 13-15 December 2005, New York

[4] See: http://unstats.un.org/unsd/envaccounting/seea2003.pdf

[5] See: www.footprintnetwork.org

[6] See: www.yale.edu/esi

[7] See: www.yale.edu/epi

[8] See http://go.worldbank.org/3AWKN2ZOY0

[9] See; www.redefiningprogress.org/newprograms/sustIndi/gpi/index.shtml

Table 1.1: Conceptual frameworks used in selected national indicator sets

Country	Conceptual frameworks
Austria	Theme
Brazil	SD dimensions
EU	Theme
Finland	SD dimensions/themes
France	Theme
Germany	Theme/SD dimensions
Hungary	Theme
Iceland	Pressure-State-Response (PSR)
Norway	Capital/Theme
Republic of Korea	Theme/SD dimensions
Spain	Theme
Czech Republic	Theme/SD dimensions
Switzerland	Theme
Japan	Index (scores 0-100)/SD dimensions (nature, society, economy, well-being)
Taiwan	Pressure-State-Response (PSR) (P: Ecological resources, Environmental Quality; S: Social, Economic; R: Institutional Response)

1.3 Recent international trends

The UN through CDS has been and is still the prime supplier of premises to the international community on how to frame and select SDIs. However, in recent years there have been an increasing number of initiatives to develop alternative SDI frameworks, primarily by key international institutions in the field, such as the World Bank, the OECD, and the EU, also in collaboration with the UN.[10] The key trends seen in these initiatives are:

- Stronger attempts to move away from GDP as the core measure of the level of national development
- Greater emphasis on Well-being, including subjective Well-being, as a key measure of national success
- More focus on the role of biodiversity and ecosystems services in Sustainable Development, although few concrete measures have been proposed.
- A focus on greening of the economy and on the role of institutions in promoting Sustainable Development
- A stronger recognition of the need to make predictions based on SDIs, to a high degree exposed by the lack of warnings given prior to the 2007 financial crises.
- An emerging interest in the concept Planetary Boundaries[11] as basis for SDIs
- A move away from rigid and mechanical SDI frameworks and towards systems that are more flexible; incorporate more narratives and underlying perspectives; and which include different types of data from more sources, in particular qualitative and perceptional data.

1.4 SDI development in China

China has for many years been concerned with the measurement of social and economic progress, and a substantial body of work has been carried out.[12] SDI initiatives in China have undergone an evolutionary process based on varying understandings and policy practices regarding sustainable development. Since the 1980s the focus has shifted from population, natural resources and environment to coordinated economic and social development interactions including social justice etc. While initially considered simply a governance tool, the concept of sustainable development is now integrated in China's national development strategy. Moreover, the application of the concept has shifted from learning by importation, to incorporating international experiences with domestic issues.

In 2004 Wen Jiabao launched a "green GDP" effort and a green GDP report was issued in 2006 by the State Environmental Protection Administration and the National Bureau of Statistics (NBS). The report corrected the GDP by subtracting environmental costs, such as the cost of resource depletion and various forms of pollution.

The UNDP Human Development Index has been calculated for the various provinces of China. An alternative has been explored by researchers at Ren-

[10] Key initiatives that have defined these trends are: 1)The Commission on the Measurement of Economic Performance and Social Progress (Stiglitz-Sen-Fitoussi Commission); 2)The Joint UN-ECE/Eurostat/OECD Task Force for Measuring Sustainable Development; 3) The EU Sponsorship Group on Measuring Progress, Well-being and Sustainable Development; 4) The European initiative "GDP &Beyond: measuring progress in a changing world"; 5) The European Commission's "Europe 2020: A strategy for smart, sustainable and inclusive growth; 6) The European Council's Renewed EU strategy for sustainable development; 7) The OECD Better Life Initiative: Measuring well-being and progress; 8) The OECD Green Growth Strategy; 9) The United Nations Millennium development goals; 10) The United Nations Human Development Index (HDI); 11) The 4th UN conference on Sustainable Development (Rio+20). For more about each of these initiatives and their relevance for the developments of SDIs in China, see the sub-report 1 (The-State-of-the-Art) from this project

[11] See: http://www.ecologyandsociety.org/vol14/iss2/art32/, and WBGU, 2011

[12] For an example of early work on this issue, see Hao Xiaohui, 1998.

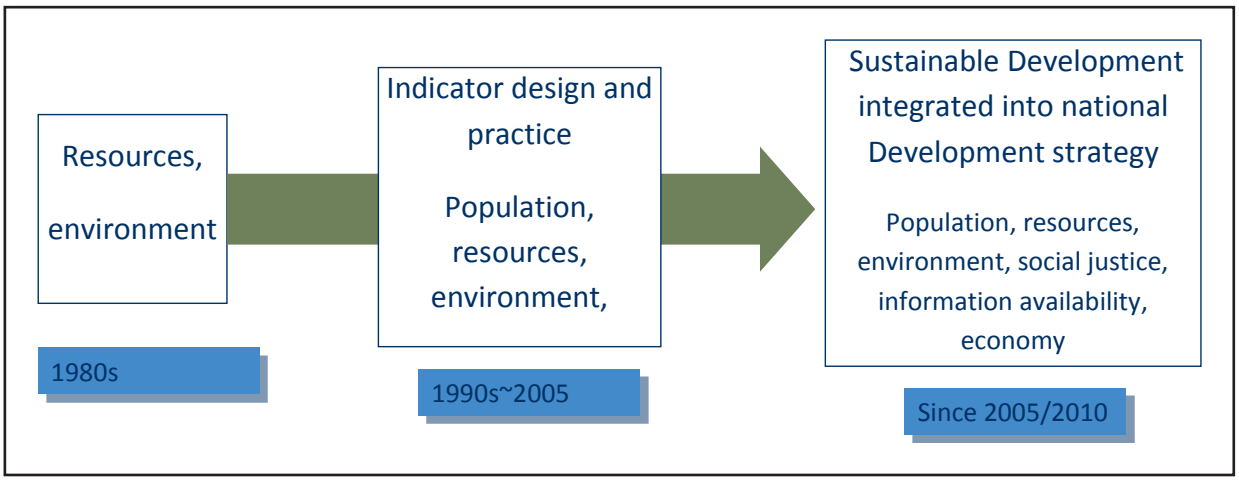

Figure 1.1: Historical evolution of SDI studies in China

min University of China. The Development Research Center (under the State Council) published for some years a Purchasing Parity Adjusted economic index, but this has now been discontinued. The Research Centre for Sustainable Development at Chinese Academy of Social Sciences (CASS) has in cooperation with WWF started work on Low Carbon Development Index for cities in China (and globally), and CASS has also done considerable research on life satisfaction. A research team at the Institute of Sociology at CASS, headed by Zhu Qing Fang, has developed a number of different indicators to measure the development of cities and regions of China (for example level of modernization, level of wealth and social development).

In recent years, research institutes and provincial statistical institutes in China have started to collect data on several new topics, including many of those advocated in the 2008 Sen-Stiglitz-Fitoussi report[13]. The Yunnan provincial statistical agency has started data collection on time-use, public security and evaluation of policies. NBS has since 2000 calculated county level data on social and economic development, but have only published data on the "top 100 counties in China". Although NBS does not currently publish any comprehensive set of indicators of sustainability and social development, several regions and cities in China have developed their own sets of indicators that they use to measure and monitor the development in their areas.

China's national and local governments have defined various eco-indicators to promote sustainable development. The State Council, for example, has proposed national emission-reduction targets in its latest five-year plan (2011–15), for which the eco-indicator is a reduction in carbon dioxide emissions per unit of gross domestic product by 40–45% in 2020 relative to 2005 levels[14] . Others include circular-economy indicators released by the National Development and Reform Commission in 2007 to address the environmental degradation and resource scarcity associated with rapid economic development[15]; national eco-industrial park indicators set up by the Ministry of Environment Protection in 2006[16]; regional sustainable-development indicators brought in by the Ministry of Science and Technology in 2009; and national environmental-living indicators put forward the Ministry of Housing and Urban-Rural Development.

Some of the challenges associated with development of eco-indicators in China include allowance of local government officials to cherry-pick their achievements and to select indicators that cast them in a positive light due to lack of standardization. Data collection on eco-indicators is also complicated when it involves different agencies. Officials need to secure cooperation from other relevant government agencies to guarantee the validity and accuracy of such data. Most eco-indicators are voluntary and can be pursued with different intentions. The relatively rich regions of eastern China have a genuine interest in improving resource efficiency and environmental performance. The poorer western regions are more likely simply to want to gain access to national financial subsidies[17].

Many of the abovementioned efforts to develop Sustainable development indicators in China build on Systems Theory and Complex System Method.

[13] The Commission on the Measurement of Economic Performance and Social Progress (Stiglitz-Sen-Fitoussi Commission);

[14] see http://go.nature.com/4k3mqo

[15] H. Li et. al. Energy 35, 4273–4281; 2010

[16] Y. Geng et. al. J. Ind. Ecol. 13, 15–26; 2009

[17] Geng Yong; Nature 477, 162; 08 September 2011

They involve a large number of indicators, and some sets try to cover every aspect of economy and society. Existing indicator sets reflect many key topics on sustainable development in China from different viewpoints, including human well-being, modernization, and transformation of development modes. However, it is difficult to quantify the indicators and to distribute weight, and some of the indicators are overlapping. The existing indicator sets are weak on biodiversity and are strongly focused on development, while the contradictions between human and economic development and environmental protection remain unsolved. Moreover, the existing indicator sets put little emphasis on identifying thresholds and threats to sustainability in China.

Hence, a strong need remains for a well-structured system of sustainable development indicators for China which is not only comprehensive and informative, but also reflects dynamics and the relationships between different indicators. The new SDI set should combine a strong theoretical framework with policy relevance. Therefore, it must to a large extent take into account the national context and priorities of the country. The next chapter outlines a framework for developing such an SDI set for China.

Chapter 2: Theoretical and Conceptual Basis for Measuring Sustainable Development in China

2.1 Defining Sustainable Development

The most frequently quoted definition of Sustainable Development comes from the report by the World Commission on Environment and Development, also known as the Brundtland commission[18], published in 1987:

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

This rather ambiguous definition contains two key concepts: First, the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and second, the idea of limitations imposed by technology and social organization on the environment's ability to meet present and future needs.

The Brundtland report basically envisions Sustainable Development as a continuation of previous mainstream development paradigms[19], focusing on the need for economic growth; justness in the distribution of resources and wealth; public participation; and the belief that unwanted effects of development, e.g. negative environmental effects, can be controlled by technological development and appropriate organization of the society. However, compared to the previous mainstream development paradigms, Sustainable Development adds one important dimension: the concern for future generations and a long-term perspective of preserving opportunities, including a stronger focus on preservation of natural resources and the environment.

To provide a meaningful basis for developing a conceptual SDI framework for China, there is a need to make some fundamental clarifications regarding the definition of Sustainable Development. The first is to clarify whether the various dimensions and priorities of Sustainable Development (as defined by the Brundtland report) - economic growth; social equality; and environmental sustainability - are compatible with each other, or whether some dimensions or priorities are more important than other. Secondly, there is a need to clarify what to sustain and the relationships between sustainability at different scales - from local to global; and thirdly, there is a need to clarify the time dimension and the meaning of "future generations".

2.1.1 The question of priority

The Brundtland report from 1987 argued that Sustainable development could be achieved by an integrated policy framework embracing the three main pillars of Sustainable Development: Economy; Society; and the Environment, and that continued economic growth can be achieved without degrading the natural resource base and the environment. This perspective is consolidated in the recent report from the UN General Secretary-General's High-Level Panel on Global Sustainability "Resilient People, Resilient Planet: A future worth choosing", which has been called "the new Brundtland report"[20], in which the panel states its long-term vision as: "to eradicate poverty, reduce inequality and make growth inclusive, and production and consumption more sustainable, while combating climate change and respecting a range of other planetary boundaries".

Critics have argued that this "official" definition of sustainable development contains too many objectives and that many of them are contradictive. Many critics also argue that by "merging all good intentions" in the concept the key novelty of it (compared to pre-

[18] United Nations World Commission on Environment and Development (WCED), 1987: Our Common Future, Oxford University Press, Oxford.

[19] The need for economic growth was the core of the "Economic Growth" paradigm which dominated development thinking in the 1950s and early 1960s (and still is a key aspect in mainstream development strategies). The "Growth with Re-distribution" paradigm commonly referred to in the late 1960s and early 1970s can be seen as a reaction to the negative effects of Economic Growth paradigm, and focused on the importance of various economic sectors, particularly the agricultural sector, in economic growth. A stronger reaction to the Economic Growth paradigm was introduced by ILO in the late 1970s and early 1980s with the "Basic Needs" development paradigm. This paradigm stated that elimination of poverty and the fulfillment of the basic needs of the poor could not be guaranteed by growth itself. Instead it was argued that resources had to be redirected towards the poor by direct government interventions rather than relying on the market forces. Hence, prior to the introduction of the "Sustainable Development" paradigm in 1987, mainstream development paradigms had already covered the main economic and social – or economic growth and social redistribution aspects - of development.

[20] United Nations Secretary-General's High-level Panel on Global Sustainability, 2012: Resilient People, Resilient Planet: A future worth choosing, United Nations, New York.

vious development concepts) – the focus on future generations and the preservation of natural resources and the environment – loses its value.

A general critique of the Brundtland/UN definition and focus of Sustainable Development is that it gives too much priority to the development and human construct aspects of the concept compared to the Sustainability and environmental aspects. This perspective holds that the global environment possesses some finite boundaries for human activity and that human activity must adapt to these boundaries, implying that the environmental dimension of Sustainable Development has primacy over the social and economic dimensions, and that the sustainability of human activity and human constructs, such as economic and social systems, is reflected by its impacts on the environment.

An increasingly common view, e.g. in ecological economics, is that human development based on the current growth paradigm is incompatible with sustainability, and that the only way out of the present unsustainable trend is to reduce the total metabolism (the flow of matter and energy) in the human society and thereby reducing the pressure on the environment on which our well-being depends. The perspective of reducing social metabolism is commonly referred to as *de-growth* and reflected in an alternative definition of Sustainable Development by Daly and Goodman[21]:

> *"[Sustainable development is] development without growth in throughput of matter and energy beyond regenerative and absorptive capacities."*

2.1.2 What to sustain? – And the questionof scale

Another key question is what to sustain? The ambiguous nature of the Sustainable Development concept has led to wide range of uses – and misuses – of the term, and the concept has been used to justify almost whatever various actors have been interested in sustaining. In this respect, the relationship to the question of priority is quite obvious in the way that defined development goals, such as increased industrial production; public consumption; or even increased human well-being, might be in conflict with core sustainability principles such as preservation of biodiversity.

Most of the ambiguity regarding what to be sustained is related to scale. What can be seen as sustainable at one level might be unsustainable if seen in context at a higher level. For instance, a household that generates sufficient income, food, and other necessities to satisfy the needs of its members and which is part of economic, political, and social networks that enable maintenance of this situation might be defined as a sustainable household. However, if the household's wealth is based on over-exploitation of natural resources, involvement in unsustainable economic activities or exclusion of other actors in satisfying their needs, there is little meaning in talking about a sustainable household. A highly relevant parallel to this example is the relationship between national and global sustainable development where economic and social development of nations often is attributed to undermining global sustainability, e.g. by increasing use and dependency of energy and natural resources, and increased pollution and environmental pressure from human activities related to development and growth.

A key principle of Sustainable Development (although not undisputed) is that for anything to be defined as sustainable it cannot contribute to undermining sustainability at higher scales. Hence, sustainability at one level, e.g. national sustainability, must always be related to sustainability at higher scales, and ultimately global sustainability is the core reference to any assessment of sustainability at lower scales.

2.1.3 Sustain for how long?

The last key question that typically comes up when discussing Sustainable Development is what time span we talk about for something to be sustained. This question is particularly relevant for practical policy purposes and the process of defining policy objectives for Sustainable Development.

There are no exact answers to this question. The best guideline is probably to relate time frames to the scale dimension discussed in the previous paragraph. Different systems, e.g. political and economic systems; industrial sectors or activities; and communities, have different life-cycles which should be taken into account when considering the time dimension of Sustainable Development.

A general problem when it comes to the time dimension and sustainability is that lower level systems tend to be preserved or sustained for too long while the highest level – the global level – tend to be considered in a too short time frame. This phenomenon is related to the scale discussion above and the fact that we invest more in sustaining an industry or an

[21] Herman Daly and Robert Goodland, "Environmental Sustainability: Universal and Non-negotiable," Ecological Applications, Vol. 6, no. 4 (1996), p. 1002.

economic activity that might undermine higher level sustainability compared to preserving the natural environment and the global basis for human life in the longest imaginable sense.

As with the scale dimension, a key principle of the time dimension of Sustainable Development is that the global level is the ultimate reference point, and that every lower unit's sustainability must be seen in relation to the time frame of the global system and the preservation of the basic requirements for human life. Hence, the highest level time frame of Sustainable Development should – at least in theory – be "forever".

In practical – and political - terms, Sustainable Development Policies should focus on a time frame between around 5 and 60 years, of which the lower limit is defined by (above) one parliamentary period while the upper limit is defined by approximately a "man-age", where generations (children, grandchildren) are taken into considerations and where time is sufficient to develop and implement new solutions to sustainability challenges.

2.2 Searching the ideal or addressing the un-ideal?

The ambiguous nature of the Sustainable Development concept, and the fact that different groups of people perceive what Sustainable Development means in different ways based on different world perspectives or narratives, makes it unsuitable as a reference point for measurement. Instead of searching for the ideal picture of the concept, it can be more convenient to define what is unsustainable, and to use unsustainable trends and thresholds as reference points for measuring Sustainable Development.

In this perspective it is possible to identify indicators of Sustainable Development by identifying threats and opportunities for Sustainable Development with reference to the core principles of the concept discussed in the previous section, and particularly the principle of preserving the life-support systems for human life at the global scale.

One way to conceptualize threats to Sustainable Development is to distinguish between "external" and "internal" threats or "unsustainabilities". External threats refer to threats associated with human impacts on its surrounding environment and hence the threats of undermining the life-support systems that we all depend upon. This perspective is rooted in the "environmental boundaries" tradition which claims that there are certain ecological thresholds that should not be passed in order to avoid radical changes in man's surrounding environment which might lead to severe effects on human life as we know it. Examples of such threats have been defined by the concept of Planetary Boundaries[22].

Internal threats refer to unsustainable aspects within the human society, such as poverty; lack of food and water; bad health, etc. These "unsustainabilities" are more related to the development dimension of Sustainable Development, but with focus on provision of basic needs and the basic requirements for a healthy life and which in principle can be attributed to thresholds that should not be passed.

In addition to identifying external and internal threats to Sustainable Development as basis for identifying Sustainable Development indicators, there is also a need for identifying some obvious opportunities for promoting Sustainable Development. These opportunities are generally related to economic, political, and social initiatives and interventions in order to deal with the external and internal threats, and are hence essential to promote and support policies and decision-making for Sustainable Development. Examples of opportunities that can be used to identify SDIs are shifts towards renewable energy sources; greening of the economy; lifting the level of basic education; and innovation for sustainability. An actor's (e.g. a government or a business corporation) aspiration to promote sustainability may be reflected by its willingness to sacrifice (relatively secure) short-term gains with (relatively insecure) longer-term gains/opportunities.

2.3 Sustainable Development as a systemic challenge

Sustainable Development whether defined as an ideal or through the concept of unsustainabilities (see previous section) is a complex concept where components and processes at various scales and between scales interact. Hence, the concept is deeply rooted in systems thinking and in the concept of a system, which can be defined as:

> *An assembly of components which functions a whole because of the interactions between the components*

This definition implies two key characteristics of systems that can be useful in conceptualizing SDI frameworks: 1) they have an identifiable structure including

[22] See: http://www.stockholmresilience.org/research/researchnews/tippingtowardstheunknown/quantitativeevolutionofboundaries.4.7cf9c5aa121e17bab42800043444.html

internal interconnections between components, and 2) they possess some behavioral properties as wholes. Furthermore, systems interact with other systems at the same scale, e.g. industrial businesses in a market, and with systems at higher scales, e.g. a community agricultural system and the global climate system.

A systems perspective is useful in three ways in conceptualizing an SDI framework:

1. *To construct a logical and consistent framework based on the structural characteristics of the system of interest.*
2. *To enable analysis of the relationships between the components (indicators) in the system*
3. *To test the degree of coevolution of individual indicators and the system as a whole*

Theories about the structure of systems are generally derived from observing how various systems as wholes behave under different circumstances. Typical measurable behavioral properties of systems that reflect the sustainability of general systems are productivity (how much a system does produce in relation to the inputs it uses), stability (the stability of the productivity over time), and equity (the distribution of the productivity within the system). Recently, much attention has been given to a fourth behavioral property of systems –resilience, or the robustness of a system to deal with pressure or shocks.

Similar to the "unsustainabilities" approach presented above, resilience theory focuses primarily on the boundaries or thresholds within human activity should operate to avoid negative consequences in the form of system changes at higher scales. A key focus of resilience theory is also the interplay between human institutions (in a broad sense) and the environment, with particular attention to how the institutions adapt to a constantly changing environment. Much of this theory is captured in the so-called adaptive cycle[23].

The adaptive cycle seeks to describe how social-ecological systems, at any level, adapt – or fail to adapt – to a changing environment or context (systems at higher scales). A system, e.g. a nation or a firm, typically emerges with a phase of growth (e.g. due to the recognition of market opportunity in a given context at a given time) (phase α in figure 2.2). After some time the context changes while the system seeks to preserve its position by spending relatively more energy on conservation activities (phase K in figure 2.2).

The conservation strategy works well until a certain point (tipping point) where the business activity has no more resources to use on conserving its position or ability to manipulate the context to maintain its original structure and activity (phase Ω in figure 2.2). The system then moves into a phase of re-organization, often characterized by innovation, to be able to adapt to the changed context (phase r in figure 2.2). If the re-organization is successful the system moves into a new adaptive cycle, while if not successful the system may collapse (phase x in figure 2.2).

The adaptive cycle is useful in describing many of the aspects discussed in the previous sections of this chapter. For instance, both the question of scale and what to sustain, as well as for how long, can be related to phases of the adaptive cycle. A key point of which the adaptive cycle is particularly good at clarifying is the distinction between *sustaining* and *conserving*. Sustainment, e.g. of a particular economic, political, or social system, is not actually sustainable in this perspective if it is not adapted to its context and should rather be termed conservation and related to the K-phase of the adaptive cycle.

2.4 Economic growth, Sustainable Development and Wellbeing

The Sustainable Wellbeing Index (SWI) for China aims to provide an overview of "sustainable development" trends in China, using the concept of "wellbeing" as the end objective of sustainable development. The index has been developed to assess socio-economic and environmental effects of rapidly growing economies in general, and their implications for the ability of sustaining the wellbeing created by the economic growth.

In section 1.3 it was stated that one of the recent and most substantive international trends regarding measurement of development, including sustainable development, is to emphasize on wellbeing, and implicitly move away from GDP as a key focus of development. In this perspective GDP (economic growth) is seen as a factor that provides opportunity for development rather than being an end goal in itself. Wellbeing, however, can be seen as an end goal of development, and hence wellbeing is a way of operationalizing the concept of development.

The SWI for China is based on this perspective of development, which constitute the overarching framework of the conceptual model of the index (figure 2.1). Other key criteria for the conceptual model are presented in the next section (2.5). The model consists of four

[23] Source of image, and reference: Gunderson L. H. and C. S. Holling (eds.), 2003: Panarchy: Understanding Transformations in Systems of Humans and Nature; Island Press, Washington DC

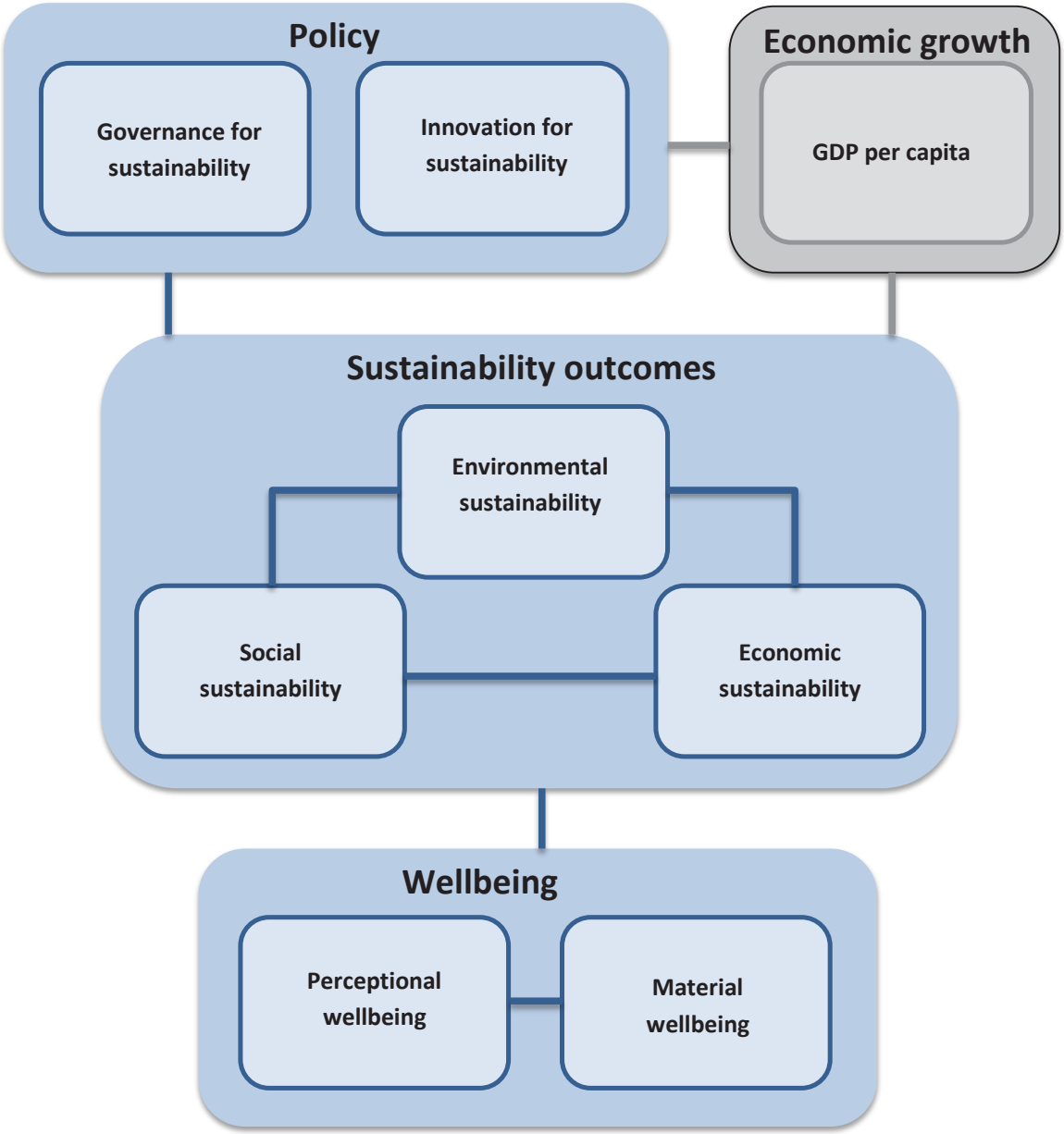

Figure 2.1: A conceptual model for measuring sustainable wellbeing in emerging economies

parts, of which economic growth (GDP) is basically considered as an independent variable. GDP influences "sustainability outcomes, which is primarily a set of "classical" sustainable development indicators describing status and trends with respect to environmental, economic, and social aspects. The "sustainability outcomes" describes key aspects defining people's wellbeing, which in the model is measured through objective and perception/subjective indicators. The last part of the model is labelled "policy inputs/outputs" and refers to policy and innovation activity and its influence on the other parts in the model, hence also its contributions to sustainable development and wellbeing.

This first version of the index, however, can be regarded as a pilot system which aims to test the data availability, the indexation methodology, and the usefulness of the results generated from the index. The present version also focuses primarily on the classical aspects of sustainable development, i.e. socio-economic and environmental aspects, and to a less degree on wellbeing explicitly. The reason for this is that the main data on wellbeing are generated through a specially designed "sustainable wellbeing survey" (SWS), which has been carried out only once up to now (2013). Once a time series of data is available from this survey, "wellbeing" will be included as a separate "sector" in the index framework (see figure 2.1). This first version of index, however, is based on a preliminary framework constituting mainly of the two parts "policy inputs/outputs" and "sustainability outcomes" in figure 2.1 (see figure 2.3).

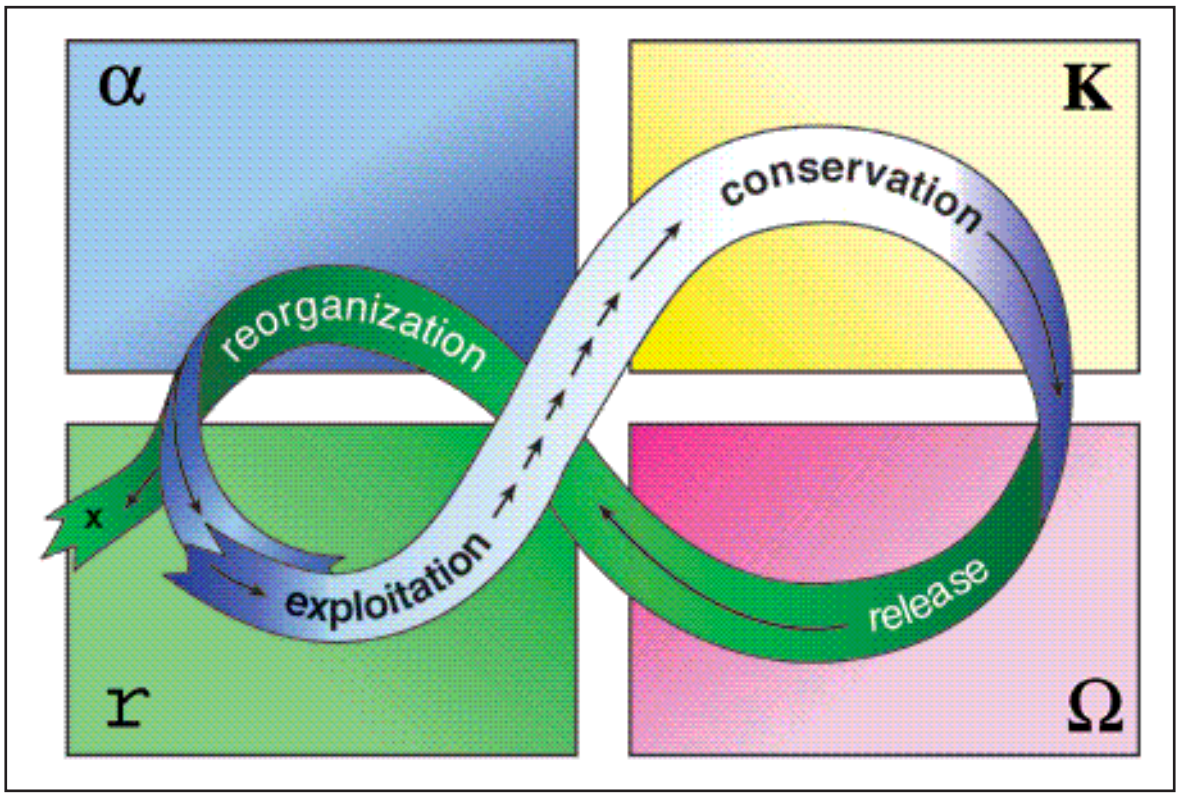

Figure 2.2: The Adaptive Cycle

2.5 Key Criteria for Developing an SDI Framework for China

On basis of the discussion in the previous section, and earlier sub-reports of this project[24], we have settled upon the following key criteria for developing an SDI framework for China:

The SDI set should provide new and added statistical information for decision-making compared to already existing statistics

Added statistical or decision-making value can be achieved in three different ways: 1) by focusing on the core dimensions and principles of the Sustainable Development concept as discussed in this report, and particularly focusing on threats and opportunities according to these principles; 2) by ensuring conceptual consistency of the framework to enable analyses of existing data in new ways based on the systems concept and the core principles of Sustainable Development; and 3) by collecting new data on key aspects of Sustainable Development in China, e.g. survey data on well-being.

The SDI set should include relevant indicators on innovation and social structure

Innovation is a key aspect of the problem solving ability of a society as well as in seizing the opportunities in a transition towards a more sustainable society. However, innovation in a sustainability perspective should comply with the core principles of Sustainable Development, e.g. be concerned with society's ability to deal with yet unknown challenges and long-term aspects rather than with promoting shorter term development objectives such as economic growth. In this perspective it can be seen as a fascinating paradox that the same innovative capacity that has put us in the current environmental predicament is actually what can be used to push us out of it[25].

The SDI set should focus on "threats" and "opportunities" for Sustainable Development in a Chinese context

By applying the "threats and opportunities framework" presented above to identify indicators, the SDI set should be policy relevant as well as publicly relevant in China, also in the short term. As an example we have settled on threats that are related to environmental externalities of rapid economic growth, such as air pollution, and to increasing social inequality e.g. between the population in rural and urban areas. We have identified opportunities related to increased well-being based on the economic growth as well as investments in future sustainability.

[24] Including a review of existing sets of SDIs presented in the first sub-report from phase one of this project (The state-of-the-art).

[25] See http://www.stockholmresilience.org/download/18.33db2ae-01355ec8e8f227c8/Insights_innovations.pdf

The interpretation of the SDIs should be based on dynamic benchmarks (reference values for assessing whether a result indicates a positive or negative change with respect to SD), i.e. benchmarks that change according to changes in the development context of China.

For many measures it is impossible to settle on long-term ideal benchmarks for assessing how to interpret change in an indicator, or for defining which values of a measure indicate threats or opportunities for sustainable development. Therefore benchmarks that are currently agreed upon can only be valid for limited periods of time and in the context of China's current development situation. Hence, the assessment and interpretation of indicators and values must be re-assessed regularly.

The SDI set should provide opportunities for international comparison of Sustainable Development, and include indicators reflecting recent international trends in priorities and in measurements of Sustainable Development

One of the objectives of developing SDIs for China is to be able to compare aspects of Sustainable Development in countries experiencing rapid economic growth, with initial priority on China, India, and Brazil. This will be pursued by applying the same conceptual principles to develop SDI sets in the three countries and by harmonizing the data collected. Moreover, the SDI frameworks should incorporate the signals from recent key international sources on priorities of Sustainable Development and SDIs. These aspects include the focus on well-being strongly advocated by the Stiglitz-Sen-Fitoussi Commission, and the focus on planetary boundaries, greening of the economy and institutions focused on in the report from the UN Secretary-General's High-level Panel on Global Sustainability.

The SDI set should avoid the main conceptual and methodological problems identified in existing SDI sets

Lastly the SDI set should take lesson from the analytical and methodological limitations identified in existing international SDI sets. The main problems are: inconsistencies and lack of focus of the SDIs; a heavy focus on input indicators, such as investments in interventions assumed to promote development; and limited added value due to heavy reliance on already existing statistics combined with the conceptual inconsistency.

2.6 Structure of the indicator set

Figure 2.3 shows the general structure of the proposed conceptual framework for measuring Sustainable Development for China. The structure is based on the discussion and the key criteria presented in the previous sections.

The structure consists of four hierarchical levels of indicators, starting from the highest level:

1. *An overall expression of Sustainable Development for China*
2. *Sector indicators*
3. *Theme indicators*
4. *Sub-indicators and Measures*

The sector indicators reflect the conventional dimensions of Sustainable Development: Environment, Society, and Economy. In addition an institutional dimension is added, which again is sub-divided into the sectors of Governance and Innovation. However, the structure is constructed to provide opportunities to organize the indicators according to other frameworks such as according to behavioral properties of systems, e.g. productivity, resilience, and equitability. A global dimension is also possible to extract from the proposed structure although the five global theme indicators are organized according to their relationships to the various sectors in the basic structure (marked with bold letters in figure 2.3).

The two institutional sector indicators – Governance and Innovation – basically focus on the opportunity aspects of Sustainable Development, and how they contribute to promote a sustainable development. The three remaining sector indicators – Social; Economic; and Environmental Sustainability – primarily focus on observed and potential threats to Sustainable Development in China. Hence, they also reflect the effects of the performance within the governance and the innovation sectors. The social sector, in which the actual life of people is the key focus, is in the center of the system, reflecting that the key measurable attribute of sustainable development – human well-being – is part of this sector, and that it can be seen as a result of the conditions in the other sectors.

Under each sector indicator a number of theme indicators are listed, selected to reflect the agreed-upon conceptualization of each of the sector indicators. The theme indicators are composite indicators focusing on core aspects of Sustainable Development.

Under the broad sector indicators, each theme indicator is a composite indicator measured by a number of sub-indicators and measures. The selection of sub-indicators and measures is based on a combination of conceptual value and practical considerations of data availability. The aim is for the measures to reflect the conceptual indicator above it in the hierarchy - to the extent possible given the constraints posed by data availability and resources.

Chapters 3-7 describe each of the five sectors in the SWI for China in detail, including its sub-indicators and measures.

Figure 2.3: The structure of the first version of the SWI for China

Chapter 3: Governance for sustainability

3.1 Governance and Sustainable Development

Sustainable development included aspects such as: promoting sustained, inclusive and equitable economic growth, creating opportunities for all, reducing inequalities, raising basic standards of living, fostering equitable social development and inclusion, and promoting integrated and sustainable management of natural resources and ecosystems. Inter alia, sustainable development supports economic, social, and human development, while facilitating ecosystem conservation, regeneration and restoration to develop resilience with respect to new and emerging challenges. China, being a country undergoing a transition from a developing to developed country, is facing a number of threats to sustainable development, as seen historically in other countries that have previously undergone the same transition, including pollution, social imbalances, growing income gaps, etc. At the same time, economic growth and social transition provides unprecedented opportunities for sustainable development such as improved education opportunities, improved health, and green technological advances.

China and other countries have to make efforts to deal with threats and opportunities related to sustainability, not only in the short term, but also in the long term. China's ability to do so depends to a large extent on how the country's institutional set-up as well as policies and government efforts are suited for dealing with environmental and social sustainability challenges, and for providing opportunities to promote sustainability.

In order to assess the sustainability of governance in China, we assess indicators of five major aspects of sustainable governance, namely: Government's responsiveness to sustainable development challenges; Governance efficiency; Government's promotion of sustainable development; Public participation in governance (termed Inclusive Governance); and China's engagement in global sustainability affairs (termed Global governance responsibility).

3.2 Indicators of Sustainable Governance

Theme indicator 1: Government responsiveness to sustainable development challenges

Responsiveness to SD Challenges are indicators of the Government's ability and effort to deal with threats or challenges to sustainable development. This is measured by indicators of responsiveness to environmental challenges and responsiveness to poverty. Measures of responsiveness to environmental challenges are chosen because environmental sustainability lies at the core of the SD concept and environmental issues are considered to be the major external threat to long-lasting sustainable development throughout the literature. Three measures are selected for assessing government responsiveness to environmental challenges, and include: positive administrative rulings related to environmental destruction; urban waste collection; and environmental pollution control investment.

Government responsiveness to poverty is here defined as government efforts to alleviate poverty and/or improve the living standards of the poor. Poverty is considered the most glaring threat to sustainable socio-economic development throughout the literature, and government input to poverty alleviation is therefore a "minimum requirement" indicator of the extent to which a government takes responsibility for responding to threats to sustainable socio-economic development. One measure is selected for assessing government responsiveness to poverty, namely, government funding of social relief relative to total fiscal expenditure.

Table 3. 1 presents the measures selected for assessing government responsiveness to sustainable development challenges.

Theme indicator 2: Governance efficiency

Governance efficiency is here defined as the government's performance in provision of public services. This is selected because it indicates general governance capacity, which is crucial for implementing any policy, including those aimed at alleviating both environmental and social threats to sustainable development. Table 3.2 presents the measures selected for assessing governance efficiency.

Theme indicator 3: Government promotion of sustainable development

Government promotion of sustainable development means efforts made by the government to ensure that politico-administrative structures and rules, as well as the natural environment, enable continued sustainable development in the future. It means promoting opportunities for sustainable development and preventing challenges or threats to sustainability from arising, rather than reactively responding to threats.

Table 3. 1: Measuring government responsiveness to sustainable development challenges

	Measure	Definition	Relevance	Data source	Formula
1.1	Number of positive administrative rulings related to environmental destruction (10,000 cases)	The measure shows the number of administrative cases that are related to environmental issues in which administrative punishment decisions have been made.	In order to improve responsiveness to environmental challenges, the government emphasizes paying increased attention to environmental crime and enforcement of environmental laws. An increase in the number of administrative environmental punishment decisions is here considered to indicate increased government efficiency in administrative enforcement of environmental laws. An increase in the number of punishment cases is therefore considered to be an indicator of improvement with regard to government responsiveness to environmental challenges.	China Statistical Yearbook on Environment (2000-2010)	
1.2	Percentage of waste garbage collected and disposed of according to environmental safety standards (% of total urban garbage)	The measure shows the percentage of urban garbage that has been sorted according to their source materials and safely disposed of. In China, urban household garbage has been divided into four categories: Recyclable waste, kitchen waste, hazardous waste and other waste. The aim is for garbage to be collected by category and deposited through four waste disposal methods: Comprehensive utilization, sanitary landfill, incineration and composting.	Urban household garbage disposal is a worldwide problem due to accelerated urbanization, sharp increases in urban household garbage, and insufficient capacity for garbage treatment. The measure of urban garbage collection is an indicator of the government's performance in responding to this environmental challenge.	China Statistical Yearbook on Environment (2000-2011)	
1.3	Percentage of environmental pollution control investment in GDP (% of GDP)	The measure shows the government's financial input to environmental pollution control investment, as percentage of GDP. Environmental pollution control includes investments in the following four issue areas: Urban environmental infrastructure construction, industrial pollution control, and so-called "three simultaneous" environmental protection of construction projects (建设项目“三同时”环保投资).	The measure is an indicator of the extent to which the government makes financial contributions in response to the environmental challenges connected with economic growth.	Statistical Yearbook of China (2000-2011)	Environmental pollution control investment/ GDP *100
1.4	Funds allocated by the central government to social relief, as percent of total fiscal expenditure (% of total fiscal expenditure)	The measure shows the sum of funds allocated to social relief programmes in China, as percentage of fiscal expenditure. Funds for the following social relief programmes are included: Social welfare and other social relief; urban minimum living guarantee (最低生活保障); other rural social relief funds; rural "five guarantees" (五保); and natural disaster relief.	The measure indicates the extent of government contributions to financial assistance for the poorest in society and is as such an indicator of the government's financial responsiveness to poverty.	Ministry of Civil Affairs Statistical Yearbook (2000-2010)	Social relief funds/ Total fiscal expenditure *100

Table 3.2: Measuring government efficiency

	Measure	Definition	Relevance	Data source	Formula
1.5	Public perception of government corruption	Public perception of government corruption is measured by the survey question "In general, how serious would you say that official corruption is as a problem in society today?". Reply alternatives are very serious, rather serious, not serious, and not a problem at all.	High levels of corruption indicate poor government performance and pose serious threats to sustainable development by undermining government legitimacy and efficiency. Prevalence of corruption is notoriously difficult to measure and validate. The measure used here indicates citizens' subjective evaluation of the extent to which corruption poses a social problem in China.	Survey (P2)	
1.61	Public dissatisfaction with central government performance	Public dissatisfaction with government performance is measured by the survey question "Generally speaking, do you feel satisfied with how the central government is performing?". Reply alternatives are very satisfied, somewhat satisfied, somewhat dissatisfied, and very dissatisfied.	The measure indicates citizens' subjective evaluation of the overall performance of central government.	Survey (GS1,GS2)	
1.62	Public dissatisfaction with county government performance	Public dissatisfaction with government performance is measured by the survey question "Generally speaking, do you feel satisfied with how the county government is performing?". Reply alternatives are very satisfied, somewhat satisfied, somewhat dissatisfied, and very dissatisfied.	The measure indicates citizens' subjective evaluation of the overall performance of county government.	Survey (GS1,GS2)	
1.7	Percentage of government expenditure to total fiscal expenditure (%of total fiscal expenditure)	The most common measure of government expenses in Chinese statistics prior to 2007 was "administrative expenses". From 2000-2004 administrative expenses included expenses for the staffing and administration of public security, the armed police, diplomacy and foreign aid; however, these issues were separated out from the "administrative expenses" numbers in 2005 and 2006. In 2007, the measure was adjusted and replaced by the concept "General public services (expenses)". General public services (expenses) includes expenditures for staffing and administration of general public services management (public offices and a range of other domestic issues); Foreign affairs; Defense; and public safety. It should be noted that general public spending in 2007 and 2008 also includes domestic and foreign bond interest expense, but since 2009 this was taken out, and since 2010, domestic debt interests have been listed separately and not included in the numbers for general public expenditure.	The measure indicates how much expenditure the government spends on administering its normal operations. If a lower percentage of fiscal expenditure is spent on government administration, more fiscal funds are available for financing public services, public investment, or public savings. As such the measure may serve as an indirect indicator of government efficiency. Hence, a decrease in the percentage of government expenditure to total fiscal expenditure is assumed to indicate a positive change in terms of sustainable governance.	Statistical Yearbook of China (2000-2011)	Government expenditure /Total fiscal expenditure *100
1.8	Days required to start up new enterprises (total days on average)	The measure shows how many days is spent on average to go through the bureaucratic procedure required to establish a new company.	The measure is used as an indicator of bureaucratic efficiency.	The world bank (2000-2012)	

Government promotion of sustainable development means not only promoting environmental sustainability, but also social sustainability. For indicating government promotion of sustainable environment we include measures of the government's efforts to ensure that the national environment can be sustained in the long term, thereby preventing external threats to sustainable development. Promotion of social sustainability is here measured as government input to prevention of social problems through ensuring the population's opportunity to obtain education and enjoy basic social protection in ill-health and old age. Table 3.3 presents the measures selected for assessing government promotion of sustainable development.

Theme indicator 4: Inclusive governance

Inclusive governance is crucial for a government to be perceived as legitimate and responsive to its citizens' preferences. Hence, inclusive governance is selected as a core indicator of sustainable governance. Given China's governance system, dichotomous measures of democracy/non-democracy would provide little added information about the system in place or changes over time. Therefore, measures have been selected for assessing the extent to which citizens, social organizations and the private sector participate in governance through the channels available in China. Table 3.4 presents the measures.

Theme indicator 5: Global governance responsibility

As China's international influence and interests are expanding, it is becoming an increasingly important actor for constructing and sustaining international political, social, economic and financial systems. Many hope that China will increasingly contribute to global sustainable development through more active participation in global governance. The theme indicator "global governance responsibility" has been selected to reflect the extent to which China is taking on such a role. Table 3.5 describes the measures selected for assessing China's contribution to global governance.

Table 3.3: Measuring government promotion of sustainable development

	Measure	Definition	Relevance	Data source	Formula
1.9	Percentage of Renewable energy investment to GDP (% of GDP)	The measure shows public and private sector expenditures on developing CO2 substituting energy, as percentage of GDP. The original data was in USD, and the data for each year was converted based on the average exchange rate in that year between RMB and USD .	One of the most effective ways to decrease carbon emissions is to develop and employ substitutive energy or green energy. Development of alternative energy sources is therefore a crucial tool for promoting a sustainable environment.	UNEP and the People's Bank of China (2004-2011)	Renewable energy inverstment /GDP *100
1.10	Percentage of the country designated as Nature Reserves (% of total landmass)	The measure shows the size of nature reserves as percentage of the country's total landmass.	In nature reserves, the ecological system's stability and sustainability is promoted through nature conservation.	China Statistical Yearbook on Environment (2000-2011)	Size of nature reserves / Total size of country's landmass *100
1.11	Public expenditure per enrollment in 9-year compulsory education (RMB per student enrolled)	The measure shows government financial input to 9-year compulsory education.	Basic education is a fundamental opportunity for sustainable development in a country. Thereby, this is a low-threshold measure of government input to the fundament for social sustainability.	Statistical Yearbook of China (2000-2009)	Public investment in 9-year compulsory education/ Total enrollment in 9-year compulsory education
1.12	Public pension expenditure per person aged 60+ (RMB per person 60+)	The measure shows government financial input to pensions per old person aged 60 years or more in China. Note that due to data availability issues we measure public pension expenditures per person aged 60 years or more, no matter whether the person is retired or not.	The measure indicates to what extent the government contributes to sustaining basic livelihood needs for old-age citizens.	Statistical Yearbook of China (2000-2011)	Public pension expenditure/ Population 60+
1.13	Public health expenditure per capita (RMB per capita)	This is a measure of government financial input to public health services per person.	The measure indicates to what extent the government contributes to securing access to healthcare services for its population.	Statistical Yearbook of China (2001-2010)	Public health expenditure/ Population

Table 3.4: Measuring inclusive governance

	Measure	Explanation	Relevance	Data source	Formula
1.14	Change in number of registered social organizations (year-on-year change)	The measure shows change in the number of "social organizations" (社会团体) registered by China's Ministry of Civil Affairs. In the Chinese context, the concept of "social organizations" refers to organizations with varying degree of autonomy from the state, from the China Family Planning Association and other organizaitons set up by the government to more autonomous groups such as Friends of Nature.	Social organizations offer opportunities for citizens to make their views heard or participate in provision of common goods. Hence, an increase in the number of regisetered social organizations indicates an increase in public participation in governance.	Statistical Yearbook of China (2000-2011)	Number of registered social organizations in current year-Number of registered social organizations in previous year
1.15	Number of proposals raised by representatives to the National People's Congress (NPC)	The measure shows the number of proposals raised by representatives in the NPC every year.	The measure indicates the level of activity by delegates to the NPC. The NPC is officially the highest state body in China. It consists of about 3000 delegates elected by provincial people's assemblies.	Statistical Yearbook of China (2000-2013)	
1.16	Number of proposals raised by the Chinese People's Political Consultative Conference (PCC)	The measure shows the number of proposals raised by representatives in the PCC every year.	The measure indicates the level of activity by delegates to the PCC. The PCC functions as an advisory body and consists of more than 2000 members representing political parties, organizations, or independents.	Statistical Yearbook of China (2000-2013)	

Table 3.5: Measuring global governance responsibility

	Measure	Definition	Relevance	Data source	Formula
1.17	Foreign aid as percentage of GDP	China's contributions to foreign aid relative to its GDP is measured based on the value of the following four types of transfers to developing countries: First, donation of money or goods; second, interest-free or preferential low-interest loans; third, project assistance and planning assistance; and fourth, emergency assistance loans.	The measure indicates the relative size of China's financial contributions to developing countries which, although mostly unconditional, may be used for purposes such as eradicating poverty, strengthening science and technology development, and improving working and living conditions.	Statistical Yearbook of China (2002-2011)	Foreign aid/ GDP *100
1.18	Personnel in international peacekeeping operations (persons)	The measure shows the number of Chinese personnel currently engaged in international peacekeeping operations. International peace-keeping operations are intended to create stable, peaceful relations in conflict affected areas through civil and military means. They are generally based on a UN mandate, and are as a rule guided by the following principles: impartiality, the consent of the conflicting parties to the deployment of the peace-keeping troops, and minimal use of force.	The measure indicates China's contributions to international peacekeeping efforts.	Statistics of UN Peacekeeping (2000-2012)	

Chapter 4: Social Sustainability

4.1 Human society and Sustainable Development

As described in Chapters 1 and 2, the concept of sustainable development has two main aspects: First, maintaining the sustainability of the ecological system through responding to "external" threats to sustainable development and promote opportunities to improve it. The second aspect regards "internal" sustainability, namely, maintaining the sustainability of the human society by satisfying current and future generations' needs without damaging the ecological environment. Therefore, the Sustainable Development Index includes a substantive number of indicators of both threats to and opportunities for the sustainability of human society, i.e. sustainable social development.

The index measures sustainable social development from the perspective of quality of life, defined as the objective and subjective benefits enjoyed by people living in specific conditions; and the operational and developmental conditions of societal elements directly or indirectly affecting such benefits.[26]. Hence, quality of life consists of two dimensions: Individual quality of life and social quality of life[27]; this comprehensive understanding of quality of life is often referred to as "well-being", signifying all aspects of life and all elements affecting this well-being. The objective dimension of this concept includes all aspects of living conditions related to individual well-being, such as health, education, housing, income, consumption, employment, social security and so on, which are interrelated elements. Subjective Quality of Life, also called Subjective Well-being, is for the purposes of the sustainable development index defined as people's life satisfaction evaluated according to their own standards, both in general terms and with regard to specific issues.

In consideration of the aim of assessing social sustainability in China both in the short and long term, the attention to quality of life is not limited to what people actually get and their degree of satisfaction, but also focuses on whether individuals have the ability to realize what they are going for and whether they can positively and consciously drive their own way of life according to their preferences. The aim of sustainable social development is not simply to improve quality of life, but also to achieve a foundation that provides individuals or households with opportunities to further improve their own situation and abilities. The sustainable development of society therefore includes a number of elements affecting individual welfare, such as stability, equality, fairness and justice.

Overall, the selection of indicators of sustainable social development in China is based on a theoretical framework whereby the relationship between sustainable social development and quality of life is seen as interdependent; the aim of sustainable social development is to improve quality of life, which again strengthens the sustainability of social development. Quality of life is conceptualized as consisting of individual and societal quality of life. Specifically, social sustainability is measured through nine theme indicators: Health status; Health risks; Living conditions; Social security; Public safety; Social equality; Social cohesion; Population structure; and Global social capital.

4.2 Indicators of Social Sustainability

Theme indicator 1: Health status

Human health and sustainable development are inextricably linked. The quality of the environment and the nature of development are major determinants of health. Health is also a crucial prerequisite for other aspects of development. Healthy people are more productive economically, and more importantly, good health is a goal in itself. Physical and mental health is a fundamental determinant of quality of life. In many aspects, economic development in China and other countries can be assumed to improve opportunities for obtaining good health for example through better access to medicines and treatment. Ideally, objective and subjective indicators of both physical and mental health should be included for measuring the sustainability of developments in health. Due to lack of measurement methods and data validity, the set does currently not include mental health measures. Table 4.1 describes the measures selected.

[26] Xing Zhanjun et al. 2011, PublicPolicy-oriented Quality of Life Research, Shandong University Press, P25

[27] Noll, H.-H.: Konzepte der Wohlfahrtsentwicklung: Lebensqualität und neue Wohlfahrtskonzepte. WZB Discussion Paper,Berlin: Science Centre, 2000. Quoted from: Xing Zhanjun, 2011, Public Policy-oriented Quality of Life Research, Shandong University Press, P1

Table 4.1: Measuring health status

	Measure	Description	Relevance	Data source	Formula
2.1	Prevalence of Non-Communicable Diseases (‰ of the population)	Non-communicable diseases (NCDs) are medical conditions that are non-infectious and non-transmissible between persons. We use WHO's definition of NCDs as consisting of the following four groups of diseases: Cardiovascular diseases, Cancers, Diabetes, and Chronic lung diseases. The indicator is calculated as the weighted sum of prevalence in different age groups, by size of population in each age group. In the data used here, prevalence of NCD is measured as follows: Proportion of the surveyed population who had been diagnosed with one of these four groups of diseases within half a year before the survey; or who had been diagnosed with one such disease by a doctor earlier but experienced symptoms during the past six months and had received medical treatment for the disease, such as medication or therapy.	Non-communicable diseases (NCDs) have become the leading causes of death globally, killing more people each year than all other causes combined. NCDs are particularly relevant in a sustainability perspective because they are to a large extent caused by four behavioral risk factors that are pervasive aspects of economic transition, rapid urbanization and 21st-century lifestyles: tobacco use, unhealthy diet, insufficient physical activity and the harmful use of alcohol. NCDs pose a particularly grave threat to sustainability because NCDs are important drivers to the downward spiral that leads families towards poverty, particularly in low – and middle-income countries.	National Health Services Survey (2003,2008)	$\sum_{agei} \left(\frac{x_{chronic}}{x_{chronic}} * N_{agei} * (x_{cardiovascular} + x_{cancers} + x_{diabetes} + x_{chronic\ lung\ disease}) \right)$
2.2	Average life expectancy (year).	Average life expectancy of the population born in the same period, given that current mortality rate is stable. Total average life expectancy is derived by the World Bank from male and female life expectancy at birth. The indicator is calculated as mean of male and female life expectancy. The sources include: (1) United Nations Population Division. World Population Prospects, (2) United Nations Statistical Division. Population and Vital Statistics Reprot (various years), (3) Census reports and other statistical publications from national statistical offices, (4) Eurostat: Demographic Statistics, (5) Secretariat of the Pacific Community: Statistics and Demography Programme, and (6) U.S. Census Bureau: International Database.	Average life expectancy is an outcome measure not only of a population's health conditions, but also of a country's socioeconomic situation and the quality an accessibiility of the healthcare services in the country.	World Bank(http://data.worldbank.org/indicator/SP.DYN.LE00.IN) (2000-2010)	(Men life expectancy + Women life expectancy) / 2
2.6	Self-rated health status	Subjective evaluation of one's own health conditions, meausured by the following survey question: "Generally speaking, how would you describe your physical health situation?".	The measure is an indicator of subjective health status, which is a crucial determinant of subjective individual well-being.	Survey (B5)	

Theme indicator 2: Health risks

Economic development also leads to changes in lifestyle which is likely to increase the morbidity of some diseases. We therefore include risks to health as second theme indicator of sustainable social development. Table 4.2 describes the selected measures.

Theme indicator 3: Living conditions

The third theme indicator of the social sustainability sector aims to assess well-being through measures of people's living conditions – that is, the material conditions provided by a society to its members.

The theme indicator includes both objective and subjective measures of individual material well-being. Objective indicators include income and expenditure measures in addition to measures of housing conditions. As mentioned in the introduction on social stability, people's feelings about their own well-being and quality of life is of considerable importance in addition to objective measures of living conditions and their

Table 4.2: Measuring health risks

	Measure	Definition	Relevance	Data source	Formula
2.7	Per capita daily alcohol consumption (Kg)	Alcohol consumption is measured slightly differently in urban and rural areas in China. We therefore use two different measures to reflect per capita alcohol consumption in China: First, urban resident household per capita liquor purchase, and second, rural resident household per capita liquor consumption. The measure is then calculated as weighted sum of urban and rural data, with weight equal to the proportion of urban and rural population each year. All household members are included, both adult and non-adult. The types of alcohol measured is mainly white liquor, fruit wine, and beer.	High rates of alcohol consumption is a threat to social sustainability, as alcohol abuse is harmful for individual health and may cause numerous social problems.	China Statistical Yearbook (2000-2007)	Urban per capita daily alcohol comsumption/ purchase*proportion of urban population+rural per capita daily alcohol comsumption*proportion of rural population
2.8	Per capita daily tobacco consumption	This measure is derived from Chinese domestic yearly cigarette sales volume divided by the total population aged 15 years and more. Daily per capita tobacco consumption is then calculated by yearly consumption divided by 365 days.	Smoking rates are a key indicator of unhealthy and thereby unsustainable lifestyle. As a threat to individual health and well-being, high smoking rates are negative for social sustainability.	"1. Tobacco Industry Economic Operation Communique, State Tobacco Monopoly Administration (2000-2006); 2. Cheng Yingshan and Tian Song's Cigarette Consumption Analysis based on Macroeconomic Data, Chongqing and the World, Nov. 2012 (2007-2011)"	Yearly cigarette sales/ population 15+/ 365
2.9	Obesity (% of adult population)	Obesity rates are here measured as the percentage of obese persons in the adult population. Obesity is measured by Body Mass Index (BMI), in formula: body weight/square of height(kg/m2), at evaluation criteria: BMI<18.5 "underweight", 18.5≤BMI<24.0 "normal weight", 24.0≤BMI<28.0 "overweight", BMI≥28.0 "obese". Note that the definition of the adult population varies in different data sets used in the SDI. Data from 2002 are provided by the Chinese national nutrition and health survey,whose statistical calibre for "adult population" was the population aged 18+. Data from 2005 and 2010 are provided by the Nationals Physical Quality Surveillance Communique in 2010, whose statistical calibre for "mature population" was the population aged 20+.	Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health. Obesity as an illness is closed related to environmental factors, unhealthy nutrition and lack of physical activity. It reduces functional ability and increases the risks of cardiovascular diseases and cancers, thus posing a threat to sustainable health and sustainable social development.	"1. Chinese national nutrition and health survey, published by Ministry of Health of China (2002); 2. Nationals Physical Quality Surveillance Communique in 2010, published by General Administration of Sport of China (2005,2010)"	

distribution. For the China SDI, subjective well-being is measured through two survey questions, described in Table 4.3.

Theme indicator 4: Social security

Social security is an important determinant of living conditions and central to social sustainability. Appropriate social security systems may both respond to internal sustainability threats and do in themselves provide opportunities for enhancing well-being and social sustainability. China and many other countries base their social security on social insurance systems, which provide support in cases of disability, unemployment or ill-health. The Sustainable Development Index for China therefore uses measures of social insurance to assess the level of and changes in social security.

Table 4.3: Measuring living conditions

	Measure	Definition	Relevance	Data source
2.10	Urban household yearly per capita disposable income (RMB, adjusted by CPI, base year 2000)	The measure shows the actual income at the disposal of members of the households which can be used for final consumption, other non-compulsory expenditure and savings.This equals to total income minus income tax and personal contributions to social security and subsidies. Given constant prices in 2000, the data is subject to adjustment based on CPI.	Urban household per capita disposable income is deemed as the most important determinant of consumption expenditure, serving as an important indicator of urban residents' income levels and future consumption capacities. In sum, the measure is an important indicator of changes in overall economic well-being among urban residents.	China Statistical Yearbook (2000-2011)
2.11	Rural household yearly per capita net income (RMB, adjusted by CPI, base year 2000)	The measure is the sum of per capita rural households' incomes from all sources, after subtracting any charges, including current operating expenses, taxes, productive fixed assets depreciation and rural gifts between relatives and friends. Given constant prices in 2000, the data is subject to adjustment based on urban CPI.	As for urban household per capita disposable income, rural household per capita net income is the most important available indicator of rural residents' income levels and future consumption capacities.	China Statistical Yearbook (2000-2011)
2.12	Urban yearly per capita living expenditure (RMB, adjusted by CPI)	The measure is a sum of urban per capita expenditures on ordinary living consumption, including food, clothing, home equipment and services, medical care, traffic and communication, entertainment/education/ cultural services, residential expenses, additional commodities and services. Given constant prices in 2000, the data is subject to adjustment based on CPI.	The measure indicates average consumption level and capacity, which indirectly indicates residents' living conditions and the regional economic development level. By measuring how much money is spent and how, the indicator adds valuable knowledge about citizens' economic well being which is not provided by income measures alone.	China Statistical Yearbook (2000-2011)
2.13	Rural yearly living expenditure(RMB, adjusted by CPI)	The measure is a sum of rural per capita expenditures on ordinary living consumption, including food, clothing, home equipment and services, medical care, traffic and communication, entertainment/education/ cultural services, residential expenses, additional commodities and services. Given constant prices in 2000, the data is subject to adjustment based on CPI.	The measure indicates average consumption level and capacity, which indirectly indicates residents' living conditions and the regional economic development level. By measuring how much money is spent and how, the indicator adds valuable knowledge about rural residents' economic well being which is not provided by income measures alone.	China Statistical Yearbook (2000-2011)
2.14	Engel coefficient (% of food expenditure)	The Engel coefficient measures the percentage of food expenditure in personal total consumption expenditure. Data is available for urban and rural Engel coefficient, separately. The indicator is calculated by the weighted sum of urban and rural engel coefficient, with weight equal to the proportion of urban and rural populations.	Food is the most basic component satisfying individual physiological demands. The lower the Engel coefficient is, the more resources will be available to citizens for spending money on other goods than fundamental survival, indicating stronger economic well-being and thereby more sustainable social development.	China Statistical Yearbook (2000-2011)

Table 4.3: Measuring living conditions (*continued*)

	Measure	Definition	Relevance	Data source
2.15	Annual average residential energy consumption per capita (kgce).	Residential energy consumption refers to the consumption of six types of household energy resources, namely, coal, electricity, kerosene, liquefied petroleum gas, natural gas and coal gas.	According to past experience in China and abroad, residential energy consumption can be expected to rise with increased household well-being.	China Statistical Yearbook (2000-2010)
2.16	Per capita housing size (m2)	Due to data availability issues, slightly different measures are used for urban and rural areas. In urban areas, per capita housing size is measured using data on the size of house floor area. The so-called floor area starts from the exterior wall line and includes the area occupied by house structures (i.e. walls and columns). In rural areas, per capita housing size is measured using data on usable house floor area. The so-called usable house floor area refers to the housing area starting from the interior wall line, excluding the area occupied by house structures (i.e. walls and columns). The conversion coefficient of the urban "house floor area" to the rural "usable house floor area" is usually 0.75. Hence, urban per capita housing size is recalculated as: 0.75*house floor area of urban residents. The measure is calculated by the weighted sum of urban and rural per capita housing size, with weight equal to the proportion of urban and rural population.	Housing size is an important aspect of housing conditions together with other factors such as house structure, internal facilities, and surroundings. We choose housing size as a measure to reflect housing conditions because this is the aspect that can most easily be measured quantiatively and be subject to international comparison.	China Statistical Yearbook (2000-2011)
2.17	Urban Unemployment rate	Urban unemployment rates for 1995-2007 are all calculated by Cai Fang,according to ILO's definition. The percentage of urban economically active people who are unemployed according to ILO's definition. The ILO definition of unemployment covers people who are: out of work, want a job, have actively sought work in the previous four weeks and are available to start work within the next fortnight; or out of work and have accepted a job that they are waiting to start in the next fortnight. The 2008 data is calculated by Li Peilin and Chen Guangjin (2008), who did not provide definitions of unemployment and calculation method.	A high unemployment rate not only implies ineffective utilization of available labor resources, but also brings about serious social problems, and may therefore threaten social sustainability. Currently, only data on urban unemployment rates are available. These data are of questionable quality, as they are based on re-calculatins and adjustments of registered urban unemployment rates rather than on survey data. Starting from 2013 China's government will publish survey data on unemployment. Surveyed unemployment rates published from 2013 are more reliable and should be the preferred data source for China's SDI in the future.	"1. Cai Fang's Population and Labor Green Paper, Social Sciences Academic Press (1995-1999, 2001-2004, 2006-2007); 2. National census data in 2000 (2000); 3. National 1% population sampling data (2005); 4. National general social survey data prepared by CASS Institute of Sociology in May-August 2008, Li Peilin and Chen Guangjin (2008); "

Table 4.3: Measuring living conditions (*continued*)

	Measure	Definition	Relevance	Data source
2.18	University graduates unemployment rate (% of all university graduates)	The measure shows the proportion of university graduates who have no job upon graduating from university. University graduates who have signed job contracts or employment agreements with companies and institutes, self-employed individuals, freelancers, persons who take advanced studies or go abroad are counted as employed.	Unemployment among college graduates is a threat to social development because it leaves educated human resources unused and may give rise to social instability among households who are frustrated that high investments in education and high expectations about return from the education are not met. It is quite normal for university students not to have obtained a job at the moment they graduate; hence, a more ideal measure should be unemployment among university graduates a certain time period after graduation, such as six months or one year. For some years, data is available on unemployment among university graduates six months after graduation; this is as expected much lower than the unemployment rate at the time of graduation. Unfortunately time series data on unemployment six months after graduation is not available. However, the unemployment rate among college graduates at the moment they finish school is counted by every university and college, then collected and released by the Ministry of Education(MOE) every year. Hence, we select the less-than-ideal measure for data availability reasons.	Ministry of Education (2000-2010)
2.19	Ratio of mean wages among newly employed undergraduates, to the mean wage among urban employees.	The ratio of monthly average income among university graduates half A year after graduation, to monthly average salaries among urban non-private business employees.	The measure is an indicator of the relative economic well-being of young persons with higher education. In China, disappointment among young, highly educated people due to poor work opportunities and low wages is assumed to be significant threat to the legitimacy of the regime and thereby to social sustainability.	Chinese college graduate's employment annual report/China Statistical Yearbook (2006-2011)
2.20	Self-reported happiness	We measure this indicator by the following survey question: "All in all, how happy would you say you are now?" Respondents are asked to select one of the following reply alternatives: Very happy, somewhat happy, neither happy nor unhappy, somewhat unhappy, very unhappy.	Self-reported happiness is an indicator of subjective well-being, which can directly reflect individual quality of life.	Survey (H1, H2)
2.21	Expected standard of living in the future (% of worsening)	Expectations for the future is measured by two survey questions. First: "How do you think your standard of living will be 5 years from now?" The reply alternatives are as follows: Much better, better, the same, worse, much worse, or impossible to estimate.	People's confidence in their own future can reflect the sustainability of current well-being. Strong faith in future improvements is assumed to indicate higher levels of well-being, rather than reflecting the current situtation.	Survey (R4, R5)

The SDI includes measures of both the coverage and depth of different types of social insurance. Insurance coverage refers to the proportion of the population covered, while depth of coverage refers to the benefits provided to those covered. It is important to consider both factors when assessing social security, as in some cases social insurance systems may offer generous benefits but only to a limited part of the population, while in other cases most citizens are covered by insurance, but the benefits provided are small and therefore have limited effect. Table 4.4 describes the measures chosen for assessing the sustainability of social security in China.

Table 4.4: Measuring social security

	Measure	Definition	Relevance	Data source	Formula
2.22	Health insurance coverage (% of total population)	Health insurance coverage refers to the percentage of population covered by any "basic medical insurance" in China. "Basic medical insurances" include three types of government-subsidized medical insurance: Urban Workers' Basic Medical Insurance (UWBMI); Urban Residents' Basic Medical Insurance (URBMI); and New Rural Cooperative Medical Insurance (NRCMI). Enrollment is voluntary. Urban residents employed in a work unit may enroll in the UWBMI; urban residents without employment may enroll in URBMI, and rural residents may enroll in NRCMI. Eligibility and level of reimbursement varies considerably across the different schemes, with the insurance for urban workers being the most generous. Medical insurance coverage is derived from the sum of the population enrolled in either of these three basic medical insurances, divided by the total Chinese population. It should be noted that the New Rural Cooperative Medical Insurance did not exist before 2003 and has only been available nationally since 2005. Data on NRCMI is therefore only available after 2005.	Medical insurance is a particularly important social sustainability issue in China. In recent years, high medical expenses has become a social issue of major concern to Chinese citizens. Lack of insurance coverage and/or insufficient reimbursement rates have been found to push households into poverty and to cause persons with limited financial resources to refrain from needed medical care, threatening the health and well-being of considerable parts of the population.	1. China Human Resources and Social Security Yearbook(2001-2011); 2. China Health Statistical Yearbook(2005-2011); 3. China Statistical Yearbook(2001-2011)	(Population covered by urban insurance+population covered by rural insurance)/ Total population
2.23	Average health insurance reimbursement rate (Reimbursement rate per insurance enrollee)	The measure shows the reported reimbursement rates for the three major health insurance schemes in China as an average per insurance enrollee. The average reimbursement rate is calculated as the weighted sum of reimbursement rates for the three main types of health insurance: Urban workers' basic medical insurance, urban residents' basic medical insurance, and new rural cooperative health insurance. For the years 2005-2011, exact numbers on reimbursement rates are not available; in the audit statistics, reimbursement rates for basic medical insurance and rural cooperative medical insurance are only published as a graph depicting the variety of reimbursement rates. Therefore, reimbursement rates for the two kinds of basic medical insurance in 2006-2010 are based on estimations, by reading data from the graph.	The measure is included because the effect of insurance is determined not only by the size of the populations it covers, but also by the benefits provided to those who are enrolled. In China households that have medical insurance may be pushed into poverty or refrain from medical treatment because the insurance reimbursements do not cover a sufficiently large proportion of their medical expenses. Reimbursement rates vary across the different insurance schemes and across localities.	1. China Human Resources and Social Security Yearbook (2005-2011); 2. Audit result on national social security fund-2012.No.34 (2005-2011); 3.China Health Statistical Yearbook(2005-2011)	(urban worker's basic medical insurance reimbursement rate* urban worker's basic medical insurance participants population + urban resident basic medical insurance reimbursement rate * urban resident basic medical insurance participants population + new rural cooperative medical insurance reimbursement rate * new rural cooperative medical insurance participants population)/ (urban worker's basic medical insurance participants population+ urban resident basic medical insurance particpants population + new rural cooperative medical insurance particpants population)

Table 4.4: Measuring social security (continued)

	Measure	Definition	Relevance	Data source	Formula
2.24	Percentage of pension receivers among the population aged 60+ (% of population aged 60+)	Different pension insurance schemes are available in China. Employers and individual citizens may purchase private pension insurance, which may vary widely with regard to eligibility rules and benefits. In addition, the central government subsidizes urban and rural basic pensions of 55 RMB per month. The basic pension may vary across provinces, as provincial governments may provide further subsidies. The percentage of pension receivers among the population eligible for retirement is derived from the population receiving pensions, divided by the total population aged 60+. In China, the stipulated retirement age varies according to type of employment. For ordinary workers, the retirement age is 60 for men and 50 for women, while for female executives the retirement age is 55. For workers engaged in underground, high-temperature, high-altitude, particularly strenuous physical labor or other hazardous work, the retirement age is 55 for men and 45 for women. For workers entirely incapable of labor due to illness or non-work-related disability, the retirement age is 50 for men and 45 for women. These workers at statutory retirement age, plus the rural population and urban jobless residents aged 60+, constitute the eligible pensioner population. However, Chinese statistics only include data on the total population aged 60+; therefore, our computation does not include urban retired workers aged <60. Urban retired workers aged <60 can be assumed to account for only a small percentage of the eligible population.	The measure is of particular relevance in China because the country is entering into an ageing society, with the elderly making up an increasingly large percentage of the population. Basic social security for those who are too old to work is critical for ensuring the quality of life of the elderly population and relieve household burdens for taking care of dependants, and thereby for social sustainable development. Old-age social insurance in China is still facing considerable challenges; large numbers of elderly persons cannot receive any pension at all, and for many of those who do the pension is insufficient for covering their of at retirement age who cannot receive pensions, or whose pension is too limited to satisfy basic livelihood needs. Therefore, pension coverage and pension benefits are the two most fundamental and important indicators for us to measure China's current pension security conditions.	"1. China Human Resources and Social Security Yearbook(2000-2012); 2. National Social Insurance Conditions(2009-2010); 3. National Economic and Social Development Statistical Communique(2011-2012); 4. China Civil Affairs' Statistical Yearbook(2005-2011)"	Total number of pension receivers/ population 60+.
2.25	Monthly average pension received by pensioners (RMB, adjusted by CPI, base year 2000).	The amount of monthly average pension among those receiving pensions is computed as the weighted sum of different types of retirement payment. It should be noted that so-called urban and rural monthly average basic pension refers to the basic pension to urban and rural residents subsidized by the central government, in the amount of RMB55 per capita per month, excluding any pension subsidied by local governments, and excluding any personal pension insurance purchased by residents. Therefore, the actual amount of urban and rural resident monthly pension will be higher than RMB55, but we temporarily compute into RMB55 since there is no specific statistics at present. Given constant prices in 2000, the data is subject to adjustment based on CPI.		1. China Human Resources and Social Security Yearbook(2000-2012); 2. National Social Insurance Conditions(2009-2010); 3. National Economic and Social Development Statistical Communique(2011-2012);	Number of retirees with urban workers basic pension insurance * urban worker's monthly average retirement pay + Number of retirees with urban and rural resident pension * urban and rural monthly average basic pension)/ (Number of retirees with urban workers basic pension insurance + Number of retirees with urban and rural resident pension).

2.26	Percentage of the unemployed receiving unemployment insurance(%)	Employers in China may provide different types of unemployment insurance for their employees. In addition, a government programme aims to provide basic income protection to the unemployed as well as to help them gain new employment; this basic unemployment protection may vary under different local governments. The measure is calculated as the number of year-end unemployment insurance recipients, divided by the urban registered unemployed population.	Unemployment insurance offers a minimum safety net in case of job loss and as such provides protection for maintaining a minimum level of social security. Ideally, it serves as a response to the threat to social development posed by lack of such basic social security and provides opportunity for sustainable social development through enhancing unemployed persons' opportunity to obtain new employment. The percentage of the unemployed population covered by unemployment insurance, and the actual amount of unemployment insurance received by the unemployed, are the two most fundamental indicators available for us to measure Chinese unemployment security conditions at present.	China Human Resources and Social Security Yearbook (2000-2011)	Number of year-end unemployment insurance recipients/ urban registered unemployed population
2.27	Monthly average benefit of umployment insurance for the unemployed (RMB, adjusted by CPI, base year 2000)	The measure is derived from the expenditure of unemployment insurance funds, divided by the urban registered unemployed population. It should be noted that the expenditure of unemployment insurance funds not only includes unemployment insurance benefits, but also includes medical subsidies during unemployment; funeral subsidies and spouse or direct relative consolation money in case of death during unemployment; professional training subsidies during unemployment; and other expenses related to unemployment insurance regulated or approved by the State Council. Given constant prices in 2000, the data are subject to adjustment based on CPI.		China Human Resources and Social Security Yearbook (2000-2011)	Yearly expenditure of unemployment insurance funds /12 /urban registered unemployed population

Theme indicator 5: Public safety

Public safety is an extensive concept and may include all events that may threaten people's life, health, property and social stability, from accidents or petty crime to terrorism, epidemic disease, rebellion, or financial security incidents. Considering data availability and usefulness, the SDI for China measures public safety by three indicators, namely the number of criminal cases placed on file per 10,000 people, traffic accident mortality per 100,000, and perceptions of safety. Table 4.5 describes the selected measures.

Theme indicator 6: Social equality

In order to assess social sustainability it is not only relevant to study the average levels of living conditions such as economic well-being, education, social security etc., but also its distribution. Large inequalities and perceived unfair distribution of social goods is commonly found to have strong negative effects on individual well-being. It is likely to give rise to social conflict, crime and lack of social trust and integration, which all pose threats to social sustainability. The SDI focuses on inequalities across income groups, between rural and urban residents, and gender-based inequality. Table 4.6 describes the measures selected.

Theme indicator 7: Social cohesion

The Sustainable Development Index also attaches importance to the value of social cohesion and social integration to economic and social development. Social cohesion is a correlation condition featured by combination or relationships between individuals and individuals, between individuals and groups, and between groups and groups, based on common emotions, morals, beliefs or values. It reflects the unity and fraternity of a society. A disintegrated society with low levels of trust and cooperation and high levels of conflict between social actors is less likely to be sustained in the long term compared with a society with high levels of trust, cooperation and interconnectedness. Table 4. 7 describes the measures selected for assessing sustainable social cohesion in China.

Theme indicator 8: Sustainability of population structure

Environmental and socioeconomic sustainable development is closely connected with population and its structure. In international comparison, we must consider how population and its structure will influence the sustainable development of all nations. A large population represents a pool of human resources which may pose opportunities for sustainable development, but may at the same time threaten sustainable development by placing strains on environmental, economic and social resources. In China's current development situation significant changes in the population size - both with respect to increases and decreases - are mainly considered to pose potential threats to sustainable development. Thus, the benchmark for assessing this measure as indicating sustainable development in China at present would be a value of 0 or close to 0.

Theme indicator 9: Global social capital

Global social capital refers to China's engagement in global social affairs, i.e. social and cultural contact, communication and interaction between people in China and people in other countries in the world. Heterogeneity and multicultural diversity are assumed to be important for sustainable development because communication across borders is likely to promote social activity and strengthen innovation and development.

Table 4.5: Measuring public safety

	Measure	Definition	Relevance	Data source	Formula
2.28	Number of criminal cases placed on file per 10,000 population	The measure shows the number of criminal cases placed on file by public security authorities, including cases of murder; injury; rape; robbery; women and child abduction and trafficking; theft; fraud; smuggling and other crimes.	The measure is an indicator of prevalence of crime in the country. Crime threatens personal safety and property and as such poses a threat to social sustainability. The measure of number of criminal cases filed is selected rather than conviction rates or other measures because the main aim of the indicator is to reflect prevalence of crime rather than the extent to which criminal cases are solved. Reported criminal cases, if assumed to be genuine, do harm to social safety no matter whether or not culprits are later convicted. It should be noted that numbers do not necessarilly reflect the actual prevalence of crime, as some cases may be unfounded while others may not have been reported or properly placed on file even though crime has taken place. In China as in all other countries it is difficult to determine whether a change in the numbers reported are due to changes in reporting practices or due to actual changes in crime prevalence. While recognizing these potential weaknesses, in the SDI for China a rise in this indicator is still assumed to indicate an increase in crime and thereby a threat to social safety and sustainability, while a decrease is assumed to indicate positive change in social sustainability.	China Statistical Yearbook (2000-2011)	Number of criminal cases placing on file / population size*10,000
2.29	Traffic accident mortality per 100,000 population	Traffic accident mortality refers to deaths caused by accidents involving vehicles (automobiles; motorcycles or other motor vehicles; and bicycles or other non-motor vehicles) on the road. This does not only include accidents caused in breach of traffic laws and regulations, but also accidents caused by earthquakes, typhoons, floods, thunder strikes and other natural disaster beyond control, excluding accidents that do not occur on the road, such as on water, in the air, on railroads etc. Chinese traffic accident mortality is registered by the national public security traffic sector.	The number of motorized vehicles in China has increased rapidly with economic growth. The use of motorized vehicles does not only consume resources and cause pollution and congestion, but they also threaten people's physical safety. According to statistics, China ranks first in the world with regard to traffic accident mortality, posing a considerable challenge to social safety and sustainability in the country.	China Statistical Yearbook (2000-2011)	Population dead in traffic accident/ population size*100,000
2.30	Perception of unsafety	We measure residents'evaluation and perception of safety in their society through the following survey question: "Do you feel safe, if you need to go outside to somewhere near your home after 10 o'clock at night?"	The perception of safety is a subjective measure of public safety in people's daily lives. Public security is the most basic environmental factor for protecting residents' well-being. Widespread feelings of being unsafe in one's immediate neighborhood and in daily life poses a threat to well-being and thereby to social sustainability.	Survey (GS4)	

Table 4.6: Measuring social equality

	Measure	Definition	Relevance	Data source	Formula
2.31	Ratio of urban/rural per capita living expenditure (adjusted by CPI, base year 2000)	The ratio of urban per capita living expenditure to rural per capita living expenditure (see definitions of living expenditure under measure 2.12 and 2.13). Given constant prices in 2000, the data are subject to adjustment based on CPI.	This ratio is used to measure urban and rural differences in living expenditure. It is an indicator of urban-rural inequality in economic well-being.	China Statistical Yearbook (2000-2011)	
2.32	Ratio of urban per capita disposable income to rural per capita net income (adjusted by CPI, base year 2000)	The ratio of urban family per capita disposable income to rural family per capita net income. (See indicators 2.10 and 2.11 for definiitons of urban per capita disposable income and rural per capita net income). Given constant prices in 2000, the data are subject to adjustment based on CPI.	This ratio is used to measure urban and rural differences in economic income, and is an indicator of urban-rural inequalities in economic well-being.	China Statistical Yearbook (2000-2011)	
2.33	Gini coefficient	The Gini coefficient is calculated based on income data of Chinese residents to represent the income distribution of a nation's residents. The income Gini coefficient measures the inequality among values of a frequency distribution of income level. The Gini index is defined as a ratio of the areas on the Lorenz curve diagram, which plots cumulative percentage of income against cumulative percentage of households. If the area between the line of perfect equality and the Lorenz curve is A, and the area under the Lorenz curve is B, then the Gini index is A / (A + B). A Gini coefficient of zero expresses perfect equality, where all people have same income. A Gini coefficient of one expresses extreme inequality, that is, one person has all the income. Therefore, the higher the Gini coefficient is, the higher is the income inequality.	The Gini coefficient mainly measures disparities in income. This indicator is particularly relevant to the equity component of sustainable development. Income or resource distribution has direct consequences on the poverty rate of a country or region and the economic incentives of participants of economic activity. It gives a numerical indicator of wealth disparity among residents and can be used to reflect and monitor wealth disparity among residents, and to predict and prevent wealth polarization among residents.	National Bureau of Statistics of China (NBSC) (2003-2012)	
2.34	Ratio of female undergraduates/Ratio of male undergraduates aged 15-24 (ratio in the age group 15-24)	The proportion of female university students in the 15-24 age group as ratio of the proportion of male university students in the 15-24 age group.	Gender inequality poses a threat to social justice and the well-being of the population, and thereby to social sustainability. The measure selected here is an indicator of gender inequality in access to higher education. High gender inequality in education further indicates inequality in future opportunities, and is therefore of particular importance.	1. Educational Statistics Yearbook of China(2004-2010); 2. China Population and Employment Statistics Yearbook(2004-2010) China Statistical Yearbook(2004-2010)	(Female undergraduates/ Women aged 15-24)/(Male undergraduates/ Men aged 15-24)
2.35	The proportion of women cadres at provincial (ministry) and above level(%)	The proportion of women cadres at provincial (ministry) and above level in the whole country	From the dimension of development,we can measure gender inequality from three levels: equality of starting point,equality of opportunity and equality of result.for the first level, we choose the indicator"gender ratio at birth",and "the chance to get higher education" for the second level. Schloars usually use "gender income gaps" to measure gender inequality from the third level, but considering the data quality and data accessibility, we use "the proportion of women cadres at provincial (ministry) and above level" to measure from the point view of equality of result.	1.The second sample survey of Chinese women's social status(2000-2002); 2.The 10th National Women's Congress(2003-2006) 3.The report on the inspection of the implementation of the Law on the Protection of Rights and Interests of Women ,the fifteenth session of the eleventh Standing Committee of the National People's Congress(2008) 4.The Organization Department of the CPC Central Committee(2009)	

Table 4. 7: Measuring social cohesion

	Measure	Definition	Relevance	Data source	Formula
2.37	Charity participation	"We measure charity participation through two survey questions: 1) In the past 12 months, have you ever donated money or goods?(not including donations to temples or churches). 2) In the past 12 months, have you ever taken part in other kinds of charitable activities?(volunteering or donating blood etc.). "	Partitipation in charitable activities indicates social solidarity and social participation. An increase in charity participation is thus considered to indicate positive change for social integration and thereby for social sustainability.	Survey (PA1)	
2.38	Per capita social donations (RMB per capita per year)	Social donations refers to the sum of funds (including the value of of materials) donated from domestic and foreign sources to Chinese domestic civil affairs authorities and other authorities at all levels as well as non-governmental organizations. The per capita amount is derived from the total amount of social donations divided by the total domestic population. (The data available does not allow for separating out donations made by foreign nationals).	Social donations indicate altruism among citizens and are as such an indication of social integration. Moreover, social donations may contribute to redistribution of social resources and provide help for economically weaker groups, further strengthening social sustainability.	China Civil Affairs' Statistical Yearbook (2000-2011)	Total amount of social donations/ population size
2.39	Per capita volume of voluntary blood donation (grams per capita age 15-59)	The measure is calculated as dividing the total volume of blood donations by the working age population (aged 15-59). Note that data is only availabe from 2009.	Similar to social donations, blood donations may also indicate altruism and social integration among social members. For blood donation to be considered an act of altruism it must be voluntary; ie, donors cannot have been coerced or offered incentives for donating blood. All officially measured blood donations in China are considered voluntary, as it has been illegal to offer payment for blood donations since 1998. The measure is particularly relevant as an indicator of altruism in China because resistance to donating blood is high due to beliefs related to traditional Chinese medicine.	1. Bulletin of National Health and Family Planning Commission(Ministry of Health) (2009-2011); 2. China Statistical Yearbook(2009-2011)	Yearly volume of voluntary blood donation/ population aged 15-59
2.40	Lack of general social trust	Social trust is measured through the following survey question: "Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?"	Interpersonal trust is a basis for social integration. From a social development perspective, higher trust may increase social cohesion, encourage individuals to participate more actively in society and contribute more to other social members' well-being, and reduce social conflict. From an economic development perspective, trust may directly affect a business' scale and transactional cost, and thus influence a nation's competitiveness in the global economy.	Survey (S3)	

Table 4. 7: Measuring social cohesion (continued)

	Measure	Definition	Relevance	Data source	Formula
2.41	Lack of social solidarity	Solidarity is unity (as of a group or class) that produces or is based on community of interests, objectives, and standards. An important indicator of social solidarity is the extent to which social members are willing to help each other. Social solidarity is measured in the sustainable development index through the following survey question: "Please tell me to what extent you feel that people in your village or community often help one another? (Here, the village or community means the place where the respondent currently lives)."	High levels of solidarity in a society is likely to reduce tensions and conflict. Moreover, a united society is likely to pool personal and organizational resources, and can thereby achieve outcomes far beyond the sum of personal and small organizational resources.	Survey (S1+S2)	
2.42	Size of social networks (number of persons on average)	Social networks are stable relation systems through which individuals interact and connect. In this study, we use survey questions about the number of relatives contacted during the Chinese spring festival to measure the extent of an individual's social network.	Social networks provide social resources which can motivate or be used by its members. Through interpersonal contact and cooperation, the resources inherent in a social network can help its members achieve specific economic and social objectives as well as provide emotional support. Thus, larger social networks indicate increased social integration contributing to social sustainability.	Survey (PA2)	

Table 4.8: Measuring sustainability of population structure

	Measure	Definition	Relevance	Data source	Formula
2.44	Population growth rate (‰)	The size of population change in a year divided by total population size.	Population relates to a country's economic, social and environmental sustainability. A large population, especially young population, means rich human resources, and high potential of economic production; however, a large population also means a huge demand for foods, clothing, housing, traffic, employment and all other aspects, and huge consumption of energies and resources, exerting huge pressure and challenges to social development, environmental protection and biological balance. In whatever perspective, a stable population structure is considered as more sustainable. While natural population growth directly influences the size of population, either high or negative natural population growth is not sustainable.	China Statistical Yearbook (2000-2011)	population growth = (population at yearend - polulation at the begining of year)/yearly average population×1000‰
2.45	Gender ratio at birth	Gender ratio at birth is measured by the number of living male babies divided by the number of living female babies, based on 100 living female babies.	Under normal conditions, the gender ratio at birth is determined by biological rules, around 103—107 living male babies per 100 living female babies. Since the 1980s, China's gender ratio at birth has been higher than the normal range, and it keeps rising. In 2008, the ratio peaked at 120.56. A skewed gender ratio represents a considerable challenge to sustainable development, as a surplus of males is likely to cause a series of social problems.	China Statistical Yearbook (2000-2012)	
2.46	Urbanization rate (urban population as percentage of total population).	Urbanization rate is a measure of urbanization, expressed as the ratio of the urban permanent resident population to the total population. The urban permanent resident population refers to the population that have lived in urban areas for half a year or longer.	Urbanization is a development goal for the Chinese government, as it helps increase industrial production and create jobs. Urbanization can also change people's lifestyle, increase social heterogeneity, and promote interpersonal communication. Certainly, urbanization may also cause challenges such as traffic problems, housing pressure, employment difficulties, social disorder, air pollution, water resource shortage and other problems, affecting social and environmental sustainability. Yet, the Stiglitz report holds that "the urbanization in China and the high-tech development in the United States will be the two keys to influence the human development in the 21st century deeply... China's urbanization will be a locomotive for the regional economic growth and produce the most important economic benefits". Hence, for the purpose of the sustainable development index for China increased urbanization is considered to indicate an improvement in sustainable development.	China Statistical Yearbook (2000-2011)	
2.47	Total fertility rate	Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.	This indicator shows the potential for population change in the country. A rate of nearly two children per woman is considered the replacement rate for a population, resulting in relative stability in terms of total numbers. Rates above two children indicate populations growing in size and whose median age is declining. Higher rates may also indicate difficulties for families, in some situations, to feed and educate their children and for women to enter the labor force. Rates below two children indicate populations decreasing in size and growing older,which cause the problems of aging society,such as heavy social burdens and less workforce participation in economic production.so,for the sustainable development,keep stable is best.	World Bank (1997-2011)	

Table 4.9: Measuring global social capital

	Measure	Definition	Explanation	Data source	Formula
2.48	Percentage of Chinese residents who are able to speak English (excluding Hong Kong, Macao, and Taiwan) (% of surveyed population)	The extent of English proficiency is measured by the following survey question: "Would you be able to have a conversation about your daily life in English with a foreigner you met in the street?"	English is the most widespread language in the world and plays an important role in international communication. Mastering the English language may strenghten Chinese people's ability to communicate with the rest of the world and is therefore of considerable importance for the country's global social capital.	Survey (E2)	
2.49	Number of foreign visitors to China (1000 person-times)	The measure shows the number of foreign visitors in China (excl. Hong Kong, Macau and Taiwan) registered by the Bureau of Exit and Entry Administration of the Ministry of Public Security.	The number of foreign visitors in China indicates the attractiveness of China to people in other countries, and also indicates the extent of Chinese interaction and social connection with foreigners. At the same time, foreign visitors make significant contributions to China's economy.	The yearbook of china tourism statistics (2000-2011)	
2.50	Extent of imported foreign publications (types of imported publications per year)	The measure shows the yearly number of types of imported foreign (incl. Hong Kong, Macau and Taiwan) books, newspapers, periodicals and other publications.	The measure indicates the diversity of foreign publications available in China. Imported publications enable Chinese people to learn from world-leading sciences and technologies as well as about different ideas and cultures. Increasing variety of imported publications relects diversification of the Chinese society, and the diversification of people's mindset is significant to social sustainable development.	China Publishers Yearbook (2000-2011)	

Chapter 5: Innovation for Sustainability

5.1 Innovation and Sustainable Development

Innovation refers to the process of creating and applying new knowledge, new technologies and new processes, introducing new production methods and management modes, developing new products, improving product quality, and providing new services. Original scientific research or knowledge innovation is the scientific research activities of proposing new ideas (including new concepts, new ideas, new theories, new methods, new discoveries and new assumptions). Innovation also covers opening up new areas of research and understanding of the known things in a new perspective. The combination of original knowledge and technological innovation enrich and improve the system of human knowledge and cognitive ability, and improve products.

The concept of sustainable development is essentially an innovative development concept in the sense of "understanding of known things in a new perspective". It requires us to change the traditional way of thinking and to update values, and to protectively explore and utilize environmental resources to achieve sustainable development under the premise of maintaining the environment's adaptive and system capacity. Relying on science and technology (S&T) to achieve sustainable use of resources and promoting harmonious development for humans and nature is an increasingly common strategy for countries around the world. Science and technology, as the core of competitiveness, is increasingly becoming the focus of competition between countries.

Science and Technology (S&T) innovation is a major source of economic growth, as well as a source of increasing a society's resilience in the longer-term to deal with future and yet unforeseen challenges. Innovation is the main channel for improving the efficiency of resource utilization. S&T progress can ease scarcity of resources by pushing production as close to the possibility frontier as possible; moreover, S&T progress turn previously undervalued natural resources into valuable assets. S&T innovation is also the dominant force in optimizing the industrial structure, contributing to replacing and transforming traditional technologies to ensure continued increase in the efficiency of labor productivity. Spreading the results of S&T innovation can lead to changes in market structure, industrial organization and foreign trade structure. At the same time, S&T innovation is highly likely to be self-reinforcing, thereby further contributing to sustainable development.

S&T Innovation is central to the Chinese government's efforts to achieve sustainable economic growth and has been so for decades. The innovation section of the Sustainable Development Index aims to assess the sustainability of China's performance and potential with regard to S&T innovation. It does so by measures of four theme indicators: Innovation potential; Innovation output and efficiency; Innovation diversity; and Global innovation capital.

5.2 Indicators of Innovation for Sustainability

Theme indicator 1: Innovation potential

Innovation potential is the capacity to develop and advance further, including the ability to solve future and yet unforeseen challenges. It is the foundation of sustainable development for a country. This potential can be reflected in four aspects: Human capital, material and financial resources, and enterprises. The Sustainable development index assesses innovation potential through measures of the population's education, and the extent of science and technology investment and enabling measures.

Theme indicator 2: Innovation output and efficiency

Innovation output and efficiency directly reflects current innovation results and performance, thereby indicating the ability of a country to produce innovative output from scientific research, the efficiency of innovation efforts, and overall S&T strength.

Theme indicator 3: Innovation diversity

Diversity is a key driver of innovation and an important component of sustainable development. The relationship between diversity and innovation is that diversity is crucial to encourage different perspectives and ideas that foster innovation.

Theme indicator 4: Global innovation capital

This theme indicator refers to the human capital flow in and out of a country, i.e. China's engagement in global innovation flows, thereby reflecting a country's integration into innovation at the global level.

Table 5. 1: Measuring innovation potential

	Measure	Definition	Explanation	Data sources	Formula
3.1	Share of Graduates in Undergraduate and Junior Colleges of Sciences & Engineering (% of all graduate students)	The number of graduates of Science & Engineering in current year divided by the number of all graduates in current year	Sciences & Engineering graduates indicate the future availability of human resources for innovation, especially for technological innovation.	Educational Statistics in 2000-2010 (2000-2010)	Number of graduates in Science & Engineering / Number of all graduates
3.2	Average educated years of population aged 6 or more (years)	The measure shows the average length of education among the population at school age and above.	Education is a basic prerequisite for innovation; as such, a population's education level is an important indicator of a country's innovation poential. Preferably, the indicator should measure the education among adults rather than including children that are currently in school, since it is the education of the current adult population that is assumed to have an impact on the country's innovation capacity. However, data is only available on education for the age group 6 and up. In order for this indicator to be useful data should be improved in the future so as to include data on the education level of the adult population.	China statistical yearbook (2001-2009,2011)	
3.3	Higher education gross enrollment rate (% of age group 18-22)	The number of 18-22 year-olds enrolled in higher education divided by the total population aged 18-22.	Higher education enrollment is an additional indicator of the extent to which the population inhibits the knowledge and skills favorable for science and technology innovation. It is a more specific indicator than the general education level, as science and technology innovation usually requires advanced skills obtainable through higher education.	Unesco (2000-2011)	
3.4	Research and development as percentage of GDP (% of GDP)	The measure shows the amount of gross domestic expenditure on research and development as percentage of GDP. In statistics, gross domestic expenditure is measured as the aggregate expenditures on Research and experimental development (R&D) activities performed within a national territory in a given year. R&D is defined as creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.	The measure indicates the R&D input intensity of a nation. R&D activity is not only the core of S&T activity and knowledge creation and the source of innovation, but also provides basic ability to absorb new knowledge and new technology for a nation in a globalized environment. Therefore, this ratio does not simply reflect the input on science and technology, but also reflects the level of innovation resources and as such of innovation potential.	China statistical yearbook on S&T (2000-2011)	

Table 5. 1: Measuring innovation potential (continued)

	Measure	Definition	Explanation	Data sources	Formula
3.5	Share of R&D personnel in the population (person-year per 10.000 persons)	The number of R&D personnel includes all persons employed directly on R&D as well as those providing directly related services such as R&D managers,administrators, and clerical staff. Person-years chosen as measuring unit, as this reflects the time spent on R&D activities rather than simply the number of people somehow involved in it. For example, a person who normally spends 30% of his/her time on R&D and the rest on other activities (such as teaching, university administration and student counselling) per year should be considered as 0.3 person-year. Similarly, if a full-time R&D worker is employed at an R&D unit for only six months, this results in an 0.5 person-year.	The measure indicates the human resources currently dedicated to research and development activities. Human resources capacity is key for a country's potential for technological innovation, which is again a core factor for sustainable competitiveness.	China statistical yearbook on S&T/China statistical yearbook (2000-2011)	R&D personnel / Population size in 10,000
3.6	Internet access (persons with access to the internet per 100 persons)	The measure shows the percentage of the population using the Internet through any kinds of platform or payment methods during the last 12 months.	The measure indicates the population's access to the Internet. Internet is a key channel for knowledge dissemination and sharing. Therefore, an increase in this measure can reflect improvement in and development of the knowledge-flow infrastructure.	World Bank (2000-2011)	Number of persons with access to the internet / Population size in 100
3.7	Number of enterprises in Technology Business Incubators (total number per year)	The measure shows the total number of enterprises registered in Technology Business Incubators (TBI) during a year.	China's TBIs are designed explicitly to promote S&T innovation and are largely considered to be successful in that respect; hence an increase the number of enterprises in such incubators indicate an increase in the potential of enterprises to achieve innovation.	Torch High Technology Industry Development Center of MOST (2004-2011)	
3.8	Number of Technology Business Incubators (total number per year).	The measure shows the total number of Technology Business Incubators (TBIs) existing in China in a given year. TBIs have become important in national strategies for fostering innovative and high-tech small firms by pooling resources and helping them through the start-up phase. China has invested heavily in TBIs to push innovation, and the extent and number of such incubators has increased dramatically since they were introduced in 1988.	China's TBIs are designed explicitly to promote S&T innovation and are largely considered to be successful in that respect; hence an increase the number of such incubators indicate an increase in the country's potential for achieving innovation.	Torch High Technology Industry Development Center of MOST (2002-2011)	

Table 5.2: Measuring innovation output and efficiency

	Measure	Definition	Explanation	Data source	Formula
3.9	Number of sustainable development/ greening related patents	There is no fixed definition and therefore no specific data available on the exact number of sustanable development/ greening related patents. Instead, we measure the number of environmental technology patents per year.	The number of environmental technology patents is used as a proxy indicator for assessing the extent of sustainable development/greening related patents granted per year. The measure reflects the number of patents in a field directly related to sustainable development, which is of particular relevance with regard to the impact of innovation on sustainable development.	State Intellectual Property Office of the P.R.C -STATISTICS (2007,2010,2011)	
3.10	Number of published papers in the fields of energy and environment	Number of papers published by all Chinese journals within the fields of Environmental Science and Technology and Science and Technology of Energy Sources (according to classifications of the "People's Republic of China national standard subject classification and code").	Publications are another indicator of innovation, and energy and environment are of particular relevance with regard to sustainable development.	Chinese S&T papers statistics and analysis (2000-2010)	
3.11	Number of invention patents granted (cases per 10000 persons)	Number of invention patents applied for to the State Intellectual Property Office of the People's Republc of China per 10000 persons in given year.	The number of invention patent applications indicates the level of invention activity and efforts in China. Three types of patents can be granted in China: invention patents, utility model patents, and design patents. Invention patents are the most valued and have the most technical content among the three types of patens.	1. China statistical yearbook on S&T (2000-2011) (data on patents) 2. China statistical yearbook (data on population)	Cases of invention patents granted / population size in 10,000
3.12	Number of papers cited in Thomson's Science Citation Index (10.000 papers per 5-year time period)	The measure shows the number of Chinese articles cited in the major citation index, namely Thomson's Science Citation Index (SCI).	The measure indicates the output of a country's knowledge production in a number of aspects. The extent to which papers are cited reflect not only the number of papers published, but also the global spread and impact of publications, and is as such an indirect indicator of the quality of publications. Since innovative publications are more likely to be cited, the measure may also reflect the "innovativeness" of research publications.	China statistical yearbook on S&T (2000-2011)	
3.13	Growth rate of total factor productivity (TFP %)	Total factor productivity is a variable which accounts for effects in total output not caused by the traditionally measured inputs labor and capital.	The rationale the output efficience of other factors than the traditional input factors labor and capital, namely, science and technology, reform of regime, innovation and so on.	China statistical yearbook on S&T (2003-2011)	Percent of growth year-by-year

Table 5.3: Measuring innovation diversity

	Measure	Definition	Explanation	Data source	Formula
3.14	Diversity index of publications	"Diversity index of published papers. Following the method of the Shannon weaver diversity index, the calculating formula for the index is as follows: $H' = -\sum_{i=1}^{S} p_i \ln p_i$ H is the index, pi is the number of paper published by all Chinese journals in S number of different fields during a certain year. 39 different fields are included, among others mathematics, mechanics, information and systems sciences, physics, chemistry and so on. Hence S=39.	Published papers are a key indicator of the level and extent of innovation in different research fields. Hence, the diversity of published papers is an important indicator of innovation diversity.	Chinese S&T papers statistics and analysis (2000-2010)	$H' = -\sum_{i=1}^{S} p_i \ln p_i$

Table 5.4: Measuring global innovation capital

	Measure	Definition	Explanation	Data source	Formula
3.15	Number of Chinese students obtaining degrees from abroad (number of persons)	Number of Chinese students obtaining a degree from a university located outside of China's border during a given year.	The measure is an indicator of the human capital flow out of China. Higher numbers of foreign graduates are seen as indicating stronger global innovation capital and thereby strengthen sustainable development.	China statistical yearbook (2000-2011)	
3.16	International students studying at Chinese universities (number of persons)	The number of international students studying at Chinese universities in a given year	This indicator is the reflection of human capital flow into China.	China Association for International Education (2000-2011)	
3.17	Participants in international cooperation projects in Science and Technology (Person-times)	The measure shows the person-time spent participating in international cooperation exchange for Science and Technology.	The most prominent manifestation of innovation globalization in the age of the Internet is increasing international cooperation in the fields of science and technology. Through international S&T cooperation, developing countries can contribute to global innovation and enhance their own innovative capability.	China statistical yearbook on S&T (2000-2011)	
3.18	Percentage of Chinese patent applications in the world (% of total new patent applications in the world)	The ratio of Chinese international patent applications under the Patent Cooperation Treaty (PCT) to the total number of PCT patent applications.	The measure indicates Chinese researchers' innovative activity relative to those in other countries.	WIPO statistics database (2000-2011)	Number of Chinese patent applications / total new patent applications in the world
3.19	R&D fund from abroad/R&D fund	The ratio of R&D fund from abroad to the gross domestic expenditure on R&D	This indictor reflects the globalization of R&D fund, which is one of the most improtant factor of research and development activities.	China statistical yearbook on S&T (2003-2011)	
3.20	R&D human resource from abroad/R&D human resource	The ratio of R&D human resource from abroad to the R&D personnel.	This indictor reflects the globalization of R&D human resorce, which is one of the most improtant factor of research and development activities.While, there is no statistics on R&D human resource form abroad we choose the number of Chinese students obtaining degrees from abroad as the proxy. Because most of them all got the bachelor degree or above and will involve in S&T activities.	China statistical yearbook/ China statistical yearbook on S&T (2000-2011)	

Chapter 6: Environmental Sustainability

6.1 Environment and Sustainable Development

Environmental protection is crucial to sustainable development. Environment is a generic term referring to both natural resources and the ecological environment. The environment provides resources that are fundamental for production and livelihoods and for ensuring a viable space for socioeconomic development. In order to protect natural resources and the ecological environment, development must happen in a way that ensures that utilization of natural resources is sustainable and that utilization of ecological resources do not exceed the environment's limit for pollution absorption.

A benign cycle of environmental and socioeconomic development can be achieved if socioeconomic development provides financial and technical support for environmental protection and improvement, which in turn make up favorable conditions for further socioeconomic development. In contrast, socioeconomic development happening at the cost of the environment can cause over-consumption and exhaust natural resources in addition to causing environmental pollution, ecological damage and other problems which in turn restrain further socioeconomic development, thus impairing the competence for environmental protection and improvement. Based on this logic, the following four theme indicators have been selected for the evaluation and measurement of environmental sustainability in China: Resource consumption, environmental pollution, environmental status, and global environmental impact.

6.2 Indicators of Environmental Sustainability

Theme indicator 1: Sustainable resource consumption

Natural resources provide the material basis for human existence and development. However, their ability to meet human demands for current and future development is limited. With growing populations and accelerating economic development across the world, our demands for and consumption of resources increase strongly, leading to concerns about how much support natural resources can provide. Sustainable resource consumption reflects the share of natural resources that are produced by and consumed in typically "sustainable" means, e.g. ecological food production and renewable energy production.

Theme indicator 2: Environmental pollution

Global environmental protection starts from controlling the emission of environmental pollutants. Pollution commonly rises in tandem with economic growth, but is highly likely to undermine growth and development in the long term and is therefore one of the major threats to sustainable development. Chinese environmental protection started with attempts to control the emission density and volume of environmental pollutants from corporate sources, and environmental pollution emissions has become the most important indicator of environmental protection in China. Pollution reduction in China will continue to be a serious challenge in the future, as strong economic growth and rapid urbanization is likely to add continuous and increasing pollution pressure while the basic national condition of limited environmental capacity will not change.

Theme indicator 3: Environmental status

The ultimate purpose of environmental protection, no matter for resources consumption control, environmental pollution control, or environmental management policy and infrastructure construction etc., is to protect or improve ecological and environmental quality and maintaining a viable ecological environment. The main efforts in Chinese environmental protection are water and air pollution governance and quality improvement. The theme indicator environmental status seeks to assess China's performance in protecting and improving environmental conditions by measuring the status of key environmental attributes through subjective and objective measures.

Theme indicator 4: Global environmental impact

China's environmental performance does not only affect the areas within its own borders, but has also regional and global environmental impacts. Therefore a theme indicator is included to assess the extent to which activities in China may threaten or strengthen environmental sustainability at the global level.

Table 6.1: Measuring sustainable resource consumption

	Measure	Definition	Explanation	Data source	Formula
4.1	Total unclean energy consumption (10,000 tons)	unclean energy consumption by households and industry.	Industrial development and people's living require considerable energy consumption. Although higher levels of energy consumption indicate higher living standards and well-being, their consequences may threaten sustainable development: First, coal, oil, gas and other non-renewable resources are irreversibly depleted; and second, energy consumption cause air pollution including greenhouse gas emissions. Therefore, effective control of energy consumption is essential to help relieve energy security challenges and climate change, which are serious threats to sustainable environmental development. Coal, oil, and other non-renewable resources are gradually depleting, but may be replaced by "clean", renewable energy sources. Increasing the proportion of clean energy utilization would not only be helpful for reducing energy shortage, but can also reduce the emissions of greenhouse gases and other pollutants.	China Statistical Yearbook (2000-2011)	
4.2	Proportion of ecological food production by total food production (% of total food production)	Total production of certified ecological food.	Ecological food, also called green food or organic food in China, and the process of planting, harvesting, processing, storage and transportation have adopted non-polluting technologies to ensure food safety. These foods are labeled with a green or organic logo by the relevant departments of certification.	Report On the State of the Environment In China (2006-2012)	
4.3	Water consumption deficiency (m3/person)	The measure shows the extent of water shortages in China's provinces (excl. Hong Kong, Macau and Taiwan) based on the following calculation: ∑ ((per capita water consumption- per capita water capacity)*population of the province)/national population.	Water is the most important natural resource for human existence. China's per capita water capacity is only 1/4 of the world average, and more than 200 cities in the country are short of water. Water shortage tends to be concentrated in certaina areas and is therefore a regional rather than a national issue. Therefore we use the sum of water deficiency in all water-scarce areas, weighted by the average of the total national population, to measure China's water shortage.	China Statistical Yearbook (2003-2010)	∑ ((per capita water consumption- per capita water capacity)*population of the regions with water shortage)/national population.

Table 6.2: Measuring environmental pollution

	Measure	Definition	Explanation	Data source	Formula
4.4	Total Chemical Oxygen Demand (COD) discharge (10,000 tons)	The measure shows the extent of pollutants which may reduce the content of dissolved oxygen in water. The indicator is calculated as sum of total industrial and household chemical Oxygen Demand (COD) discharge.	Chemical Oxygen Demand (COD) is an important indicator of water pollution. Higher COD in a water body indicates more serious impact of toxic-reducible substances pollution. COD can reduce the content of dissolved oxygen in water, which causes death of aquatic organisms and bad smell.	Report On the State of the Environment In China (2000-2011)	Industrial chemical Oxygen Demand (COD) discharge + Household COD discharge
4.5	Total SO2 discharge (10,000 tons)	The measure shows the prevalence of acidic chemicals in the air. The indicator is calculated as sum of total industrial and household SO2 discharge.	Sulfur Dioxide (SO2) is an odor acidic chemical and an important indicator of air pollution. Breathing in air polluted with SO2 can cause upper respiratory tract infections, chronic bronchitis, emphysema and other diseases, which is harmful to human health. At the same time, SO2 is a major factor in the formation of acid rain, which posits a wide range of dangers to the ecological environment.	Report On the State of the Environment In China (2000-2011)	Industrial SO2 discharge + Household SO2 discharge
4.6	PM10 discharge concentration (mg/m3 per day)	The measure shows prevalence of a particulate matter in the air which may pollute air quality and visibility, measured in selected main cities in China. The indicator is calculated as weighted sum of PM10 in the selected main cities, with weigh equal to the population in each city. The following cities are included in the calculation: Beijing, Tianjing, Shijiazhuang, Taiyuan, Hohhot, Shenyang, Changchun, Harbin, Shanghai, Nanjing, Hangzhou, Hefei, Fuzhou, Nanchang, Jinan, Zhengzhou, Wuhan, Changsha, Guanzhou, Nanning, Haikou, Chongqing, Chengdu, Guiyang, Kunming, Lhasa, Xi'an, Lanzhou, Xining, Yinchuan and Urumqi.	PM10 (particulate matter smaller than or equal to10 micrometers in the air) and PM2.5 (particulate matter smaller than or equal to2.5 micrometers in the air) are important indicators for air pollution control. Particulate matter suspended in the air for a long time causes smog and haze, reducing air visibility. More seriously, these particles consists of a complex chemical composition that may cause diseases such as asthma, bronchitis, cardiovascular disease and cancer. The measure is designed to indicate not only the extent of the pollution, but also how many people are affected by it. Therefore, population is used as a weight to calculate a weighted national indicator, so that areas with higher population size are given higher weight.	"1. China Statistical Yearbook (2003-2011); 2. China provincial Statistical Yearbook (2003-2011) "	∑ (PM10 * population in the city) / total population of selected cities
4.7	Total CO2 discharge (10.000 tons per year)	The measure shows the extent of discharge of Carbon dioxide (CO2) into the air. Energy consumption has been conversed to standard coal equivalent; 1kg of standard coal discharges 0.68kg carbon, which produces 2.493 kg carbon dioxide. Therefore, the indicator is calculated as total amount of standard coal equivalent fossil consumption per year * 2.493.	Carbon dioxide (CO2) is a greenhouse gas. Large amounts of CO2 emissions have serious impact on ozone depletion and global climate change, which may cause rising sea levels, erratic weather, drought and pests. Adjusting the energy structure, controlling carbon emissions and developing of low-carbon economies have become important strategies for combating climate change.	China Statistical Yearbook (2000-2011)	Total amount of coal consumed each year * (1kg standard coal= 0.68kg carbon = 2.493kg carbon dioxide)

Table 6.2: Measuring environmental pollution (continued)

	Measure	Definition	Explanation	Data source	Formula
4.8	Lead discharge in industrial waste water (ton)	The measure shows the amount of discharge of the toxic heavy metal pollutant lead in industrial waste water.	Heavy metal pollution pose a great hidden risk to people's health. Lead discharged through wastewater, even with small concentration, can be accumulated in algae, sediments, soil and the food chain. Accumulations of such discharge can lead to disease outbraks, evolving into a serious safety threat. a	China Environment Statistical Year report (2001-2011)	
4.9	Outdoor air pollution attributable deaths in urban cities with 100,000 or more inhabitants	The measure shows the number of deaths estimated to have been caused by outdoor air pollution, estimated by the World Health Organization for most countries in the world in 2004 and 2008. Burden of disease was calculated by first combining information on the increased (or relative) risk of a disease resulting from exposure, with information on how widespread the exposure was in the population (in this case, the annual mean concentration of particulate matter in the urban population of cities above 100'000 inhabitants). This allowed calculation of the fraction of disease seen in a given population that can be attributed to the exposure, in this case the annual mean concentration of particulate matter. Applying this fraction to the total burden of disease (e.g. cardiopulmonary disease expressed as deaths), gave the total number of deaths that resulted from urban outdoor air pollution.	The measure indicates the extent to which outdoor air pollution threatens people's health and lives, which is again the major threat to sustainable development posed by pollution. Outdoor air pollution results from emissions from industrial activity, households, cars and trucks which are complex mixtures of air pollutants, many of which are harmful to health. Of all of these pollutants, fine particulate matter has the greatest effect on human health. In high-income countries, urban outdoor air pollution ranks in the top ten risk factors to health, and is the first environmental risk factors.	World Health Organization, Global Health Observatory Data Repository (http://apps.who.int/gho/data/node.main.156)	

Table 6. 3: Measuring environmental status

	Measure	Definition	Explanation	Data source	Formula
4.10	Heavily polluted seawater in coastal areas (%of total coastal area)	The measure shows the percentage of water in coastal areas defined as "heavily polluted". Sea water is assessed by environmental and sea management authorities according to the national standard defined in government document GB-3097-1997. "Heavily polluted" sea water is deemed to be so polluted it has almost no use, not even for offshore development or exploitation.	Ocean pollution is usually happening in coastal areas near the mainland. Dumping of industrial wastewater and solid waste into the sea causes changes in sea water temperature, pH, salinity, transparency and species that disturb the ecological balance of the oceans. Coastal pollution also undermines seaside tourism resources.	China Environment Statistical Yearbook (2003-2010)	
4.11	Heavily polluted fresh water (% of total fresh water area) (Xiaoli ,we need CLEARER EXPLANATION on different grade)	The measure shows the percentage of fresh water defined as being of worse than level V quality. Fresh water is assessed by environmental authorities according to national standards defined in government document GB-3838-2002. Fresh water of worse quality than grade V is deemed to be so polluted that it has almost no use, not even for industrial or agricultural purposes.	China's major river systems and lakes are subject to different degrees of pollution, affecting people's production, life and health. The effects of pollution are not only limited to the place where pollution occurs, but are soon transported with the river flow, damaging the entire river's ecological environment. In addition, rivers are important sources of drinking water, and contaminated drinking water is directly toxic to humans in addition to indirectly endangering human health through the food chain and irrigated farmland.	Report On the State of the Environment In China (2001-2011)	
4.12	Perceptions of pollution problems	The population's subjective perception of the extent of environmental problems in China is measured through the following survey questions: "In general, how serious would you say that pollution is as a problem in society today?"; "Do you feel that pollution has affected your health?"; "How serious are the health effects?"; "Do you think that pollution will affect your health in the future (5 years from now)?"	Assessments by people living in an environment is one important indicator of the state of that environment. One major threat to sustainable development posed by pollution is its impact on human health and well-being; considering this aspect, the perceptions of the people who are affected by pollution is a partiucarly relevant measure.	Survey (P7-P10)	
4.13	Forest coverage (% of total landmass)	The measure shows the percentage of the total land area covered by forest.	The forest coverage rate indicates national or regional forest area occupancy and richness of forest resources. Forests are one of the most important terrestrial ecosystems and have important ecological functions regulating regional climate, beautifying the environment, cleaning the air, producing oxygen and so on. Moreover, forest resources are important for national economic construction and people's production and living environment.	China Statistical Yearbook (2000-2011)	

Table 6. 4: Measuring global environmental impact

	Measure	Definition	Explanation	Data source	Formula
4.15	Ecological footprint	The ecological footprint is a measure estimated by the Global Footprint Network for most countries in the world. It is an accounting system which tracks the demand for and supply of natural resources in a certain population. On the demand side, the measure tracks how much land and water area a human population uses to provide all it takes from nature. This includes the areas for producing the resource it consumes, the space for accommodating its buildings and roads, and the ecosystems for absorbing its waste emissions such as carbon dioxide. These calculations account for each year's prevailing technology, as productivity and technological efficiency change from year to year. On the supply side, the accounting system documents how much biologically productive area is available to provide these services (biocapacity). Finally, human demand is compared against nature's supply of biocapacity to measure the ecological footprint of a population, such as an individual, city, business, nation, or all of humanity.	Since the 1970s, humanity has been in "ecological overshoot" with annual demand on resources exceeding what Earth can regenerate each year. Overshoot is an underestimated threat to human well-being and the health of the planet, and thereby to sustainable develpment. By measuring the Footprint of China, we can assess its pressure on the planet.	Global Footprint Network (2000-2008) (http://www.footprintnetwork.org/en/index.php/GFN/page/footprint_for_nations/)	Ecological Deficit= Ecological Footprint- Biocapacity $\sum_{i}^{n}\left[Net\ Saving_i * \left(\frac{Export\ to\ China_i}{Total\ Export_i}\right) * \left(\frac{Total\ Export_i}{GDP_i}\right)\right] = \sum_{i}\left[Net\ Saving_i * \left(\frac{Export\ to\ China_i}{GDP_i}\right)\right]$
4.16	Contribution of China to the global genuine saving from import	This measure shows the overall sustainability situation of China's trade partners in terms of investments in domestic development, depletion of natural resources and damage caused by pollution. The measure used here is an aggregated genuine saving rates of the countries from whom China imports commodities; the genuine saving rates are weighted by the country's total exports and GDP. Calculation formula:	The measure is an indicator of China's contribution to sustainable development in the countries from which it imports goods. It reflects the overall condition of the trade-off between domestic growth and environmental depletion in the countries from which China imports goods. The sustainability situation of China's trade partners is measured by the commonly used sustainability indicator Genuine savings (also known as adjusted net saving), which builds on the concepts of green national accounts. It measures the true rate of savings in an economy after taking into account investments in human capital, depletion of natural resources and damage caused by pollution. Negative genuine saving rates imply that the country is consuming its natural resources without using the proceeds for investments. Negative savings rates are therefore unsustainable.	UN (2005-2008) (http://comtrade.un.org)	n = Number of countries exporting commodities to China

Chapter 7: Economic Sustainability

7.1 Economy and Sustainable Development

An economically sustainable system should be able to produce goods and services on a continuing basis within manageable levels of environmental damage and resource depletion, in order to maintain macroeconomic stability, provide sufficient economic incentives, and to avoid sectorial imbalances which damage agricultural or industrial production.

7.2 Measuring Sustainable Economic Development

Theme indicator 1: Economic performance

Economic performance is the fundament for current and future development. High economic growth may, if invested wisely, ensure sustainable access to financial resources now and in the future, which may again – if spent rightly – be used to secure sustainable environmental and social development.

Theme indicator 2: Greening of the economy

A green economy is one that should result in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. "Greening of the economy" refers to activities operating with the primary intention of reducing conventional levels of resource consumption, harmful emissions, and minimizing all forms of environmental impact. The green economy includes inputs, activities, outputs and outcomes related to the production of green products and services. This theme indicator reflects

Table 7.1: Measuring economic performance

	Measure	Definition	Explanation	Data source	Formula
5.1	GDP per capita (RMB, adjusted by GDP inflator, base year 2000)	Levels of GDP per capita are obtained by dividing annual or period GDP at current market prices by population. The current price estimates of GDP are adjusted by GDP deflators at base year 2000. Population surveys enable the conversion of total GDP to per capita levels, while exchange rates and other conversion factors are used to arrive at values based on a common unit of currency. Real GDP is derived by extrapolating total value-added in the base year with production indicators in physical terms or by deflating current price values by a price deflator.	As a single composite indicator of economic growth, GDP per capita is the most powerful summary indicator of the economic state of development in its many aspects. GDP per capita not only indicates the level of growth but also the foundation for follow-up development. Poverty, natural resource exploitation, consumption and production are all intimately connected to economic growth or the lack of it.	China Statistical Yearbook (2000-2011)	2000-2010
5.21	Incremental capital output ratio (I/△GDP)	The incremental capital output ratio (ICOR) is defined as the ratio between investment in some previous period(s) and the growth in output in the subsequent period.	Overall, a higher ICOR value is not preferred because it indicates that the country's production is inefficient. The measure is used predominantly in determining a country's level of production efficiency.	China Statistical Yearbook (1990-2011)	
5.22	government deficit/GDP	This indicator shows the ratio of total government/surplus to GDP.A fiscal deficit is when a country's government spends more than it takes in from taxes or other forms of revenue.	Because nations that run a fiscal deficit must make up the difference by borrowing, the ratio compares what a nation borrows to what it produces. The deficit to GDP ratio provides an indication of the country's ability to pay back its debts.Higher ratios of deficits and debt to GDP place nations at risk of higher inflation, high interest rates and lower economic growth, making it even more difficult for governments to repay their debts.	China Statistical Yearbook (1990-2012)	

input (aspirations) to a greening of the economy, while the actual effect may be reflected by e.g. the ecological footprint divided by GDP.

Theme indicator 3: Economic environmental efficiency

Economic environmental efficiency refers to an economy's performance in coming as closely as possible to minimum use of resource input, conditional on desirable output and the conventional inputs. In simple terms, an environmentally effective economy produces as much as possible at the lowest possible cost to the environment.

Theme indicator 4: Economic robustness

Economic robustness refers to an economy's ability to deal with pressure and shocks. This directly influences economic growth and future prospects. Issues related to stable economic development, e.g., labor supply, energy security, etc., are included in this theme indicator.

Theme indicator 5: Economic equality

It is not only total economic growth or performance that is important for sustainable development; so is the question of how economic benefits or burdens are distributed. High levels of economic inequality pose threats to economic growth because it is likely to lead to lack of capital investment (both in material and human capital) and economic instability. Threats posed by economic inequality to sustainable social development are further discussed in the section on social sustainability.

Theme indicator 6: Economic globalization

Economic globalization is the increasing economic interdependence of national economies across the world through increase in cross-border movement of goods, service, technology, information and capital. This theme indicator assesses China's engagement in cross-border flows, and hence the extent to which China participates in economic globalization.

Table 7.2: Measuring greening of the economy

	Measure	Definition	Explanation	Data source	Formula
5.3	Gross output of environmental industry as percentage of Gross industry output (%)	The measure shows the relative output of environmental industry in China. Environmental industry in China refers to the following issues: Environmental protection products, comprehensive utilization of resources, environmental services and clean products.	The three main definitional criteria of "greening of the economy" include an economic perspective, a technical perspective, and a development process perspective (ECO Canada). To measure "greening of the economy" from the economic perspective, "green sectors" is the core element. Green sectors include, but is not limited to: Renewable energy; green buildings; clean transportation; water management; waste management; and land management. In China, "environmental industry" can be viewed as a proxy indicator of the greening of the economy, covering many of the above-mentioned aspects. Ideally, "greening of the economy" should be measured by studying the extent of and changes in "green sectors", including renewable energy industries and energy saving and environmental protection industries. However, comprehensive data on these industries is currently not available in China. Therefore, we used instead the indicator of "gross output of environmental industry as percentage of gross industry output", which can be obtained from NBSC. However, China has formulated a national plan to promote "strategic emerging industries" including almost all the green sectors, and development of the statistics system is part of this plan. If a statistics system for these sectors will be developed by the NSBC in the near future, this will be used in later work on the Sustainable Development Index for China.	National Bureau of Statistics of China (NDRC) (2004-2010)	Gross output of environmental industry / Gross industry output

Table 7.3: Economic environmental efficiency

	Measure	Definition	Explanation	Data source	Formula
5.4	Energy consumption per unit GDP (tonnes per 10,000 RMB GDP, year 2005 constant prices)	The measure shows the ratio of total energy use to GDP. Energy is measured in thermal unit or ton coal (or oil) equivalent. GDP is measured in constant price of local currency.	Energy is essential for economic and social development, but consumption of fossil fuels is the major cause of air pollution and climate change. Improving energy efficiency and delinking economic development from energy consumption, particularly of fossil fuels, is essential to sustainable development. Trends in overall energy use relative to GDP indicate the general relationship of energy consumption to economic development and provide a rough basis for projecting energy consumption and its environmental impact on economic development.	China Statistical Yearbook (2000-2010)	
5.5	CO2 emission per unit GDP (tonnes per 10,000 RMB GDP, year 2000 constant prices)	The measure shows the ratio of anthropogenic emissions of carbon dioxide (CO2) to GDP. Annual CO2 emissions are measured in tons. GDP is measured in constant price of local currency. See indicator 4.7 for the calculation of total CO2 emissions.	The amount of carbon dioxide has increased by more than 30% since pre- industrial times and is currently increasing at an unprecedented rate of about 0.4% per year, mainly due to the combustion of fossil fuels. A doubling of the CO2 concentration in the atmosphere is believed to cause an increase of 1.5 to 4.5°C in the global mean temperature, posing a severe threat to sustainable development. In order to avoid climate change despite upholding economic development, CO2 emission efficiency needs to be increased	China Statistical Yearbook (2000-2010)	Total CO2 emission per unit GDP (tonnes per 10,000 RMB GDP, year 2005 constant prices)
5.61	Waste water discharge per unit industry output (tonnes per 10,000 RMB, at 2000 constant price)	The ratio of waste water discharge of industry to industrial output.	Generation of pollution from industry as an indicator is intimately linked to the level of economic activity in a particular country or region. It is also an indication of the patterns of production and consumption of raw materials.	China Statistical Yearbook on Environment (2000-2010)	Waste water discharge / Total industry output at 2000 constant price
5.62	S02 emission per unit industry output (tonnes per 10,000 RMB, at 2000 constant price)	The ratio of SO2 emission of industry to industrial output.		China Statistical Yearbook on Environment (2000-2010)	SO2 emission / Total industry output at 2000 constant price
5.63	Solid waste discharge per unit industry output (tonnes per 10,000 RMB, at 2000 constant price)	The ratio of solid waste discharge of industry to industrial output.		China Statistical Yearbook on Environment (2000-2010)	Solid waste discharge / Total industry output at 2000 constant price
5.71	Fertilizer input use per agricultural production (tonnes per 10,000 RMB, at 2000 constant price)	The ratio of fertilizer input use to agricultural land area. Fertilizer use is measured in tonnes, while agricultural land area is measured in thousand hectares.	A major challenge for agriculture is to increase food production in a sustainable way. This indicator shows the potential environmental pressure from agricultural activities. Extensive fertilizer use is linked to eutrophication of water bodies, soil acidification, and potential contamination of water supply with nitrates. Pesticides can be persistent, mobile, and toxic in soil, water, and air; and can impact on humans through the food chain. They tend to accumulate in the soil and in biota, and residues may reach surface and groundwater. Humans can be exposed to pesticides through food.	China Statistical Yearbook on Environment (2004,2005, 2007-2010)	Fertilizer input use / Total agricultural output at 2000 constant price
5.72	Pesticides input use per agricultural production (tonnes per 10,000 RMB, at 2000 constant price)	The ratio ofpesticides input use to agricultural land area. Pesticides use is measured in tonnes, while agricultural land area is measured in thousand hectares.		China Statistical Yearbook on Environment (2004,2005, 2007-2010)	Pesticides input use / Total agricultural output at 2000 constant price

Table 7. 4: Measuring economic robustness

	Measure	Defintion	Explanation	Data source	
5.81	Male labor force participation	"The labor force is the actual number of people available for work. The labor force of a country includes both the employed and the unemployed but looking for a job, as we called economically active. Labor force participation rate often refers to the proportion of the population ages 15-64 (working-age persons) that is economically active (labor force).Therefore, the male labor force participation rate is the ratio between the male labor force and the overall size of their cohort (national male population of the same age range, e.g. the population ages 15-64)."	The participation rate is important in analyzing the labor supply and unemployment rate. The participation rate and working-age persons data should be observed in tandem to give a better understanding of the overall employment status.	World Bank (1990-2012)	
5.82	Female labor force participation	The female labor force participation rate is the ratio between the female labor force and the overall size of their cohort (national female population of the same age range, e.g. the population ages 15-64).	High female participation will increase labor supply and production.At the same time,it will also reduce poverty among women and children.	World Bank (1990-2012)	
5.9	Newly added labor force supply (10,000 persons)	Newly added population size at the working age (15-64), compared to the previous year.	The change of labor market will undoubtedly influence the economic growth. In current China, mainly due to the restriction of labor force supply at working age, the cost of labor keeps growing in recent years. Therefore, the newly added labor force supply at working age is currently used as one of the most direct policy indicator, referred by the Chinese policy makers.	China Statistical Yearbook (2000-2009)	
5.10	Export dependency (% of GDP)	The measure shows the percentage of exports to GDP.	It is widely acknowledged that an economy's vulnerability to exogenous economic shocks is largely determined by its degree of exposure to the global economy. For economies highly dependent on exports, the volatility in both export earnings and economic growth associated with economic shocks makes them extremely vulnerable. Given that exports constitute a significant and growing share of GDP for most developing economies, an increased dependence on exports results in significant fluctuations in export earnings. Furthermore, export revenue volatility is strongly linked to growth volatility, so significant fluctuations in export earnings result in fluctuations in economic growth.	China Statistical Yearbook (2000-2011)	Total export/ GDP*100
5.12	Import dependency of energy (% of net energy import to total energy consumption)	Import dependency of energy shows the proportion of energy that an economy must import. It is measured by net imports divided by the sum of gross inland energy consumption plus bunkers.	Access to energy is a prerequisite for sustainable development in any given country as a fuel to power the economic engine. Threats to energy security often lead to macroeconomic fluctuation. High import dependency threatens energy security and is thereby a potential threat to sustainable development.	China energy statistical yearbook (2000-2010)	Net energy imports / sum of gross domestic energy consumption

Table 7.5: Measuring economic equality

	Measure	Definition	Explanation	Data source	Formula
5.13	Gini coefficient	The Gini coefficient is calculated based on income data of Chinese residents to represent the income distribution of a nation's residents. The income Gini coefficient measures the inequality among values of a frequency distribution of income level. The Gini index is defined as a ratio of the areas on the Lorenz curve diagram, which plots cumulative percentage of income against cumulative percentage of households. If the area between the line of perfect equality and the Lorenz curve is A, and the area under the Lorenz curve is B, then the Gini index is A / (A + B). A Gini coefficient of zero expresses perfect equality, where all people have same income. A Gini coefficient of one expresses extreme inequality, that is, one person has all the income. Therefore, the higher the Gini coefficient is, the higher is the income inequality.	The Gini coefficient mainly measures disparities in income. This indicator is particularly relevant to the equity component of sustainable development. Income or resource distribution has direct consequences on the poverty rate of a country or region and the economic incentives of participants of economic activity. It gives a numerical indicator of wealth disparity among residents and can be used to reflect and monitor wealth disparity among residents, and to predict and prevent wealth polarization among residents.	National Bureau of Statistics of China (NBSC) (2003-2012)	
5.14	Regional income inequality (gini index of GDP per capita on province level)	The measure shows the Gini index of GDP per capita among 31 Chinese provinces, so as to measure the regional inequality.	Regional income inequality is recognized as a major sustainability challenge in China, and efforts are made to spur development in less developed areas. This indicator is useful to measure changes in income inequality across geographical areas and over time. The data at province level is used instead of county level because the data quality at county level is too bad.	China statistical yearbook (2000-2010)	

Table 7.6: Measuring economic globalization

	Measure	Definition	Explanation	Data source	Formula
5.15	Ratio of Outward Foreign Direct Investments (OFDI) by China in other countries to Global FDI(%)	The measure shows the ratio of outward foreign direct investment (OFDI) by China in other countries to Global FDI. OFDI data is collected in USD.	Foreign Direct Investment represents the leading edge of economic globalization in the sense that increasing foreign ownership of productive assets may provide direct influence over production. The rapid development of China's OFDI activities reflects not only its economic maturity and integration into the global marketplace but also its need to expand overseas to supply China with natural resources, new markets, and advanced technology.	"Statistical Bulletin of China's Outward Foreign Direct Investment ;UNCTAD (World invest report)"	OFDI by China in other countries / Global FDI *100
5.16	Ratio of FDI by other countries in China to Global FDI(%)	The measure shows the ratio of foreign direct investment (FDI) by other countries in China to Glbal FDI. FDI data is collected in USD.	Foreign Direct Investment is "a category of international investment made by a resident entity in one economy (direct investor) with the objective of establishing a lasting interest in an enterprise resident in an economy other than that of the investor (direct investment enterprise)" (OECD, 1999). Higher levels of FDI by other countries in China indicates economic opportunities and integration into the global economy.	China Statistical Yearbook;UNCTAD (World invest report)	FDI by other countries in China / Global FDI *100

Chapter 8: Data sources and analysis

8.1 Introduction

In order to test and further explore the utility of the SWI, data for most indicators were collected and analyzed in 2013. Data were mainly collected from existing statistics. In addition, a SWI survey was conducted in the spring of 2013 to produce primary data to complement the set of existing data.

This chapter describes the secondary (existing) and primary (survey) data sources, and the methods used for data aggregation and analysis of the data.

8.2 Data sources and collection

8.2.1 Use of existing data

Secondary data of altogether 103 measures were collected for analyzing the SWI for China for the years 2000-2013.

Most data for all the five sectors of the index were directly collected from Chinese official annual data, released mainly by the National Bureau of Statistics of China (NBSC). These data sources include China Statistical Yearbook, China Statistical Yearbook on Environment, China Human Resources and Social Security Yearbook, and the China Health Statistical Yearbook. For some indicators secondary data has been collected from official surveys, which are implemented by ministries every two to five years. For instance, data on prevalence of non-communicable diseases are drawn from the Ministry of Health's National Health Services Surveys.

The quality of Chinese official statistical data is sometimes doubted due to risk of intentionally inaccurate reporting. Government officials, especially at the local level, have been suspected of altering data in order to further political or personal career gains. In addition, other factors such as incorrect or nonstandard measurement methods may also make some data inaccurate. However, although official data are in some cases controversial, they are often the only available data to have been collected over a long time period with standardized methods in China. Therefore, official data are usually the most suitable for indicating long-term trends in China's development, although awareness about their potential weaknesses is important.

Data on some indicators were collected from international sources, including data from UNEP, the World Bank, and the UN. International data have been used when domestic data do not exist (for example data on days needed to start up new enterprises); when the quality of the international data was deemed to be better than domestic data (for example, data on average life expectancy is collected and recorded in more detail by international organizations); or when data collected or calculated by international organizations were more convenient for international comparison (e.g. data on personnel in international peacekeeping operations).

In some cases, data which did not exist at all or had not been collected over time in official Chinese statistics were instead collected from surveys conducted by universities, companies or research institutes. For example, data on mean wages of newly employed undergraduates were drawn from Chinese College Graduates' Employment Annual Report, which was released by MyCOS Data, a Chinese company specializing in higher education consulting. A challenge with data from such surveys is that these surveys are usually conducted for a geographically limited area and only for one or a few years. Therefore they are not representative of the entire country and cannot show developments over time. Moreover, lack of strict sampling methods in many of these surveys affected the validity and accuracy of the data.

Some challenges were encountered during the course of secondary data collection and calculations/analysis.

A first challenge was lack of data continuity. Some data are not collected or released by the official statistical bureau yearly. For instance, for calculating the indicator on use of chemicals in agriculture/production (Table 7.3), we found data on chemical input use in 2004-2005, and 2007-2010, but not for 2000-2003, or for 2006. Other indicators have received attention only in recent years, thus no long-time official monitoring statistics are available, such as air quality measurements of PM2.5 particles.

Second, some of the data collected did not perfectly reflect the meaning of the indicators. An example is the theme indicator Greening of the Economy (Table 7.2). In our opinion, "greening of the economy" should be measured by studying the extent of and changes in "green sectors", including renewable energy industries and energy saving and environmental protection industries. However, comprehensive data on these industries are currently not available in China. Therefore, we used instead the indicator of "gross output of environmental industry as percentage of gross industry output", which can be obtained from NBSC. However, China has for-

mulated a national plan to promote "strategic emerging industries" including almost all the green sectors, and development of the statistics system will be a task or goal of this plan. If a statistics system for these sectors will be developed by the NSBC in the near future, this will be used in later work on the SWI for China.

Third, some indicators are currently not included in the indicator set due to lack of adequate data. An example is Age standardized Disability-adjusted life years (DALYs), which is considered a very good indicator for measuring the overall disease burden of a country. However, for China only data for the years 2002 and 2004 are provided by the World Health Organization (WHO), so efforts should be made to collect or calculate DALY data for China in the future.

Fourth, data on some indicators are based on problematic measurement methods. An example is data on unemployment rates. Until 2013 the only unemployment data available both from the China Human Resources and Social Security Yearbook and the World Bank show urban registered unemployment rate, which cannot reflect the real situation with regard to unemployment rates in China. However, data on surveyed unemployment rates have been collected by the NBSC and were released for the first time in late 2013. These data are of higher quality and will be used in the future development of the index.

8.2.2 Existing data to be collected in the future

A number of measures which the research team had originally decided to include in the SWI based on their conceptual and theoretical value were excluded from the current data analysis for various reasons. This includes measures for which secondary data was not available, for which data quality was deemed too bad to be used, and measures for which data was only available for a very few years. These measures are listed in Table 8.1, and should be included as soon as data of better quality are available.

Some measures are included but need to be improved in the future, such as "Average educated years of population aged 6 or more". Such issues have been noted in the previous chapters.

8.2.3 SWI survey data

A survey was conducted to collect data of particular relevance which was not available from secondary sources. The primary data produced was mainly related to well-being, which Stiglitz, Sen and Fitoussi emphasize as particularly important for measurement of sustainable development.

The survey was developed by a research team consisting of members from CASTED, Fafo and Statistics Norway. Questionnaire design was based on literature on measurement of sustainable development, quality of life, well-being and economic and social development both from China and abroad, and lessons were drawn from experiences with international survey questionnaires such as the World Value Survey, and the General Social Survey.

A pilot survey was conducted in Sichuan province in November 2011 by CASTED and Fafo, in cooperation with the School of Public Administration of Southwest Jiaotong University. Face-to-face interviews were conducted with urban residents in Chengdu city, Dujiangyan county and rural residents in Pujiang county. Altogether 344 face-to-face interviews were completed. The pilot tested the duration of interviews as well as the validity and reliability of the questionnaire in order to ensure that question formulation was clear, unambiguous and useful. The final questionnaire was modified according to lessons learned from the pilot survey.

The final questionnaire included 10 sections, namely demographic background variables; happiness and well-being; social cohesion and social trust; social networks and participation, and social capital; standard of living/relative deprivation; satisfaction with government service delivery; problems in society and environment; governmental satisfaction and safety; English proficiency and internet use; and education and jobs (See Appendix 2: The SWI questionnaire on subjective well-being and happiness).

The full-scale survey was conducted from April 11th to May 24th, 2013. The survey was carried out by Millward Brown ACSR Beijing, a leading joint venture on marketing research in China. The sample included urban, rural and migrant populations in Jiangsu, Hubei and Gansu province. Each province had a sample size of 1020 respondents, bringing the total sample size to 3060 respondents (See Appendix 3: Sampling design – SDI survey April 2013).

In order to reduce costs and enable regular execution of the "SWI survey" in China in the future, telephone interviews based on landline phones were used. However, the use of telephone interview also presented challenges, the most serious of which was respondent bias. In China, a large part of the population only has mobile telephones, especially among migrants and youth. Yet, our survey was only based on landlines, because good lists of mobile telephone numbers are currently not available in China. In order to reduce such bias to largest extent, fixed interview quotas were required based on age, gender, place of residence and household

Table 8.1: Measures currently excluded from the SWI due to data availability issues

Governance for Sustainability
Government responsiveness to SD Challenges
Ratio of administrative punishment decisions related to environmental issues / Total cases of general pollution level (%)
Governance Efficiency
Number of employees in public security sector OR Number of police per 1000 inhabitants OR other measures about public security
Government Promotion of SD
Green education
Global Governance Responsibility
Ratified multilateral agreements (gross total number)
Investments in/aid to global environmental protection to GDP (% of GDP)
Investments in national reduction of climate gasses emissions to GDP (% of GDP)
Chinese monetary contribution in world peace keeping
Prevalence of border conflicts

Social Sustainability
Health Status
Age standardized Disability-adjusted life years (DALYs)
Prevalence of mental disorders (%)
suicide rate(per 100,000 persons)
Social Security
Coverage of work-related injury insurance
Maternity leave + pre and post natal healthcare insurance coverage
Social Equality
Ratio of rural undergraduates/Ratio of urban undergraduates
Gender inequality on wage
Gender inequality on leadership
Population Structure
Total fertility rate

Innovation for Sustainability
Global innovation capital
Monetary investment from abroad in China in R&D
Human resource investment from abroad in China in R&D

Environmental Sustainability
Resource consumption
Total unclear energy consumption (10000 tons per year)
Proportion of ecological food product in total food product
Consumption of nuclear energy
Environmental Pollution
Food transmitted diseases/sales figures of medicine
Water born diseases/sales figures of medicine
Environmental Status
Use(emission) of hazardous substances
Biodiversity index

Economic Sustainability
Economic Performance
Government deficit as percentage of GDP
Ratio of change of GDP to total investment
Greening of the Economy
Employment in environmental industry
Employment in new energy (from new statistics on strategic emerging industries)
Share in GDP of new energy (from new statistics on strategic emerging industries)
Economic Robustness
Male labor force participation rate 15-64
Female labor force participation rate 15-64
Economic Globalization
Outward Foreign Direct Investments (FDI) by China in other countries (% of global FDI)
Foreign Direct Investments (FDI) by other countries in China in (% of global FDI)
Import dependency of food

residence registration. Only persons aged 18 and above were qualified for the survey. The following lessons were learned with regard to handling challenges related to conducting telephone surveys in China in the future:

- We should endeavor to obtain better information about mobile telephones in China
- Panel survey is one alternative solution to the problem of obtaining a good sample; however a potential problem with panel surveys is that initial samples may not be representative in the longer term
- Survey data may be combined with other surveys carried out regularly in China by other actors in order to validate results.

8.3 Data aggregation and analysis

8.3.1 Data preparation

A composite index was used for analyzing the collected data. Before the composite index could be constructed, considerable data preparation had to be conducted. The secondary data collected for many indicators were not complete over the entire study period, and the different measures were expressed in different units and scales, such as number of persons, currency unit, percentage etc. Before the composite index could be constructed, the secondary data had to be prepared in a standardized way to be combined into one index. This was done through imputation of missing data and normalizing all secondary data collected.

Imputation of missing data

Secondary data for altogether 106 measures were collected for constructing the SWI composite index for the period 2000-2013. However, it was possible to obtain a complete time-series for only two of the measures in the index. For the rest, missing data had to be imputed. Different methods were applied for imputation of missing data, depending on the nature of the data.

- Most missing data were imputed by conducting Loess regression in R.
- Some missing data were imputed by assuming that the data followed a linear trend (7 measures: 2.1, 2.2, 2.9, 2.22, 2.39, 4.13, 4.15).

- A few measures were imputed by assuming that the data trend did not change in the missing years (3 measures: 1.17, 2.24, 2.25)
- Finally, for 3 measures it was not possible to impute data (2.39, 3.09, 4.16). The measures were then still included in the construction of the composite index, but data for certain years were missing.
- 5 measures were computed by aggregating secondary data collected for urban/rural areas or for men/women (5 measures: 2.01, 2.02, 2.06, 2.14, 2.16). Urban and rural data were aggregated by assigning weights equal to the proportion of the urban/rural population. The urban/rural weight differs across years. Data for women and men were aggregated by assigning equal weight to women/men.

Data normalization

Measures expressed in different units and scales were converted into a single unit by normalization. Different normalization methods will provide different results for the composite index. Therefore, overall robustness tests were carried out to assess their impact on the outcomes. Several normalization methods are available, and four methods of normalization procedures were selected for testing.

In general, for each normalization method, normalization was conducted in slightly different ways for different measures, depending on the character of benchmarks used for assessing each measure:

- High: When a high numeric value is considered positive (eg. GDP per capita)
- Low: When a low numeric value is considered positive (eg. Concentration of PM2.5)
- Equal to a: When there is a fixed value that is considered to be desirable (eg. Sex ratio at birth at 1.04)

Before normalization, benchmarks were set for each measure, reflecting what would be considered a sustainable trend for the measure in question. However, in many cases, it is not possible to define a perfect benchmark for a very long term, and there are limits to how much most measures can grow before they reach the ideal status. Therefore, when setting benchmarks for measures in constructing the composite index, the key concern was the current development situation and context in China. In the longer term, the benchmarks may need re-adjustment depending on how the country develops.

Below, the four methods of normalization are presented as following: t is years, and i is the measure. Data normalization was conducted for each measure.

1. Rank:

For each measure, data for each year was normalized by its ranking among the 14 years studied. Normalization formula:

High: $I_t^i = rank^i(x_t^i)$

Low: $I_t^i = rank^i(-x_t^i)$

Equal to a: $I_t^i = rank^i(-|x_t^i - a|)$

2. Standardisation (z-scores):

$\bar{x^i}$ is the average across t years for each measure i, σ^i is the standard deviation across years for each measure i. For each measure, data for each year was normalized by subtracting the mean of the 14 years series and dividing by the standard deviation of the series.

Normalization formula:

High: $I_t^i = \dfrac{x_t^i - \bar{x^i}}{\sigma^i}$

Low: $I_t^i = \dfrac{\bar{x^i} - x_t^i}{\sigma^i}$

Equal to a: $I_t^i = \dfrac{\overline{|x_t^i - a|} - |x_t^i - a|}{\sigma^i}$

3. Min-max rescale:

$min^i(x_t^i)$ and $max^i(x_t^i)$ are the minimum and maximum values across the 14 years for each measure i. For each measure, data for each year is normalized by subtracting the minimum value across the 14 years series and dividing by the difference between maximum and minimum value across the 14 years series.

Normalization formula:

High: $I_t^i = \dfrac{x_t^i - min^i(x_t^i)}{max^i(x_t^i) - min^i(x_t^i)}$

Low: $I_t^i = \dfrac{max^i(x_t^i) - x_t^i}{max^i(x_t^i) - min^i(x_t^i)}$

Equal to a:

$$I_t^i = \frac{max^i(|x_t^i - a|) - x_t^i}{max^i(|x_t^i - a|) - min^i(|x_t^i - a|)}$$

4. Distance to a reference (base year 2000):

x_0^i is the value of each measure in reference year 2000. For each measure, data for each year was normalized by dividing by the value in the reference year.

Normalization formula:

High: $$I_t^i = \frac{x_t^i}{x_0^i}$$

Low: $$I_t^i = \frac{-x_t^i}{x_0^i}$$

Equal to a: $$I_t^i = \frac{-|x_t^i - a|}{|x_0^i - a|}$$

Weighting

Weighting is to large extent a subjective choice. Many composite indicators rely on equal weighting (EW). However, it is not uncommon to assign weights to measures, so as to reflect the statistical quality and policy focus of the data. A criticism about equal weights is that by combining variables with high degree of correlation, an element of double counting may be introduced into the index. Weighting systems can be constructed based on statistical models. Statistical correlation of indicators, such as Pearson correlation, can be conducted. Either only the measures with low degree of correlation are used or the weights for those with high correlation are adjusted accordingly. Furthermore, principal components analysis (PCA) or factor analysis (FA) are also commonly used to group all the measures, so as to get a set of weights which reflect the contribution of each measures. However, such adjustment only based on statistical analysis is also considered inappropriate, as it is equally important to analyze the indicator itself. The problem with weighting based on statistical analysis is that it might be biased towards the readily available indicators and the data that is statistically more problematic is underrepresented. Alternatively, weighting systems can also be based on opinion. Participatory methods incorporate the opinions of the public, experts or politicians. For example, budget allocation (BAL) method brings together experts with knowledge and experience to help establish a proper weighting system.

In the SDI framework, some selected measures are essentially similar to each other and some measures interpret similar problems from different angles. For example, urban (rural) family per capita disposable income and urban (rural) per capita living expenditure are highly correlated but both are important measures to interpret the living conditions. Another example is chemical input use of fertilizer and pesticides. They are not definitely correlated with each other, but are different indicators related with chemical input use in agriculture production. In such cases, elements of double counting may be introduced into the index. Therefore, when several similar measures used, weights are applied so that they sum up to have same weight as other measures.

Eight groups of similar measures are identified and measures in one group share the weight equally within the group. The groups of similar measures and weights applied are listed in Table 8.2.

Table 8.2 Weights for indicators

Group	Measure		weight
Group 1	1.61	Public dissatisfaction with central government performance	0.5
	1.62	Public dissatisfaction with county government performance	0.5
Group 2	2.10	Urban household yearly per capita disposable income	0.25
	2.11	Rural household yearly per capita net income	0.25
	2.12	Urban yearly per capita living expenditure	0.25
	2.13	Rural yearly living expenditure	0.25
Group 3	2.17	Urban Unemployment rate	0.5
	2.18	University graduates unemployment rate	0.5
Group 4	2.31	Ratio of urban/rural per capita living expenditure	0.5
	2.32	Ratio of urban per capita disposable income to rural per capita net income	0.5
Group 5	2.40	Lack of general social trust	0.5
	2.41	Lack of social solidarity	0.5
Group 6	5.61	Waste water discharge per unit industry output	0.33
	5.62	S02 emission per unit industry output	0.33
	5.63	Solid waste discharge per unit industry output	0.33
Group 7	5.71	Fertilizer input use per agricultural production	0.5
	5.72	Pesticides input use per agricultural production	0.5
Group 8	5.81	Male labor force participation	0.5
	5.82	Female labor force participation	0.5

- Level 4: 119 measures (106 measures based on existing data and 13 measures from the survey)
- Level 3: 28 theme indicators (5, 9, 4, 4, 6 indicators, respectively, in each of the 5 sectors listed below)
- Level 2: 5 sector indicators (Governance for Sustainability, Social Sustainability, Innovation for Sustainability, Environmental Sustainability and Economic Sustainability)
- Level 1: Overall SWI index for China.

Figure 8.1: The indicators hierarch of the SWI for China

8.3.2 Constructing the composite index

A composite index is increasingly recognized as a useful tool in policy analysis and public communication. A composite index is constructed to combine a large number of factors or indicators in a standardized way, so as to provide a useful statistical measure of overall market or country performance. It provides simple comparison of countries and identifying trends and draws attention to particular issues. However, poorly constructed composite indexes can mislead users to draw simplistic conclusions. Therefore, several methods were tested and sensitivity tests were conducted to arrive at the best way to construct the SWI for China[28].

Based on the structure of the conceptual framework for measuring Sustainable Development in China, indicators were constructed at four hierarchical levels, as shown in figure 8.1.

The composite index was calculated for level 1 to level 3 indicators, following the following steps:

1. All the measures were normalized with different methods as described above.
2. The mean of all the measures under the same theme indicator was calculated as a composite index for each theme indicator.
3. The mean of all the theme indicators under the same sector indicator was calculated as a composite index for each sector indicator
4. The final SWI composite index for China was calculated as the mean of the five sector indicators

8.3.3 Performance tests and preliminary results

Composite indexes with different normalization methods

Figure 8.2 shows the values of the composite index for sustainable governance, social sustainability, innovation for sustainability, environmental sustainability and economic sustainability, respectively, based on the four different normalization methods. Results vary significantly according to normalization method. Over the period between 2000 and 2013, the mean of the 5 sector indicators normalized by rank method varies from 6.41 to 9.42, while normalized by z-score method the mean of the 5 sector indicators varies from -0.27 to 0.48, and with re-scale method the mean varies from 0.37 to 0.63. The distance to reference method results in the composite index with largest variation, varying from 0.18 to 6.99 over the period between 2000 and 2013.

Even though the values of composite indexes produced by different normalization methods are significantly different from each other, the composite indexes show similar general trends over years. The sum of the five sector indicators grew steadily over the years from 2000 to 2013, regardless of which methods that were applied. Furthermore, the composite index at sector level also shows a similar trend for all the four normalization methods. The composite index for the environment sector continuously decreases while the composite indexes for the other four sectors grow over years.

When looking closer at the contribution of composite indexes for sector indicators and rankings of composite indexes, although the general trends do not change, there are differences across normalization methods when it comes to certain aspects. Generally speaking, the rank and re-scale method produce quite close results, with the least variations over the 14 years between 2000 and 2013. Z-score and distance method yielded much higher variation of composite indexes. Moreover, the rankings of composite indexes over the years are also slightly different across normalization methods. Based on rank method, the final SWI composite index was lowest in 2000, with 2004 and 2005 next to 2000. It is lowest in 2004 and 2005 with re-scale and z-score method. However, the distance method produced a rather different picture from the other three methods, as the final composite index based on distance method continuously grew

[28] Nardo, M. et al., "Handbook on Constructing Composite Indicators: Methodology and User Guide", OECD Statistics Working Papers, 2005/03, OECD Publishing. http://dx.doi.org/10.1787/533411815016

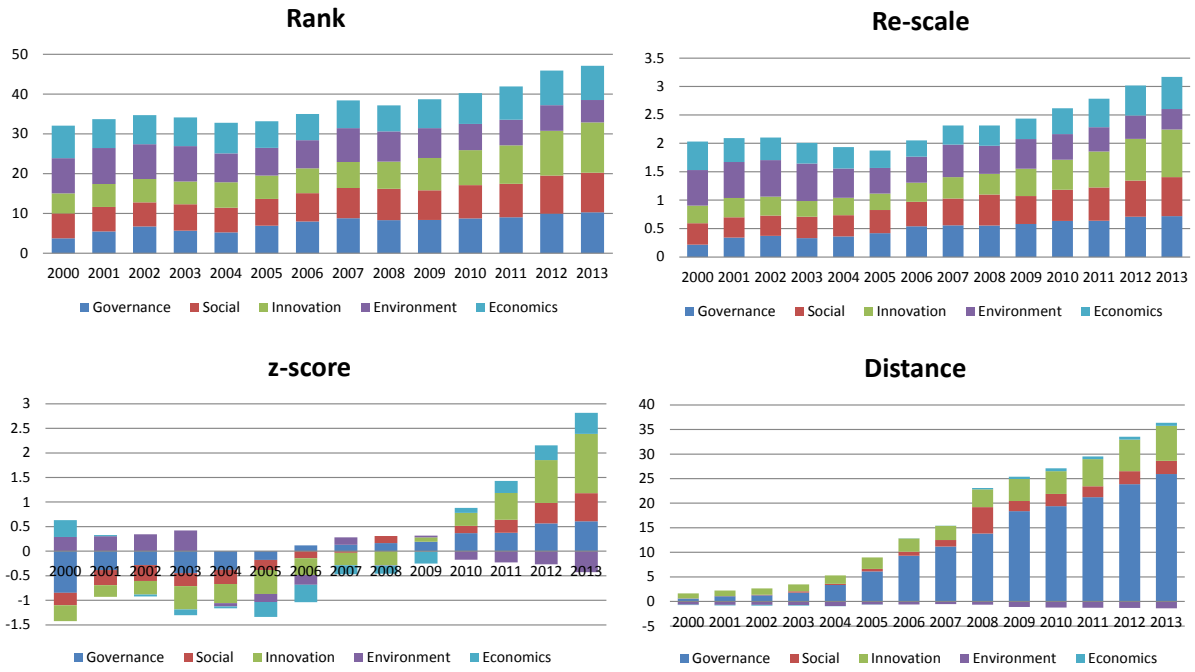

Figure 8.2: Composite indexes based on four methods

from 2000 to 2013. On the other hand, all the four methods are similar in that all results show a general trend of growth since 2006.

The four methods also behave differently regarding to the sector composite indicators. Figure 8.3 shows the composite indexes for the five sector indicators based on different normalization methods. Due to the large variation of indexes with different normalization methods, two different scale systems are used for the line graphs for each sector. Rank and distance methods use scale from 0 to 30, while z-score and re-scale use scale from -1 to -1.5. It should be noted that the actual value of the indexes with different normalization methods does not really matter here, while the trend of the indexes over years is important for comparing the different methods.

All the composite indexes show the same trend: Namely, a negative contribution of from the environment sector and positive contributions from the other four sectors. Yet, the relative contribution of each of the five sectors is rather different with different normalization methods. When distance method was used, the governance sector contributed most to the final stage composite index and increased rather rapidly over years; the innovation sector also contributed positively to the final stage index but much less than the governance sector; while the contributions of the rest of sectors were rather minor. When rank and re-scale methods were used, the contributions from each of the five sectors were rather equal, with the largest positive change from the innovation sector; and the smallest positive change from the social sector; and negative change from the environment sector over the years. Finally, when z-score method was used, the contributions of each sector to the final stage composite index was also relatively equal, with negative change in environment, and the largest positive change in innovation and governance sectors between 2000 and 2013.

In all, when different normalization methods were used, the composite indexes produced yielded rather different results with regard to the contributions of sector indicators and the values and rankings of the composite index. The rank and re-scale methods produce results with the least variations, while the distance method produces an index with unbalanced contributions from different sectors. However, the normalization methods used did not significantly change the overall trends of indexes over years (Figure 8.3). If more work is to be applied on the data in the future, for example through exploring the effects of different methods for weighting, the consequences of data treatment should be studied accordingly.

Sensitivity test

Sensitivity tests were conducted to assess to what extent the SWI is sensitive to changes in one or a few measures. The sensitivity test explored the effect of deleting each of the 106 measures, on the composite indexes of theme indicators, sector indicators and

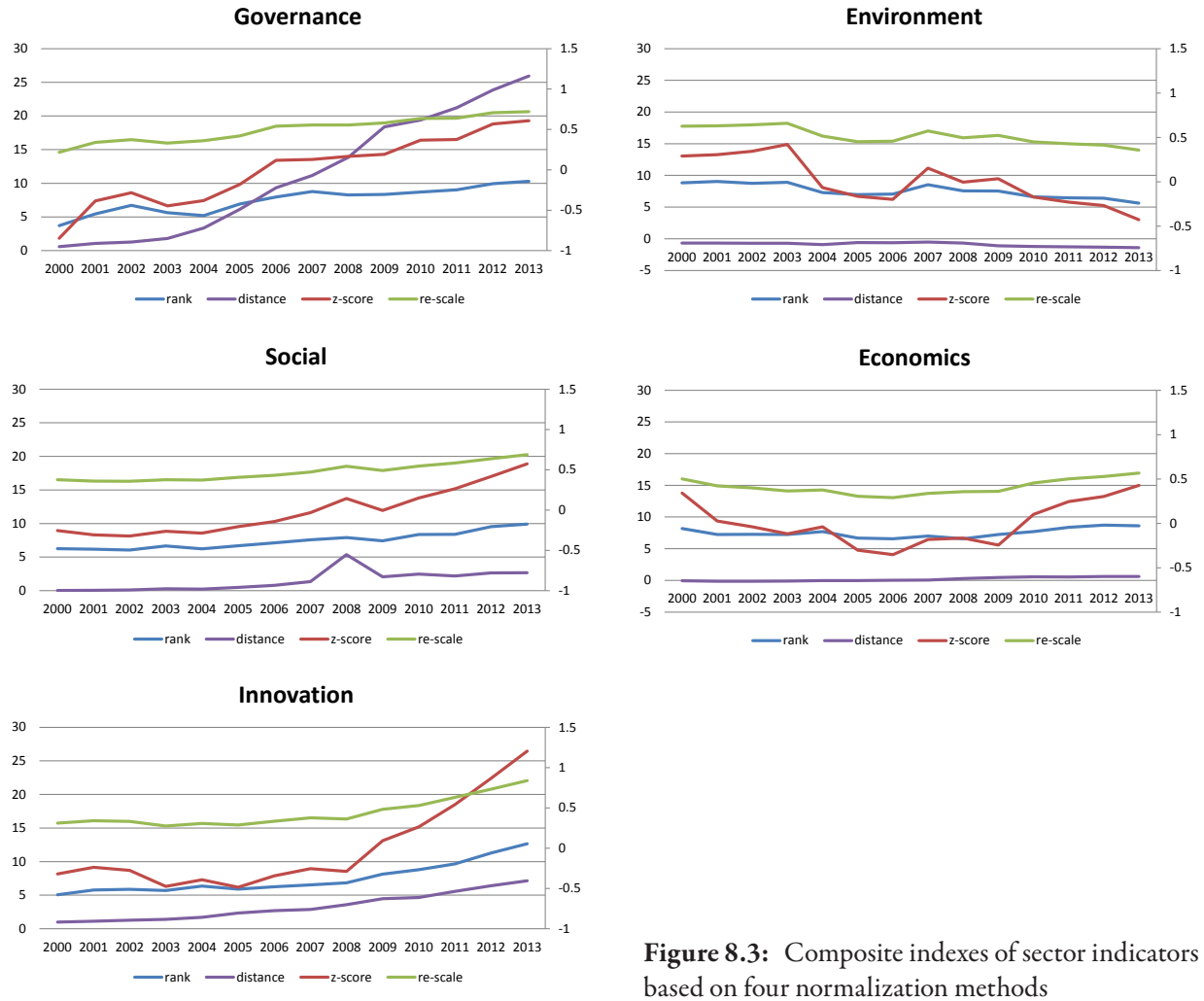

Figure 8.3: Composite indexes of sector indicators based on four normalization methods

the final SWI indicator. The aim of the sensitivity test was mainly to capture the relative shift in the position of the entire SWI system, expressed by one single number.

The formula used for the sensitivity test was:

$$\overline{R} = \frac{1}{T}\sum_{t=1}^{T} |Rank_{one\ indicator\ deleted}(CI_t) - Rank_{complete\ set}(CI_t)|$$

As indicated in the results presented on composite indexes with various normalization methods, application of different methods can lead to great variation in the value of the composite index. Therefore, it is difficult to directly interpret the value of the indexes. Instead, the ranking of the index over years is more important. Therefore, the focus of the sensitivity test is not to check for changes in the outcome of the composite indicator, but to check for shifts in the ranking of the composite indicator over the study period, as suggested in the formula.

The sensitivity test is a useful method to find out how sensitive the composite indexes are to each individual measures. However, in some cases the ranking of the composite indexes might not be sensitive to certain measures, even though the measure has a large impact on the value of the composite index. For example, the sensitivity test shows that several measures and especially one of the measures in the governance sector significantly change the value of the composite index with ratio normalization method; however, they did not change the ranking of the composite index.

The sensitivity test for the composite index of the theme indicators results in rather similar sensitivity of the theme indicators to individual measures with four different normalization methods. The sensitivity test also shows that the ratio method is least sensitive to the measures for sector indicators and final stage composite SWI, even though the value of the composite index based on the ratio method has the highest variation. The z-score method produces a final stage composite index that is more sensitive to the individual measures than the other three methods.

Chapter 9: Refinement and further development of the SWI

As stated in the foreword of this report, the SWI for China may be regarded as a pilot project in developing an indicator system to assess sustainability and longer-term well-being implications of rapid economic growth in China, as well as in other emerging economies. Hence, the index will be refined and developed further to comply as close as possible with its key visions of providing policy relevant information and being conceptually and methodologically robust.

In this respect, there are particularly four areas that will be assessed on basis of the experiences in developing the first SWI for China:

1. Policy relevance
2. Contextual clarity
3. Indexation methodology and data quality
4. Possibility to develop comparable indexes for other emerging economies

The policy relevance of the index and its underlying data will be exposed in the time after its launch. Our hope is that relevant actors, e.g. sector ministries, will provide feedback on the pilot index, and that adjustments in order to increase policy relevance can be made in consultation with them. The index web site (www.chinaswi.org) contains a blog on which comments regarding policy relevance and other suggestions for improvements are particularly welcome.

A main challenge in any indicator set or index is the balance between conceptual rigor and the inclusion of individual indicators of strong interest but which are not necessarily contributing in obtaining an overall picture of development. This index is no exception in this respect. We already received some comments on this issue in an early presentation of the index and the preliminary results in Istanbul in September 2013. These comments resulted in a change of the name of the index from SDI to SWI, and in a list of potential conceptual adjustments/refinements to be carried out in the near future. The main lesson from the Istanbul seminar was that a clearer distinction between different types of indicators in the set will increase the analytical possibilities and relevance of the index as well as strengthen its theoretical validity.

One possible adjustment in this respect may be to distinguish between a core set of indicators and a more contextual set of indicators in the system. A core set should consist of indicators that reflect key dimensions of well-being and which can show development in well-being over time ("effect" indicators). Contextual indicators should be indicators that influence well-being and which may have a looser contextual relationship to other contextual indicators. Such a conceptual framework is probably necessary in order to compare countries, due to the fact that some indicators may be treated as universal while others are and must be treated as contextual, i.e. different from country to country.

Another adjustment may be to distinguish clearly between input/output indicators (i.e. aspirations and resources invested to promote sustainability) and outcome/impact indicators (the measured effects of the investments). These types of indicators are intentionally combined in the present set, but by distinguishing more clearly between them we believe that policy relevance and general interest will be improved by providing more possibilities of comparing efforts and effects.

Regarding possible technical adjustments of the index, there is still room for mapping better and more solid data sources to replace or enrich the current list of measures. More relevant measures are expected to be included in the system, so as to better reflect sustainability of development in China.

Certain concepts such as "greening" are faced with a lot of challenges due to lack of data. Further work can be done to make such important concepts more operational and measurable. The availability of regional or lower level data is also an important obstacle to data collection in China, and further exploration of such data can also benefit the indicator system.

A final agreement must be reached on the analytical plan and statistical methods to be applied for constructing composite indexes. Among the four normalization methods tested so, the most appropriate method should be selected.

Weighting has only been applied on several groups of similar measures at the current stage of work. More sophisticated weighting system may be explored in the future. Finally, it is important to note that a composite index is never objective: Results are affected by all choices made from the selection of measures for the framework, the imputation of missing data to the normalization of data. People make decisions based on knowledge, experiences and technical analysis.

An underlying objective of developing a sustainable development index for China has from the outset been to develop similar systems for other emerging economies in order to compare developments and experiences of converting economic power into social well-being and of consolidating well-being into the future. Adjustments to the present index framework need to be carried out in order to adapt it to different contexts, e.g. by distinguishing more clearly between core ("universal") and contextual indicators.

Appendix 1: Full list of indicators in the SWI for China

1. Governance for Sustainability

Government responsiveness to SD Challenges

Number of positive administrative rulings related to environmental destruction (10,000 cases)
Percentage of urban waste collected and disposed of according to environmental safety standards (% of total urban garbage)
Percentage of environmental pollution control investment in GDP (% of GDP)
Funds allocated by the central government to social relief, as percent of total fiscal expenditure (% of total fiscal expenditure)

Governance efficiency

Public perception of government corruption
Public dissatisfaction with central government performance
Public dissatisfaction with county government performance
Percentage of government expenditure to total fiscal expenditure (%of total fiscal expenditure)
Days required to start up new enterprises (total days on average)

Government promotion of SD

Percentage of Renewable energy investment to GDP (% of GDP)
Percentage of the country designated as Nature Reserves (% of total landmass)
Public expenditure per enrollment in 9-year compulsory education (RMB per student enrolled)
Public pension expenditure per person aged 60+ (RMB per person 60+)
Public health expenditure per capita (RMB per capita)

Inclusive governance

Change in number of registered social organizations (year-on-year change)
Number of proposals raised by representatives to the National People's Congress (NPC)
Number of proposals raised by the Chinese People's Political Consultative Conference (PCC)

Global governance responsibility

Foreign aid as percentage of GDP
Personnel in international peacekeeping operations (persons)

2. Social Sustainability

Health status

Prevalence of Non-Communicable Diseases (‰ of the population)
Average life expectancy (year).
Self-rated health status

Health risks

Per capita daily alcohol consumption (Kg)
Per capita daily tobacco consumption
Obesity (% of adult population)

Living conditions

Urban household yearly per capita disposable income (RMB, adjusted by CPI, base year 2000)
Rural household yearly per capita net income (RMB, adjusted by CPI, base year 2000)
Urban yearly per capita living expenditure (RMB, adjusted by CPI)
Rural yearly living expenditure(RMB, adjusted by CPI)
Engel coefficient (% of food expenditure)
Annual average residential energy consumption per capita (kgce).
Per capita housing size (m2)
Urban Unemployment rate
University graduates unemployment rate (% of all university graduates)
Ratio of mean wages among newly employed undergraduates, to the mean wage among urban employees.
Self-reported happiness
Expected standard of living in the future (% of worsening)

Social security

Health insurance coverage (% of total population)
Average health insurance reimbursement rate (Reimbursement rate per insurance enrollee)
Percentage of pension receivers among the population aged 60+ (% of population aged 60+)
Monthly average pension received by pensioners (RMB, adjusted by CPI, base year 2000).
Percentage of the unemployed receiving unemployment insurance(%)
Monthly average benefit of umployment insurance for the unemployed (RMB, adjusted by CPI, base year 2000)

Public safety

Number of criminal cases placed on file per 10,000 population
Traffic accident mortality per 100,000 population
Perception of unsafety

Social equality

Ratio of urban/rural per capita living expenditure (adjusted by CPI, base year 2000)
Ratio of urban per capita disposable income to rural per capita net income (adjusted by CPI, base year 2000)
Gini coefficient
Ratio of female undergraduates/Ratio of male undergraduates aged 15-24 (ratio in the age group 15-24)
The proportion of women cadres at provincial (ministry) and above level(%)

Social cohesion

Charity participation
Per capita social donations (RMB per capita per year)
Per capita volume of voluntary blood donation (grams per capita age 15-59)
Lack of general social trust
Lack of social solidarity
Size of social networks (number of persons on average)

Sustainability of population structure

Population growth rate (‰)
Gender ratio at birth
Urbanization rate (urban population as percentage of total population).
Total fertility rate

Global social capital

Percentage of Chinese residents who are able to speak English (excluding Hong Kong, Macao, and Taiwan) (% of surveyed population)
Number of foreign visitors to China (1000 person-times)
Extent of imported foreign publications (types of imported publications per year)

3. Innovation for Sustainabiity

Innovation potential

Share of Graduates in Undergraduate and Junior Colleges of Sciences & Engineering (% of all graduate students)
Average educated years of population aged 6 or more (years)
Higher education gross enrollment rate (% of age group 18-22)
Research and development as percentage of GDP (% of GDP)
Share of R&D personnel in the population (person-year per 10.000 persons)
Internet access (persons with access to the internet per 100 persons)
Number of enterprises in Technology Business Incubators (total number per year)
Number of Technology Business Incubators (total number per year).

Innovation output and efficiency

Number of sustainable development/greening related patents
Number of published papers in the fields of energy and environment
Number of invention patents granted (cases per 10000 persons)
Number of papers cited in Thomson's Science Citation Index (10.000 papers per 5-year time period)
Growth rate of total factor productivity (TFP %)

Innovation diversity

Diversity index of publications

Global innovation capital

Number of Chinese students obtaining degrees from abroad (number of persons)
International students studying at Chinese universities (number of persons)
Participants in international cooperation projects in Science and Technology (Person-times)
Percentage of Chinese patent applications in the world (% of total new patent applications in the world)
R&D fund from abroad/R&D fund
R&D human resource from abroad/R&D human resource

4. Environmental Sustainabiity

Sustainable resource consumption

Total unclean energy consumption (10,000 tons)
Proportion of ecological food production by total food production (% of total food production)
Water consumption deficiency (m3/person)

Environmental pollution

Total Chemical Oxygen Demand (COD) discharge (10,000 tons)
Total SO2 discharge (10,000 tons)
PM10 discharge concentration (mg/m3 per day)
Total CO2 discharge (10.000 tons per year)
Lead discharge in industrial waste water (ton)
Outdoor air pollution attributable deaths in urban cities with 100,000 or more inhabitants

Environmental status

Heavily polluted seawater in coastal areas (%of total coastal area)
Heavily polluted fresh water (% of total fresh water area)
Perceptions of pollution problems
Forest coverage (% of total landmass)

Global environmental impact

Ecological footprint
Contribution of China to the global genuine saving from import

5. Economic Sustainabiity

Economic performance

GDP per capita (RMB, adjusted by GDP inflator, base year 2000)
Incremental capital output ratio(I/ΔGDP)
government deficit/GDP

Greening of the economy

Gross output of environmental industry as percentage of Gross industry output (%)

Economic environmental efficiency

Energy consumption per unit GDP (tonnes per 10,000 RMB GDP, year 2005 constant prices)
CO2 emission per unit GDP (tonnes per 10,000 RMB GDP, year 2000 constant prices)
Waste water discharge per unit industry output (tonnes per 10,000 RMB, at 2000 constant price)
S02 emission per unit industry output (tonnes per 10,000 RMB, at 2000 constant price)
Solid waste discharge per unit industry output (tonnes per 10,000 RMB, at 2000 constant price)
Fertilizer input use per agricultural production (tonnes per 10,000 RMB, at 2000 constant price)
Pesticides input use per agricultural production (tonnes per 10,000 RMB, at 2000 constant price)

Economic robustness

Male labor force participation
Female labor force participation
Newly added labor force supply (10,000 persons)
Export dependency (% of GDP)
Import dependency of energy (% of net energy import to total energy consumption)

Economic equality

Gini coefficient
Regional income inequality (gini index of GDP per capita on province level)

Economic globalization

Ratio of Outward Foreign Direct Investments (OFDI) by China in other countries to Global FDI(%)
Ratio of FDI by other countries in China to Global FDI(%)

Appendix 2: The SWI questionnaire on subjective well-being and happiness

Filled by interviewer			
A 1	Interviewer number	|_|_|	
A 2	Questionnaire number	|_|_||_|_||_|	
A 3	Location	Jiangsu	1
		Hubei	2
		Gansu	3

Hello,

This is telephone interviews center of Millward Brown ACSR, we are conducting a social survey on the happiness index which is commissioned by the Ministry of Science and Technology, I hope to get your support. Data about your views will be used only for overall analysis, and we will respect your privacy. Thanks again for your support!

Section 1: Background variables			
B 1	Gender	Male	1
		Female	2
B 2	Age [Notice for interviewer: ask the respondent specific age firstly and then choose corresponding age groups. If the respondent is reluctant to answer specific age, you can let him/her to choose the corresponding age group.]	|_|_|	[Notice for Programmer: Terminate when the respondent is under 18]
		Under 18	1
		18-19	2
		20-24	3
		25-29	4
		30-34	5
		35-39	6
		40-44	7
		45-49	8
		50-54	9
		55-59	10
		60-64	11
		65-69	12
		70-74	13
		75-79	14
		Over 80	15
		RF	➔Termination
B 3	Hukou status	Rural hukou	1
		Urban hukou	2
		No hukou	3 ➔Termination
		RF	4 ➔Termination
B 4	Where do you mainly live now, countryside or city?	Countryside	1
		City	2
		RF	9➔Termination
[Notice for Programmer: control the quota of respondents' type. If B3=2, respondents belong to "urban population"; If B3=1 and B4=2, respondents belong to "rural population working in urban areas"; If B3=1 and B4=1, respondents belong to "rural population"]			
B 5	General speaking, how would you describe your physical health situation?	Very good	1
		Good	2
		Neither good nor bad	3
		Bad	4
		Very bad	5
		RF	9

Section 2: Questions on happiness and wellbeing

Notice for Programmer: every respondent only need to answer one question among question H1a/b/c randomly. Make sure that in every province the proportion of respondent which successfully answer every one of the 3 questions is one-third at the end.

H 1a All in all, how happy would you say you are now?

Very happy	1
Somewhat happy	2
Neither happy nor unhappy	3
Somewhat unhappy	4
Very unhappy	5
DK	8

H 1b All in all, how happy would you say you are now?
(please place yourself on a scale from 1-7)

Extremely unhappy 01 02 03 04 05 06 07 Extremely happy DK 08 RF 09

H 1c All in all, how happy would you say you are now?
(please place yourself on a scale from 0-10)

Extremely unhappy 00 01 02 03 04 05 06 07 08 09 10 Extremely happy DK 98 RF 99

H 2 Compared to five years ago, are you happier now?
[Notice for interviewer: ask respondent about current happiness status compared to 5 years ago.]

Much more happier	1
Somewhat more happier	2
The same	3
Somewhat unhappy	4
Much more unhappy	5
Impossible to estimate	8

Section 3: Questions on social cohesion and social trust

Notice for Programmer: every respondent only need to answer one question among S1a/b/c randomly. Make sure that in every province the proportion of respondent which successfully answer every one of the 3 questions is one-third at the end.

S 1a Please tell me to what extent you feel that people in your village or community often help one another?
(In here, the village or community means the place where the respondents currently live in.)

Not at all	1
Rarely	2
Sometimes	3
Often	4
A great deal	5
DK	8

S 1b Please indicate to what extent you feel that people in your village or community often help one another, please rank on a scale from 1-7.
(In here, the village or community means the place where the respondents currently live in.)

Not at all 01 02 03 04 05 06 07 A great deal DK 08 RF 09

S 1C Please indicate to what extent you feel that people in your village or community often help one another, please rank on a scale from 0-10.
(In here, the village or community means the place where the respondents currently live in.)

Not at all 00 01 02 03 04 05 06 07 08 09 10 A great deal DK 98 RF 99

S 2 Do you feel close to the people in your village or community?
(In here, the village or community means the place where the respondents currently live in.)

Very close	1
A little close	2
Neither close nor alienate	3
A little alienate	4
very alienate	5
DK	8

S 3 Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?

Most people can be trusted	1
Need to be very careful	2
DK	8

Section 4: Questions on social networks and participation, and social capital			
PA 1			
	In the past 12 months, have you ever donated money or goods?(not including the money donated to the temple or church)	Yes No	1 2
	In the past 12 months, have you ever taken part in other kinds of charitable activities? (Likewise volunteering or donating blood etc.)	Yes No	1 2
PA 2	If you were looking for a new job, what would you do? (Multiple- choice question)	Go to employment agency(including the recruiting website) ask relatives or friends or other people to introduce Apply directly after seeing corresponding information (including information obtained from the internet, television, newspapers, radio and other channels) Job fairs Entrepreneurship by oneself / freelancers Do not look for a job/not suitable Other means_____ DK	1 2 3 4 5 6 7 8

Section 5: Questions on standard of living/relative deprivation			
R 1	How would you describe your current standard of living compared to other people in your county/city? (In here, the county/city means the place where the respondents mostly live in currently.)	Much below average Below average Average Above average Much above average Difficult to say	1 2 3 4 5 8
R 2	How would you describe your current standard of living compared to your relatives and friends?	Much below average Below average Average Above average Much above average Difficult to say	1 2 3 4 5 8
R 3	How would you describe your current standard of living compared to 5 years ago?	Much better Better The same Worse Much worse Difficult to say	1 2 3 4 5 8
R 4	How do you think your standard of living will be 5 years from now?	Much better Better The same Worse Much worse Impossible to estimate	1 2 3 4 5 8
R 5	How do you think the standard of living will be for your children compared to yours?	Much better Better The same Worse Much worse Impossible to estimate	1 2 3 4 5 8
R 6	*..."Think about your household's total economic situation, compare with other households live in this area please tell me which of the below sentences are suitable to the situation of you household? "* In here, this area means the place where the respondents mainly live in currently. [Interviewer should read the sentences following successively.]		
A	Compared with other households in this area our family's situation is rather good	Yes No DK	1 ➔G1 2 8
B	Although our household is not rich, we are still well off	Yes No DK	1 ➔G1 2 8
C	We are neither rich nor poor	Yes No DK	1 2 8

Section 6: Satisfaction with the government's service delivery			
G 1	In general, how satisfied are you with the educational system?	Very satisfied	1
		Somewhat satisfied	2
		Somewhat dissatisfied	3
		Very dissatisfied	4
		DK	8
G 2	In general, how satisfied are you with the health insurance system?	Very satisfied	1
		Somewhat satisfied	2
		Somewhat dissatisfied	3
		Very dissatisfied	4
		DK	8
G 3	In general, how satisfied are you with the pension system (old age care system)?	Very satisfied	1
		Somewhat satisfied	2
		Somewhat dissatisfied	3
		Very dissatisfied	4
		DK	8
G 4	In general, how satisfied are you with the quality of health services available to you?	Very satisfied	1
		Somewhat satisfied	2
		Somewhat dissatisfied	3
		Very dissatisfied	4
		DK	8

Section 7: Questions about the prominent problems in society and environment			
P 1	In general, how serious would you say that **inequality** is as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 2	In general, how serious would you say that **official corruption** is as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 3	In general, how serious would you say that **food safety** is as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 4	In general, how serious would you say that **safety of medicine** is as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 5	In general, how serious would you say that the **rising prices/inflation** is as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 6	In general, how serious would you say that **natural disasters** are as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 7	In general, how serious would you say that **pollution** is as a problem in society today?	Very serious problem Rather (somewhat) serious Not serious problem Not a problem at all DK	1 2 3 4 8
P 8	Do you feel that **pollution** has affected your health?	Yes No DK	1 2 ➔ P10 8 ➔ P10
P 9	How serious are the health effects?	Not so serious Serious Very serious DK	1 2 3 8
P 10	Do you think that **pollution** will affect your health in the future (5 years from now)?	Yes for sure Yes, maybe No DK	1 2 3 8

Section 8: Governmental satisfaction and safety			
GS 1	Generally speaking, do you feel satisfied with how the central government is performing?	Very satisfied Somewhat satisfied Somewhat dissatisfied Very dissatisfied DK	1 2 3 4 8
GS 2	Generally speaking, do you feel satisfied with how the county government is performing?	Very satisfied Somewhat satisfied Somewhat dissatisfied Very dissatisfied DK	1 2 3 4 8
GS 3	Generally speaking, do you feel satisfied with to what extent your rights as a consumer are secured?	Very satisfied Somewhat satisfied Somewhat dissatisfied Very dissatisfied DK	1 2 3 4 8
GS 4	Do you feel safe, if you need to go outside to somewhere near your home after 10 o'clock at night?	Always save Most time safe Most time unsafe Always unsafe DK	1 2 3 4 8

Section 9: English proficiency			
E 1	Are you able to read a newspaper article in English?	Yes, easily Yes, with difficulty No	1 2 3
E 2	Would you be able to have a conversation about your daily life in English with a foreigner you met in the street?	Yes, easily Yes, with difficulty No	1 2 3
E 3	How often do you use the internet?	Daily Several times a week Several times a month Hardly ever	1 2 3 4
PA 3	In the last spring festival, how many relatives did you contact to greet the new year with each other, including visiting, telephone, internet, SMS, and other means? How many friends do you contact? Any other acquaintances? *(if more than 97 fill in 97)*	No. of relatives No. of friends No. of acquaintances	|_|_| |_|_| |_|_|

Section 10: Education and job			
B 6	Marital status	Single/ never married	1
		Married	2
		Cohabit	3
		Divorced/ separated	4
		Widow/ widower	5
		RF	9
B 7	How many members in the household where you are currently residing? (if respondent is not sure, then read following: here means the number of people who share income with you including family members who go to school or work elsewhere, not including people who has separate from your family)	|_|_|	
B 8	Highest completed education	Never attended school/ incomplete primary	1
		Primary school	2
		Junior high school	3
		Senior high school	4
		Technical/professional school	5
		Junior college	6
		College	7
		Master	8
		PhD	9
		RF	99
B 9	What is your current main activity? (self-employment and working in agriculture also count as work)	Only Agricultural work	1→B11
		Agricultural and nonagricultural work	2→ B11
		Only Nonagricultural work	3→ B11
		Student	4
		Housewife	5
		Retired	6
		Unemployed	7
		RF	9→finish
B 10	Do you currently also have any jobs with income?	Yes	1
		No	2→ finish
		RF	9→ finish
B 11	Do you usually work more than 35 hours a week?	Yes	1
		No	2
		RF	9
	Investigator need to check (do not need to inquire the respondent) if the respondent is student, housewife or retired or unemployed. If B9=4/5/6/7, then finish the interview.	Yes	1→ finish
		No	2
B 12	What is your job?	Senior management staff	1
		General management staff	2
		Private enterprise owners / self – employed	3
		Professional and technical personnel	4
		Office staff, clerks, salespeople	5
		Skilled worker	6
		Unskilled workers	7
		Farmer(if b9=farming, circle this directly)	8
		Other ,_____	9
		Servicemen / police	10
		RF	99

B 13	What is the type of the institution where you are working at?	No institution(self-employed or agriculture)	1
		Individually-owned business	2
		State-owned enterprise	3
		Private enterprise	4
		Sino-foreign joint ventures, Sino-foreign cooperative enterprise or foreign-funded enterprise	5
		Public institution	6
		Government department	7
		Communist Youth League of China, The Labor Union, The Women's Federation, China Federation of Literary and Art Circle, etc	8
		Social league, foundation, or nongovernmental organization	9
		Villagers' committee or residents; committee	10
		Others,_____	11
		RF	99
B 14	How likely would you say it is that you will lose this job/ jobs in the next 12 months?	Very likely	1
		Likely	2
		Have no idea/don't know	3
		Unlikely	4
		Very unlikely	5
		RF	9

Appendix 3: SWI survey sample design

The document describes the sample of the telephone survey for the project "Indicators of sustainable development in China", referred to as the SWI survey. The survey was conducted in April and May 2013 for the provinces of Jiangsu (江苏), Hubei (湖北), and Gansu (甘肃).

Requirements of the sample

The design of the sample was subject to a number of constraints. The main characteristics of the sample design are the following:

- The population selected for this study is the residents currently living in three provinces of China: Jiangsu (江苏), Hubei (湖北), and Gansu (甘肃).
- The budget allowed for 3060 completed interviews. 1020 completed interviews should be carried out in each province. The completed interviews are here defined as those with complete information for all the relevant questions in the questionnaire.
- The sample design of the SDI survey does succeed in generating a sample with known design weights but with a main focus on reducing response bias in telephone surveys and that allow based on an adequate number of responses. The survey should be able to provide enough responses broken down by age groups, sex, place of residence (rural/urban) and Hukou registration.
- The questionnaire calls for persons aged 18 or above to answer.
- Respondents are accessed through telephone (landline and mobile).

The sampling frame

The sampling frame is constructed based on the number block published on web, 114 number check hot line and yellow book for the selected counties in the three provinces. The number blocks are mainly collected through web and the 114 number check hotline. The number blocks are updated for the SWI survey up to April 2013.

Table 1 Number of cities by province

	Gansu	Jiangsu	Hubei
Number of cities	60	63	68
Population size (Thousand)	224194210	786609410	546978100

Sampling design

The importance of collecting opinions of both the urban and rural population is specified in the SWI survey. Rural population take up a larger proportion of the total population than the urban one, on the contrary, the sample frame of number blocks in rural areas is more difficult to complete than the urban areas. Therefore, the sample is stratified according to location (rural or urban), in order to get sufficient sample size for both the urban and rural population. The sampling design is slightly different between the urban and the rural area. For the urban area, it is a two stage stratified cluster sampling. An extra stage is added for the rural areas.

The Primary Sampling Units (PSUs) for both the urban and rural areas are the cities (may be cities or county level cities) in the administrative divisions defined by the Chinese government. Implicit stratification was used on this stage. 34 clusters are selected with probability proportional to size (population size[29]) in each of the three provinces.

Secondary Sampling Units (SSUs) are different for the urban and rural areas since an extra sampling stage is added for the rural areas. For the urban areas, SSUs are the telephone numbers and therefore are the ultimate sampling units. But for the rural areas, SSUs are the townships (may be townships or villages) in the **administrative divisions** defined by the Chinese government. SSUs in the document will only refer to the sampling stage for rural townships or villages, to avoid confusion. Selection of telephone numbers is defined as ultimate sampling units for both the urban and rural areas. 5 rural SSUs in each of the 34 PSUs are selected through simple random sampling (SRS) for the rural areas.

[29] Information on population size for each PSUs (cities or county level cities) is get from the 2010 census.

Ultimate Sampling Units (USUs) are the telephone numbers. All the available number blocks for the selected PSUs for the urban areas and SSUs for the rural areas are collected. Random digit dialing (RDD) is used to select telephone numbers. However, some mobile numbers are appended in order to complete the quota in sample allocation, this mobile numbers are collected from the respondents during the interview. No sampling procedure is carried out for these mobile numbers.

The key elements of the sampling are the following:

- PSUs are implicitly stratified by being sorted according to their geographic location.
- PSUs are selected with linear systematic sampling proportionate to size (PPS), where the size measure is the population size of the city, published by the 2010 census.
- SSUs (townships or villages) for the rural areas are selected with SRS.
- Random digit dialing (RDD) is used to select telephone numbers. But some mobile numbers are appended during the field work with no inclusion probability.
- Quota of each cell of sample allocation is strictly required to be complete.
- Residents living at the selected areas during the survey period are the target population, regardless of whether they are temporary residents or permanent residents.
- Only people aged 18+ are qualified to answer the SWI questionnaire.

Sample allocation

The sample design of the SWI survey does not aim at generating a sample with known weight, but to reduce response bias in telephone survey based on adequate responses. Therefore, the sample is allocated in terms of sex, age group, residence place and Hukou registration.

According to the survey plan, 3060 completed interviews should be done in three provinces: Jiangsu (江苏), Hubei (湖北), and Gansu (甘肃). 1020 completed interviews should be done in each province.

1020 completed interviews of each province should be allocated in terms of age, gender, place of registration and Hukou registration. Age and gender are combined together at the province level. While place of residence and Hukou registration are combined together at the cities level.

For each of the 34 PSUs, 30 completed interviews are required. In addition, the 30 interviews should be allocated equally among urban population with urban Hukou, urban population with rural Hukou[30], and rural population with rural Huhou.

Table 2 Age and gender distribution

Province	Age 18-30	Age 31-50	Age 51+	Total
Male	170	170	170	510
Female	170	170	170	510
Total	340	340	340	1020

Implicit stratification

Implicit stratification was carried out by sorting the PSUs according to their geographic location on map[31]. Then the sorted PSUs are selected with systematic linear sampling.

Sample selection procedures

Selection of PSUs

All the cities in each province are sorted according to their geographic location and then stratified into two strata. Altogether, 34 cities should be selected in each province. Cities with large population are included in stratum 1. The threshold of population size for stratum 1 is the population size of province divided by 34. All the cities in stratum 1 are selected. The rest cities are selected with linear systematic PPS sampling in stratum 2. The size measure is the population size of the city, published by the 2010 census.

Selection of SSUs

SSUs (townships or villages) are selected with simple random sampling. Random numbers are allocated to all the townships or villages in each PSU. Five townships or villages with the highest random numbers are selected. For some PSUs, the total of SSUs is less than 5, then all the villages or townships are selected in that PSU.

Selection of USUs

Random digit dialing (RDD) is used to select telephone numbers. The number blocks used for this project contain the first 4 digits, then the missing 4 digits are generated.

[30] Urban population with rural Hukou are the population having rural Hukou registration but currently living in the urban areas.

[31] Maps with order of PSUs are attached as appendix 1.

Table 3 Place of residence and Hukou registration

PSU	Urban population with urban Hukou	Urban population with rural Hukou	Rural population with rural Hukou	Total
Completed interivews	10	10	10	30

All the possible telephone numbers are saved in a dataset. Number blocks are collected through web, the 114 number check hotline and the yellow book published by China Telecom. Web and hot-line are the main sources. The number blocks were updated up to April 2013 right before the SWI survey, but still may not be completed. Telephone numbers are randomly selected from the database until all the quota of respondents are completed.

Two number block database are constructed by urban and rural. For the urban area, all the available number blocks for the 34 PSUs (cities) are collected; and for the rural area, number blocks for the SSUs (townships or villages) are left in the other number block pool. The urban number blocks are used to interview the urban population with or without rural Hukou. The rural number block pool is used to interview the rural population with rural Hukou. Number blocks are grouped by PSUs and by place of residence (rural/urban) in order to meet the sample allocation.

Substitution

No substitution of selected PSUs/SSUs or telephone numbers is to take place.

Appended mobile numbers

For certain sub-population, e.g. age group 18-30, urban population with rural Hukou, are difficult to be accessed through landline. In order to complete the quota, mobile numbers are collected on purpose from respondents during the interview. Mobile numbers are only used for interviewing urban population with rural Hukou. When the missing quota for this sub-population takes up over 80 percent of the total missing quota, mobile numbers are added.

Table 4 Allocation of PSUs by province

	Gansu	Jiangsu	Hubei
Stratum 1	3	7	4
Stratum 2	31	27	30

Table 5 Number of SSUs by province

	Gansu	Jiangsu	Hubei
SSUs	161	170	164

Inclusion of probabilities and weights

Respondents of interview are draw with unequal probability, so the sample is not self-weighed. According to the sampling design, USUs are the telephone numbers but not individual respondent. Therefore, the weights shall be adjusted in terms of non-response and calibrated according to population distribution.

However, the inclusion probabilities and weights are not calculated at the moment with regards of the following problems:

- The sampling is designed to draw telephone numbers while individual respondents are the target population for the SWI survey. Although the weights can be and have to be adjusted according to the non-response distribution and population distribution. It is still a challenge to use the weights with regards of selection bias and standard error.
- Non-response rate is high. Complete interviews only take up 1 percent of the total number of dialing. In addition, response rate calculations can be imprecise because it can be difficult to determine whether certain telephone numbers are interviewable.
- Appended mobile numbers make the calculation of inclusion probability more complex.

If weights are going to be added in the future, technique report provided by MillwardBrownACSR (Appendix 2) shall be taken into consideration for non-response adjustment. Calibration can be done according to the population distribution shown in Appendix 3.

Table 6 distribution of respondents accessed by landline and mobile numbers

	Jiangsu	Hubei	Gansu
Landline	942	993	1020
Mobile	78	27	0
Total	1020	1020	1020