Key Performance Indicators for Rural Development in China

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INTRODUCTION

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Between spring 2018 and 2019, the Sustainable Development Policy and Finance Team at the Roberts Environmental Center (REC) conducted a literature review and policy analysis to determine a list of Key Performance Indicators (KPIs) as a framework to assess performance of IRDC projects in rural China.

IRDC and EARTH + Associates

The International Rural Development Center (IRDC) is a nonprofit organization (NGO) whose goal is to solve the social and environmental problems rural communities face as a result of rapid urbanization. The IRDC develops prototype rural communities to test strategies to mitigate the negative impacts of urbanization on rural societies, with the goal of creating long-term sustainable community templates. Additionally, the IRDC houses platforms for international collaboration between field experts and governmental authorities, and a digital forum to share discussion and projects. The IRDC is a client of EARTH + Associates, a company which develops environmentally sustainable architectural design prototypes with the goal of affordable and net positive infrastructure. EARTH + Associates works to achieve this goal by developing green design templates, providing programs to market sustainable development, and creating water management initiatives.

Goal of Key Performance Indicators (KPIs) Research

EARTH + Associates asked the REC team to determine KPIs to assess performance of rural development projects in China. The REC team identified 47 KPIs to help EARTH + Associates build a model and assess the performance of the IRDC's rural development projects. KPIs are important because they can measure the impact a certain project on the larger economy, society, and environment. In this paper, the REC team selected KPIs that address the tradeoffs between rural and urban development. Because the selection of certain KPIs to measure impact would lead to different developmental outcomes, the REC team also identified which policy goals the KPIs address.

Methodology

Each analyst in the REC team conducted an extensive literature review to create a list of KPIs that could be found in rural development focused research. These KPIs were divided into specific areas of interest: land use, energy, water, air, transportation, economy, and a more broadly defined "social aspect" subsection. After an exhaustive initial list was compiled, KPIs were judged based on a few important distinguishing factors. Most notably, each analyst investigated the face validity of certain indicators and the potential relationships between various indicators—whether there may be underlying factors that could drive both KPIs simultaneously. Afterwards, each analyst created a final list of the most important and relevant KPIs among each interest area, and researched potential sources that could be used to help gather needed data to calculate each indicator.

BACKGROUND ON SUSTAINABLE DEVELOPMENT IN CHINA

Katie O'Neill (CMC '21)

Importance of Rural Development

China has been urbanizing at a faster rate than ever seen before in world history, which has produced massive economic growth and lifted over 600 million people out of poverty in recent decades. However, the concentration of people in urban areas has several negative impacts, including the loss of traditional livelihoods, decrease in amount of agricultural land, and increased concentrations of pollution. In particular, air pollution has devastating health impacts and creates political instability. Incentivizing industry to move to rural areas can promote development in line with the United Nations Sustainable Development Goals (SDGs) by decreasing air pollution in urban areas, maintaining traditional livelihoods, and expanding economic opportunities to rural areas.

Importance of Sustainable Development Goals in China

In September of 2016, China's Foreign Ministry released a comprehensive plan to achieve the Sustainable Development Goals (SDGs). The report, titled "China's National Plan on the Implementation of the 2030 Agenda for Sustainable Development," outlines general principles, broad strategies, and specific programs aimed at fully realizing the SDGs in China by the year 2030. The report is divided into five sections, three of which are relevant to the goals of our paper: the third, fourth, and fifth sections. The first two sections reflect on lessons learned from China's efforts to implement the Millenium Development Goals (expired in 2015), which discuss general challenges and opportunities for China in implementing the SDGS. The third section explains the guiding thoughts and principles backing China's SDG strategy. The guiding thoughts are aimed at the different forms of desired development, and the principles explain the ideological and ethical goals that underpin China's development efforts. The fourth section outlines seven overall approaches to implementing SDG projects: Synergy of Strategies, Institutional Guarantee, Social Mobilization, Resource Input, Risk Management, International Cooperation, and Oversight and Review. Finally, the fifth section provides a detailed overview of the projects which will help realize the SDGs. This section consists of a table which lists each SDG and provides five to ten projects that the government aims to enact by 2030. These projects are widely varied, but most fall into one of the following broad categories: policy change, new social programs, new economic stimulation programs, resource investment, and the joining of international treaties and bodies.

Although China's SDG strategy does not rank the SDGs in terms of priority, President Xi Jinping has determined nine SDGs which are of special importance to China. In a speech at the United Nations, President Xi Jinping identified the following nine SDGs as central facets of China's overall development strategy: No Poverty; Zero Hunger; Affordable and Clean Energy; Decent Work and Economic Growth; Industry, Innovation, and Infrastructure; Reduced Inequalities; Climate Action; Peace, Justice, and Strong Institutions; and Good health and well-being for people. Given the scope of this project, we have chosen to focus on No Hunger, Zero Poverty, Affordable and Clean Energy, Reduced Inequalities, and Climate Action for our Key Performance Indicators.

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1. Climate Change KPIs

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Table 1.1. Recommended Climate Change KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Ratio of carbon sequestered to carbon emitted**	Ross W. Gorte (2009). Cacho, O., Marshall, G., & Miline, M. (2005).	**Reducing or maintaining carbon footprint despite rural development**	Angelo Sil, Felícia Fonseca, João Gonçalves, João Honrado, Cristina Marta-Pedroso, Joaquim Alonso, Maria Ramos & João C. Azevedo (2017). John O. Niles, Sandra Brown, Jules Pretty, Andrew S. BAll, and John Fay (2002).
2.	**Percentage of Waste Incinerated**	Zhang, D. Q., Tan, S. K., & Gersberg, R. M. (2010).	**Reduction of Emissions from Burning Waste**	The World Bank
3.	**Total emissions of Kyoto Protocol top 7 greenhouse gases**	Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, U.N. Doc FCCC/CP/1997/7/Add.1, 37 I.L.M. 22 (1998).	**Targeting Reduction of GHG emission**	Gess Council for Sustainable Development (2015).
4.	**CO2 emissions in passenger and freight transportation sectors**	Wang, B., Sun, Y., Chen, Q., & Wang, Z. (2018).	**Economic growth, transportation intensity, and carbon**	The World Bank (World Development Indicators: Carbon dioxide emissions

			emission	by sector)
5.	**Ratio of total greenhouse gas emissions to regional GDP**	Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havranek, M., ... & Mendez, G. V. (2009).	**Targeting Reduction of GHG emission**	Ritchie, Hannah and Roser, Max. (2017, May 11). CO_2 and other Greenhouse Gas Emissions.
6.	**Emission of Hydrofluorocarbons (HFCs) per capita**	Khalil, M. A. K., Rasmussen, R. A., Culbertson, J. A., Prins, J. M., Grimsrud, E. P., & Shearer, M. J. (2003).	**Targeting Reduction of GHG Emission**	Tsai, W. T., Chen, H. P., & Hsien, W. Y. (2002). A review of uses, environmental hazards and recovery/recycle technologies of perfluorocarbons (PFCs) emissions from the semiconductor manufacturing processes. Journal of Loss Prevention in the Process Industries, 15(2), 65-75.
7.	**Energy related carbon emissions**	Chang, C. C. (2010).	**Targeting Reduction of GHG Emission**	Chang, C. C. (2010). A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. *Applied Energy*, *87*(11), 3533-3537.

Key Takeaways

Greenhouse gas emissions are an inevitable byproduct of industrial activity. China's booming economy and rapidly growing GDP demonstrate the associated increase in greenhouse gas emissions many other developing economies face. In efforts to achieve economic growth, there exist a range of other activities that contribute heavily to greenhouse gas production. To properly identify the impacts industry has on climate change, we chose the seven indicators above, which incorporate emissions from both consumers and producers.

In an analysis of carbon emitted into the atmosphere, it is important to include how much carbon is also sequestered, as it changes the global impact of rural development. For example, if a rural development project includes significant deforestation, the amount of carbon sequestered will be reduced, and measures should be taken to either lower the carbon emitted, or increase the carbon sequestered to offset the environmental consequences. Many countries boast how much carbon is sequestered in reports, but fail to specify the amount of carbon emitted. The ratio of carbon sequestered to carbon emitted was chosen as a KPI to include a both the possible repercussions and advantages to rural development, making it a more holistic view of the carbon footprint.

China produces more than 520,00 tons of garbage per day and has pledged to burn 40 percent of its garbage by 2020 in waste-to-energy plants. They currently have 300 plants and plan to build more soon. There are some such as the Gao'Antun incinerator power plant in Beijing which uses technologically advanced scrubbers to keep emissions below EU standards; however, most do not meet these requirements. Most waste-to-energy plants are constructed as cheaply as possible with little regard to the pollutants released into the atmosphere. CO_2 is the primary pollutant as 40-50% of waste is composed of carbon. In addition to CO_2, incinerators release high amounts of N_2O particles which contribute to climate change as well. Heavy metals, dioxins, and furans are also produced which all can cause serious health issues. Establishing a trash sorting process and a robust recycling system can help to reduce the amount of waste burned by around 70%, however, it is difficult to see this happening because incineration companies are a large special interest group and hold influence over policy makers. Understanding the utilization of waste-to-energy plants will be vital as China shifts its reliance away from coal burning power plants.

Due to its industrial-based economy, China contributes approximately half of all global HFC emissions. The chemical industry is the largest producer of HFCs, though it is also emitted through aerosols, refrigerators, and air conditioning. As China develops and its GDP increases, more HFCs are projected to be emitted. HFCs were formally identified in the Kyoto Protocol as one of seven greenhouse gases that should be targeted for reduction in order to prevent further drastic climate change. The Kyoto Protocol, enacted in 2005 in Kyoto, Japan, is an international agreement ratified by 192 parties that commits them to established greenhouse emission reduction targets. A larger goal of this agreement is to prevent global temperatures from rising a net of 2 degrees Celsius. It is imperative that HFC emissions are reduced because they have extremely high global warming potential (GWP), meaning their impact per unit is thousands of times more damaging than Carbon Dioxide.

See Table 1.2 for the seven GHGs identified by the Kyoto Protocol are primary contributors to climate change and are key pollutants that should be targeted for reduction.

Table 1.2. Seven Greenhouse Gases Defined in Kyoto Protocol.

	GHG	**Major Source**	**Approximate Concentration**	**Global Warming Potential (GWP)**

			in Atmosphere	
1.	**Carbon Dioxide (CO_2)**	Fossil fuel combustion, cement production	**399.5 ppm**	**1**
2.	**Methane (CH_4)**	Coal production and transport, rice cultivation, livestock	**1834 ppb**	**28**
3.	**Nitrous Oxide (N_2O)**	Solid waste burning, fossil fuel combustion, agricultural production, mining	**328 ppb**	**265**
4.	**Hydrofluorocarbons (HFCs)**	Aerosol and chemical production, refrigerators, air conditioning	**84 ppt**	**1,300**
5.	**Perfluorocarbons (PFCs)**	Aluminum production, semiconductor industry	**74 ppt**	**11,100**
6.	**Sulphur hexafluoride (SF_6)**	Equipment sector, magnesium production, semiconductor manufacturing	**8.6 ppt**	**23,500**
7.	**Nitrogen Trifluoride (NF_3)**	semiconductor manufacturing	**0.454 ppt**	**16,100**

PPM: Parts Per Million
PPB: Parts Per Billion
PPT: Parts Per Trillion

Key Takeaways

Ratified by 192 states in 1997, the Kyoto Protocol highlights 7 primary greenhouse gases that countries should target for reduction. These 7 are leading contributors to global warming and have extensive residence time within the atmosphere. Byproducts of the developing and industrializing world, these pollutants are being emitted at an increasingly exponential rate. China especially is a culprit of greenhouse gas production, and has contributed to 10% of all anthropogenically produced methane over the past decade.

These pollutants range in their global warming potential (GWP). For the purpose of standardization and consistency, it is most prudent to measure these pollutants using their 100 year GWP timescale, as determined by the World Resource Institute's Greenhouse Gas Protocol. The GWP scale indicates how much energy one ton of gas will absorb over time relative to carbon dioxide, which is the standard basis of comparison. The larger the GWP value, the greater warming effect pollutants have on overall climate change.

Despite carbon dioxide's lower GWP, it contributes the most to overall climate-warming due to its vast concentration in the atmosphere. However, there are a number of much more potent greenhouse gasses with the potential to dramatically increase global warming as China industrializes. Notably, hydrofluorocarbons and perfluorocarbons have extremely high global warming potential. This is especially concerning in China because China's development has increased the demand for products associated with HFCs and PFCs, such as air conditioning and refrigerators.

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2. LAND USE KPIs

Katie O'Neill (CMC '21)

Table 2.1. Recommended Land Use KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Average size of public and private land holdings in km²**	Khandelwal, Sugandha and Krishnamurthi, Lakshman. (2011, September 22).	**Sustainable Development Goal (SDG) 10: Reduced Inequalities**	Khandelwal, Sugandha and Krishnamurthi, Lakshman. (2011, September 22).
2.	**Percentage private land/public land**	Huang, D., Huang, Y., Zhao, X., & Liu, Z. (2017).	**SDG 10: Reduced inequalities**	Huang, D., Huang, Y., Zhao, X., & Liu, Z. (2017).
3.	**Percentage agricultural land/industrial land**	He, C., Huang, Z., & Wong, W. (2012, October)	**SDG 9: Industry, Innovation, and Infrastructure**	Ministry of Land and Resources (2008) cited in He, C., Huang, Z., & Wong, W. (2012, October)
4.	**Breakdown of agricultural land use by product grown**	Chinese Ministry of Agriculture and Rural Affairs	**SGD 2: Zero Hunger**	Ministry of Land and Resources (2008) cited in He, C., Huang, Z., & Wong, W. (2012, October)
5.	**Breakdown of industrial lands by product manufactured**	W., He, R., & Wu, Q. (2017, December 17)	**SDG 1: No Poverty**	Ministry of Land and Resources (2008) cited in He, C., Huang, Z., & Wong, W. (2012, October)

Key Takeaways

Land use is a key component in understanding quality of life in rural areas, especially in China, where the central government has considerable agency in forming and enforcing land use policies. The first KPI analyzes the size of land holdings, both public and private, an indicator which has significant bearing on the distribution of wealth and power in a given region. The next step is to examine how much land in a region is held by the government (public) or by citizens and corporations (private). This KPI is important because it demonstrates the level of control people have over the land surrounding them and their ability to benefit from this land. The third KPI looks at how much land is being used for agriculture and industry, which is highly relevant given the Chinese government's current efforts to urbanize many rural areas through the expansion of industrialism into traditionally agricultural regions. The fourth and fifth KPIs look at the agricultural and industrial sectors and examine what the land in these sectors is being used to produce. This information can be very telling regarding the quality of life in both rural and urban areas. For example, if the majority of agricultural land in a region is being used for subsistence farming, the people of that region will typically be disadvantaged in a number of ways compared to regions where the majority of agricultural land is used for cash crops. This is because cash crops are, of course, more profitable for communities, but carry other negative consequences as they sometimes result in exploitative employment practices for farmers. Likewise, if the majority of industrial land is being used for steel mills or textile production, the people of that region will face different environmental issues than those in a region where industrial land is focused on non-polluting industries, such as flour mills. Additionally, these people will have different employment opportunities that will impact their overall quality of life.

Limitations

These indicators are highly specific and each contains a wide array of data and requires analysis to be used effectively. These variables do not seem to be highly correlated, as they each measure very specific and different factors. These KPIs are relatively straightforward and there are not face validity concerns. Further, if researchers want to look at these KPIs over time they will encounter difficulties as the Chinese government has restructured the various ministries related to land use several times in the past two decades. This process of restructuring has primarily been focused on consolidating ministries with similar or overlapping functions to increase efficiency. However, as a result, past data is scattered over a variety of sources, some of which are no longer available online. Currently, the bodies to target would be the Ministry of Agriculture and Rural Affairs and the Ministry of Natural Resources. Finally, the data from these KPIs will be easiest to gather and most useful looking at relatively small areas because there is a huge variation in land use even across a single province. Thus, it is important to analyze data on these KPIs at a local level, perhaps even community-based. This is because the implications of this data are widespread, including cultural, social, environmental, and economic impacts on communities. In this regard, the land use section has some overlap with many of the other KPI areas identified in this paper because the ways in which land is allocated and used is directly correlated with other quality of life indicators.

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3. ENERGY KPIs

Cade Moffatt (CMC '21)

Table 3.1. Recommended Energy KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Electricity consumption by province per 100 million kWh**	Dhakal, S. (2009).	**Equitable distribution of electricity access**	National Bureau of Statistics in China Census and Economic Information Center (CEIC)
2.	**Composition of energy production as a percentage**	Dhakal, S. (2009).	**Composition of fossil fuels vs. clean energy**	National Bureau of Statistics in China Census and Economic Information Center (CEIC)
3.	**Energy consumption for each Sector per 100 million kWh**	Tanaka, K. (2008).	**Understanding how energy is being used across industries**	National Bureau of Statistics in China Census and Economic Information Center (CEIC)
4.	**Energy intensity of GDP**	Tanaka, K. (2008).	**Importance of energy efficiency initiatives**	National Bureau of Statistics in China
5.	**Average residential power price by province (Yuan/kWh)**	Zhou, N. (2016).	**Availability of affordable energy**	Lawrence Berkeley National Library

Key Takeaways

When looking at KPIs relating to energy for the purpose of rural development, it is important to identify indicators that are able to give insight across regions, industries, sources of energy, and efficiency. Access to reliable and affordable energy in rural areas is incredibly important for sustainable economic growth. China has done well in supplying energy to its population, however, pollution and waste are key issues with their energy production and utilization. These energy KPIs directly impact the energy production and manufacturing industries while also shedding light on the usage of energy in China as a whole. In order to prevent serious issues arising from greenhouse gases and air pollutants such as Nitrogen Oxides, and Sulfur Dioxide, implementing rural development programs is incredibly important. Having concentrated areas with high consumption of dirty energy such as coal or crude oil can lead to unhealthy air quality and severe climate change. So, it is in the government's best interest to focus on rural development rather than building regions of high industrial density. Electricity consumption by province and energy consumption across sectors for example, gives valuable insight into which areas are utilizing smaller amounts of energy and thus are more likely to have potential for industry expansion and development. Similarly, areas which consume high amounts of energy are more likely to be crowded and a less desirable location for expansion. These two indicators alone cannot sufficiently paint a picture of the countries energy consumption. By examining the type of energy being used, the sustainability and pollutants caused by energy consumption and production can be inferred. Energy intensity by GDP identifies how efficiently energy is being used in production. Using this metric, the government can identify areas which can improve upon their energy efficiency, thus cutting down energy consumption. In 2016, 69.6% of China's energy production was from coal. China has set targets of 35% renewable energy use by 2020, however, new coal mines continue to be opened and it does not appear the use of coal in China will stop soon.

Limitations

Because of the broad nature of energy as a topic, it was difficult to find KPIs which captured the entire scope while still remaining specific, measurable, attainable, relevant and timely. This was a constant issue when determining which KPIs to research. Energy intensity by GDP, for example, is an incredibly useful KPI, however, it is not the most specific. By basing the KPI on GDP as a whole, the efficiency of the entire economy is measured. It would be useful to see a breakdown of the energy intensity of specific industries, but that would then leave out some essential elements of the concept and cause an issue with the face validity of the indicator.

China has an incredibly low average price of energy, however, it is most likely highly correlated with the composition of energy. China is able to keep prices low because they use such high amounts of coal which is a cheap and abundant source. If the use of coal begins to fall it can be expected that the price of energy will increase. This change in price may actually harm rural economies as energy will become less accessible.

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4. WATER KPIs

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Table 4.1. Recommended Water KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Arsenic concentration (mg/L)**	Meng, X., Zhang, Y., Zhao, Y., Lou, I. C., & Gao, J. (2012).	**Ensuring water safety** **Control pollution discharge**	Standards for Drinking Water Quality (MH and SAC 2006).
2.	**Total Bacteria Content (number/mL)**	The World Bank and State Environmental Protection Administration P.R. China (2007).	**Ensure water safety** **Control pollution discharge**	Annual Report (Ministry of Water Resources 2005).
3.	**Mercury concentration (mg/L)**	Meng, X., Zhang, Y., Zhao, Y., Lou, I. C., & Gao, J. (2012).	**Ensure water safety** **Control pollution discharge**	Standards for Drinking Water Quality (MH and SAC 2006). Surface Water Quality Standard (SEPA 2002).
4.	**Heavy metal concentration (mg/L)**	Meng, X., Zhang, Y., Zhao, Y., Lou, I. C., & Gao, J. (2012).	**Ensure water safety** **Control pollution discharge**	Standards for Drinking Water Quality (MH and SAC 2006). Surface Water Quality Standard (SEPA 2002).
5.	**Fresh water consumption per unit of industrial added value (m^2/ 10,000 GDP)**	Wang, S. (2009).	**Promote sustainable use of water for economic and industrial transformation**	China's Development of Low- Carbon Eco-Cities and Associated Indicator Systems (Zhou, N., He, G., Williams, C. 2012).
7.	**Water consumption per capita/day (L/capita/day)**	Wang, S. (2009).	**Equitable distribution of water**	China's Development of Low- Carbon Eco-Cities and Associated Indicator Systems

				(Zhou, N., He, G., Williams, C. 2012).
8.	**Compliance rate for quality of centralized source of drinking water (%)**	Wang, S. (2009).	**Ensure water safety** **Control pollution discharge**	China's Development of Low- Carbon Eco-Cities and Associated Indicator Systems (Zhou, N., He, G., Williams, C. 2012).
9.	**Proportion of household income spent on water and sanitation (%)**	World Bank. (2007).	**Use market mechanisms and enforce law & regulations for water**	Water Supply Pricing In China: Economic Efficiency, Environment, and Social Affordability (World Bank 2007).

SEPA: State Environmental Protection Administration of the People's Republic of China
SAC: Standardization Administration of the People's Republic of China
MH: Ministry of Health of the People's Republic of China

Key Takeaways

As a result of China's prioritization of industry and economic growth, over half of its population lacks access to clean drinking water, and relies on sources contaminated with toxins ranging from mercury to petroleum (SEPA 2002). In fact, statistics generated by SEPA reflect that that upwards of 90% of areas with heavily polluted water in China are near large cities. For those residents, effluents, toxic sludge, and heavy metals produced by manufacturing processes contribute to a host of medical detriments. This includes, yet is not limited to, respiratory illnesses, a range of cancers, and neurological ailments. The selected KPIs related to toxins were determined by synthesizing multiple factors: degree of fatality to human health, relevance in China, and frequency at which industries exceed their hazardous levels. One of the largest concerns when evaluating water quality is arsenic level, as its neurotoxic effects stunt human development, especially for children exposed for extended periods of time. Approximately 19.6 million people across China are affected by water sources severely contaminated with arsenic, which is heavily mined, processed, and exported by China in the form of arsenic trioxide and arsenic metalloid. Interestingly, China is one of the only countries in which arsenic is the targeted ore in the mining industry rather than just a byproduct. Additionally, glass and battery manufacturing industries in China produce arsenic-heavy wastewater. Fresh water consumption and water safety compliance rates are also important to evaluate to gauge gaps in clean water supply and demand, as well as the government's ability to enforce water pollution policies. All of these KPIs align with China's 5-year "Water Pollution Prevention and Control Plan" plan to improve water quality by 2020. Also known as the "Water Ten Plan," this 9.6 billion Yen (85 million USD) project aims to tackle

10 primary measures of improving water quality, while simultaneously promoting industrial growth, technological innovation, and strengthening environmental management.

Limitations

Each KPI is relatively straightforward and maintains clear face validity. Although different concentrations of toxins may indicate varying levels of water grade and quality for example, their measurements cannot be misinterpreted. The presence of different toxins and heavy metals are almost always correlated and co-occur either immediately from the point source or through mixing along water transportation and percolation networks. Water consumption per capita may also be contingent on fresh water available per marginal unit of industrial added value and fresh water compliance rate, as consumption may decrease or even be made impossible as a result of the other two factors. Failure to meet water safety compliance rate standards could severely limit accessibility to water and generate short and long term water scarcity problems. As for the SMART criteria, it may be hard to collect data on fresh water consumption related to amount of industry as it is less tractable. However, determining general consumption rates depending on location and local industry could produce representative data that could be used towards developing an overall correlation.

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5. AIR KPIs

Katie O'Neill (CMC '21)

Table 5.1. Recommended Air KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Mortality due to air quality related illnesses**	State Environmental Protection Administration & World Bank Group, Beijing. (2007, February).	**SDG 3: Good Health and Well-Being**	State Environmental Protection Administration & World Bank Group, Beijing. (2007, February).
2.	**Morbidity due to air quality related illnesses**	State Environmental Protection Administration & World Bank Group, Beijing. (2007, February).	**SDG 3: Good Health and Well-Being**	State Environmental Protection Administration & World Bank Group, Beijing. (2007, February).
3.	**Ambient concentrations of PM 2.5, PM 10 in parts per million**	The World Air Quality Index project. (n.d.).	**SDG 13: Climate Action**	State Environmental Protection Administration & World Bank Group, Beijing. (2007, February).
4.	**Ambient concentrations of SO2, NO2, CO in parts per million**	The World Air Quality Index project. (n.d.)	**SDG 13: Climate Action**	State Environmental Protection Administration & World Bank Group, Beijing. (2007, February).
5.	**Indoor pollution levels**	World Health Organization. (1994)	**SDG 5: Gender Equality** **SDG 7: Affordable and Clean Energy**	Institute of Environmental Health Monitoring, Chinese Academy of Preventive Medicine, Beijing

Key Takeaways

Most air quality research focuses now on PM2.5 pollutants; however, PM10, SO2, NO2, and CO in the air also have significant impacts on quality of life both in urban and rural areas of China. PM2.5 and PM10 are measures of atmospheric particulate matter of less than 2.5

micrometers and 10 micrometers, respectively. Industrialization in urban areas and harmful agricultural practices, such as the burning of leaves and waste, has resulted in poor air quality spanning nearly every Chinese province. Aside from more obvious results of poor air quality, such as low visibility and smog, there are also extreme impacts such as mortality and morbidity caused by health complications from air pollution. Mortality refers to the number of early deaths caused by health complications related to poor air quality. Morbidity is the term for sickness caused by poor air quality. Both mortality and morbidity due to poor air quality are increasing in China, despite new environmental regulations as the government continues to promote new industries. Further, most air quality research focuses on outdoor air quality and assumes that health risks are primarily posed to those who spend significant time outside. However, there are also high levels of indoor pollution in China, particularly in rural areas where kerosene or coal are still used for indoor heating and lighting. The WHO measured indoor air quality by comparing micrograms of certain pollutants in homes with gas stoves and coal stoves.

Limitations

Information about air quality and the effects of poor air quality is most effective when it is combined with an understanding of what is causing the air pollution. While these five KPIs do not analyze contributing factors because those would fall under other categories, such as Transportation, it is important that future researchers cross-reference these KPIs with others that show the causes of poor air quality. Additionally, there are some discrepancies between the above KPIs because, while the World Bank Group and World Health Organization reports focus on broader regions of China, the real-time air quality data measures air quality in individual cities. It is important to study both because there is a significant difference between the types of health concerns relevant to each. For example, some people may develop illnesses due to poor air quality that impact their quality of life but not necessarily the length of their life, this would be recorded as morbidity. Others may contract illnesses such as emphysema that dramatically shorten their lifespan, which would be reported as mortality. Both of these indicators are highly correlated with overall air quality, shown by the concentrations of pollutants in the air; however, the health impacts of poor air quality may change over time or region so it is important to study mortality and morbidity. For example, in a rural community with less access to healthcare the mortality and morbidity effects may be worse than in a similarly polluted urban community with better healthcare.

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6. TRANSPORTATION KPIs

Matt Psaltakis (CMC '19)

Table 6.1. Recommended Transportation KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Maximum total daily capacity of public transport as a percentage of population**	Deng, Wu & Cheshmehzangi, Ali & Dawodu, Ayotunde & Wang, Bingyu. (2017). Comparison Study of China's Eco-City Key Performance Indicator Systems.	**Accessibility through public transportation**	Michigan China Data Center China Agricultural Census
2.	**Total mileage of roads as a percentage of total land area**	Anderson, M., & Khan, T. (2014). Performance Measures for the Analysis of Rural Public Transit in Alabama. Journal of Public Transportation.	**Ground transportation infrastructure and accessibility**	ArcGIS Study
3.	**Total number of rail crossings and rail stations**	Anderson, M., & Khan, T. (2014). Performance Measures for the Analysis of Rural Public Transit in Alabama. Journal of Public Transportation.	**Rail transportation infrastructure and accessibility**	ArcGIS Study
4.	**Percentage of population owning a car or motorcycle or having regular access to one**	Brainstormed by REC Student Analyst	**Individual ground transportation and real income/living standards**	China State Statistical Bureau China Agricultural Census

Key Takeaways

Transportation KPIs were extremely difficult to find. In part, this was due to the flexibility of "transportation" as a research focus. It was possible to focus on public transport projects, shipping and logistics, air and rail, or simply road projects. While the above KPIs approach rural development from both an individualistic transportation viewpoint (i.e., cars) and a public transport viewpoint, they do not help provide an understanding of how other factors like shipping and logistics play into rural Chinese development.

These KPIs are aimed to provide reasonable approaches to understanding the main means of transportation within developing population centers and the ease of access to transportation for residents in an area. Transportation provides an important sector of understanding for future policy goals because it is inextricably linked to many different aspects of development. Notably, transportation is a key step in nearly all economic development, but also is a huge source of pollution and poor air quality. Due to this link, it is incredibly important that any development policies consider not just how these transportation indicators provide an understanding of transportation improvements for a population, but also how they will influence other study areas of interest.

On top of the important links between these transportation KPIs and other development focuses, they are meant to be relative at face value—that their relevance to the understanding of transportation studies is immediately comprehensible based simply on the name of the KPI. While there are undoubtedly other KPIs that could be used, these should create a baseline status upon which to compare past and future statistics in the transportation sphere. With different KPIs having different emphases on both public and individual transportation means, a study of these KPIs over time should help develop a sophisticated understanding of how transportation has affected populations in the past, present, and future—and how transportation changes over time. These transportation statistics will allow one to map the growth of transportation networks, and thus map the spread of urbanization and developing areas through the future.

Limitations

However, these KPIs are limited by the nature of transportation. This brings up another important issue in transportation: indicators will differ based on their area of study. For example, an urban area with more reliable, time efficient means of public transportation will be judged quite differently from a rural area with more of an emphasis on individual forms of transport. The indicators in this section attempt to understand both sides of the story. It will just be important to keep in mind that urban and rural areas should be scored very differently, or at least have very different baseline scorings or interpretations.

Additionally, these KPIs were also designed to prevent possible overlap between them. From a factor analysis approach, these four Transportation KPIs are not likely to be incredibly correlated to each other or dependent upon a hidden, unlisted KPI.

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7. ECONOMIC KPIs

Matt Psaltakis (CMC '19)

Table 7.1. Recommended Economic KPIs.

	KPI Name	Source of KPI in Existing Literature	Policy Goals Addressed	Recommended Data Source
1.	**Ratio of primary/secondary/tertiary industries as part of economic output**	Long, H., Zou, J., & Liu, Y. (2009). Differentiation of rural development driven by industrialization and urbanization in eastern coastal China. Habitat international, 33(4), 454-462.	**Industry-specific economic sector development**	China Agricultural Census China State Statistical Bureau
2.	**Total amount of land used for agriculture**	Shenggen, F. A. N., & Zhang, X. (2004). Infrastructure and regional economic development in rural China. China economic review, 15(2), 203-214.	**Geographic and regional economic development, contribution to greater national economy**	China Agricultural Census
3.	**Average level of education: men and women**	Zweig, D., & Siu Fung, C. (2007). Elections, democratic values, and economic development in rural China. Journal of Contemporary China, 16(50), 25-45.	**Education and economic development outcomes, social justice**	China Agricultural Census
4.	**Proportion or number of science and technology personnel**	Center for Regional Economic Competitiveness. (2017). Redefining Economic Development Indicators for a Field in Transition	**Technology and modern economic competition**	China Agricultural Census
5.	**Per capita income**	Long, H., Zou, J., & Liu, Y. (2009).	**Overall economic health**	China Agricultural

		Differentiation of rural development driven by industrialization and urbanization in eastern coastal China. Habitat international, 33(4), 454-462.	**and economic social justice**	Census China State Statistical Bureau

Key Takeaways

Finding KPIs that were related to the economy was deceptively difficult. This was because economy related KPIs were often very closely intertwined with KPIs in our other research categories. Thus, we had to distinguish between "KPIs loosely related to the economy" and "KPIs that have economic impact." This also limited the scope of our research to fewer papers or journals than were truly available detailing some aspect of economy. The KPIs we found most relevant were those that often appeared in a wide variety of papers—those in our economy section of research and those in other, not necessarily related sections. These KPIs should provide immediate face validity as they related to rural development in a broad sense but also in a more compartmentalized view of agricultural development as well as technology and STEM job development and how they relate to economic drivers. For example, the KPI "Ratio of primary/secondary/tertiary industries as part of economic output"—where primary industries are those concerned with extracting raw materials, secondary industries are those that convert raw materials to consumer goods, and tertiary industry refers to the service sector—should point toward the phase of that economy. This might mean that an economy is in a more traditional, primary industry driven period, in a tertiary dominated period (usually this is what would be defined as a "modern" economy), or is in some transitional period between the two. Thus, economic policy goals might aim to increase the use of technology to move populations from working in less productive primary industries to more productive secondary and tertiary ones. Education, technology, and STEM will no doubt be extremely important in this transition.

One interesting idea is that the "Elections, Democratic Values, and Economic Development in Rural China" researchers actually partnered with villages in China to collect data on the ground. This is could be a novel and effective way to collect time series data that would allow further, specific study of variables as they change. This way, data might not be limited by irregular or largely spaced out studies that only capture cross-sectional data, and a more sophisticated understanding of the economic phenomenon of an area and its rural development may become apparent.

Limitations

Because economic factors are so interconnected with other aspects of rural development, it may be important to study them in an environment that allows them to influence these other research areas. Additionally, this important influence of economic factors on rural development means that, for the most part, it should be relatively easy to find data for them from widely available sources.

A major limitation of these Economic KPIs is the nature of economic development and how it relates to geographical phenomenon within a large country such as China. For example, while one rural area might be heavily dependent on agriculture as its economic driver, another area might be more focused on energy production for the larger region. Thus, an indicator such as "Total amount of land used for agriculture" or "Proportion or number of science and technology personnel" that might be extremely useful in one region could be completely useless in another. A sophisticated factor analysis on the above KPIs may reveal that another indicator such as "Ratio of primary/secondary/tertiary industries as part of economic output" could be highly correlated and in fact drive changes in the other indicators.

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8. SOCIAL ASPECT KPIs

Ally So (CMC '21)

Table 8.1. Recommended Social Aspect KPIs.

	KPI	Source of KPI in Existing Literature	Policy Goals Addressed	Potential Resources/ Methods
1.	**Life expectancy at birth (years)**	Helliwell, John F., Haifang Huang, and Shun Wang (2017). Chapter 2: The Social Foundations of World Happiness.	**Improving Health Outcomes**	WHO published the data on healthy life expectancy for the year 2012. The time series of life expectancies, with no adjustment for health, are available in WDI.[1] Or (from Asian Development Bank Institute): World Development Indicators Online-- The World Bank
2.	**Poverty Rate**	China's Southwest Poverty Reduction Project: A Multisectoral Approach. The World Bank. United Nations Development Programme (2016). Human Development Report 2016. UNDP.	**Eliminating Extreme Poverty**	From ADBI: Povcalnet and World Development Indicators Online; Percent of population below $2 PPP a day
3.	**Social Support**	World Happiness Report 2017	**Happiness and the reliability of those around**	This is the average of the binary responses (either 0 or 1) to the Gallup World Poll (GWP) question: "if you were in trouble, do you have relatives or friends you can count on to help you whenever you need

[1] The WHO adopts the following strategy to construct the time series of healthy life expectancy at birth: first, it generates the ratios of healthy life expectancy to life expectancy in 2012 for countries with both data. Then, it applies the country-specific ratios to other years to generate the healthy life expectancy data.

				them, or not?"
4.	**Percentage of population with reliable and affordable access to healthcare**	Liu, Yuanli (May 2004). Development of the rural health insurance system in China.	**Access and affordability of healthcare**	Discusses the differences in healthcare situations, and emphasizes rural healthcare system.
5.	**Employment Rate**	Asian Development Bank Institute (2014). Inclusive Growth and the Quality of Life.	**Income generation**	This is measured as a percentage.
6.	**Employment rate of men vs. employment rate of women**	World Bank: Gender Gaps Figures and Facts (2006)	**Gender diversity and happiness of women**	The World Bank gets this information from population censuses. Also see: "Being a Woman in China Today: A Demography of Gender" by Isabelle Attane (China Perspectives)
7.	**Percent of minority ethnicity in region**	Chinese Ethnic Groups: Overview Statistics (last updated 2018). The University of North Carolina at Chapel Hill.	**Ethnic diversity and inclusivity**	Data taken from the 2010 population census: http://www.stats.gov.cn/tjsj/pcsj/rkpc/6rp/indexch.htm

Key Takeaways

Ever since the formulation of Bhutan's Gross National Happiness Index (GNH) in 1972, there has been an increasing awareness that sustainable development should take a holistic approach towards the non-economic aspects of wellbeing. Many key performance indicators (KPIs) closely related to social aspects were also indicators for other themes, such as the economy (i.e. an education indicator). Broadly, social aspects of China include topics such as health, education, demographics, and happiness.

When considering health, I chose to include the indicator of life expectancy at birth. This is because there is a large amount of data available regarding life expectancy, and is a strong indicator for the effectiveness of a hospital in the area. A major policy goal of the Chinese government is improving access to healthcare: While 95% of residents in China have healthcare, the government is still especially concerned about providing cheaper healthcare for all. Most of the 5% of people (almost 70 million people) without access to healthcare live in rural and poor areas, which makes it an important indicator for rural development.

Multiple indicators of social aspects also connect to other topics (such as education and GDP growth), and thus are not included in the social aspect part of this paper. Poverty rate, however, is included in the topic of social aspects, as it is the main indicator that shows the poverty level of areas in development.

The last broad topic was happiness. People tend to migrate to where they are happy, and most of the KPIs overall are related to happiness. There has been preliminary research on happiness as a KPI itself, such as Bhutan's Gross National Happiness Index, which includes nine domains: psychological well-being, health, cultural diversity, education, time use, and resilience, good governance, community vitality, ecological diversity and resilience, and living standards. Because of overlap with other topics in this study, only the first three domains are included in this specific sections. An important factor of happiness, as learned through multiple studies, is social support, which is done through a survey, with the question being: "If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?" This question was statistically shown to be the most effective way to quantify happiness, though it may be difficult to survey a population due to access to technology in especially rural areas. Employment rate is much easier to obtain and it has important impacts like income generation and livelihood generation.

When looking at rural development in China, the demographics of ethnicity must be considered to forecast potential issues with erasing cultural diversity. Many areas in China's autonomous regions are very ethnically separated, and gender balance is especially relevant in rural areas, especially given problems with China's One-Child policy, which has led to increased rates of female infanticide.
In terms of demographic indicators, the first is the employment rate of men versus women, which is easy to obtain and is important in understanding localized gender norms. Second, is the ethnic minority population, which can be easily obtained with census information. This is important to study because internal migration between provinces and autonomous regions (the places with more ethnic minorities) can cause tension between ethnic groups.

Limitations

It is important to note that using only one KPI cannot possibly draw mediate the issues of external validity, as what is generally true in one area may not be true to the majority of another. For example, although gender diversity may result in a higher happiness level for the general population, some individuals may not see a more diverse area as an incentive to live there. Thus, it is important to separate which indicators the policy goals address, while also noting what seems to generally connect. In addition, many of the indicators, especially ones that connect to happiness, may be highly correlated with each other, and thus doing a variance inflation factor test may be needed.

Measuring human well-being is fundamentally subjective; however, there are quantitative evaluations that can lead to inferences about a nation's happiness. For example, while employment rate may not solely determine how happy an individual is, it can demonstrate a certain level of economic stability. It then can be assumed that the more money an individual has, the more opportunities they have, and the more successful they are. Keeping this intuition in mind, research papers that studied different factors of happiness led to this analysis' conclusion that the KPIs above– even the ones not explicitly labeled for happiness– have the potential to lead to greater happiness of an individual, and thus are a sure indicator that will contribute to rural development.

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