

## SDG Indicator 11.3.1

### - Multi-scale Measurement and Preliminary Analysis

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Nov.19, 2018, Deqing, China

## Content

### Introduction

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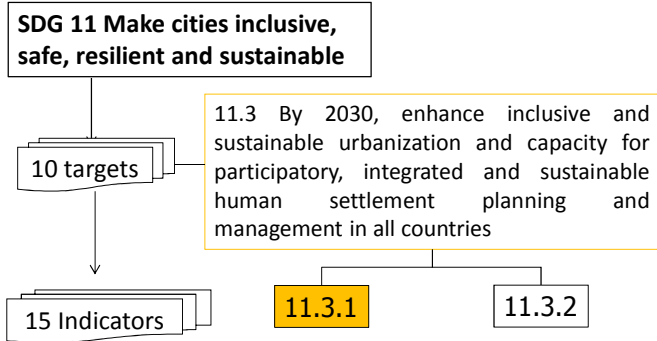
Preliminary analysis

Extend the indicator?

Summary

# SDG 11 and its Indicators

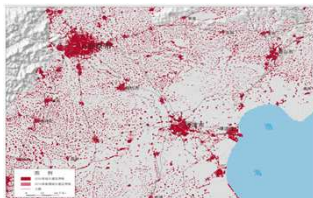
United Nations 2030 Agenda for Sustainable Development sets up 17 SDGs, 169 sub-targets and 234 indicators.



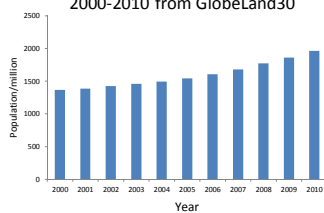
## Indicator 11.3.1



### 11.3.1 Ratio of land consumption rate to population rate



Urban expansion in Beijing during 2000-2010 from GlobeLand30



Population change in Beijing during 2000-2010

$$R = \frac{\langle \text{LN}(\text{Urb}_t(t+n)/\text{Urb}_t(t)) \rangle / \gamma}{\langle \text{LN}(\text{Pop}_t(t+n)/\text{Pop}_t(t)) \rangle / \gamma} = \frac{\text{LN}(\text{Urb}_t(t+n)/\text{Urb}_t(t))}{\text{LN}(\text{Pop}_t(t+n)/\text{Pop}_t(t))}$$

- R : ratio of land consumption rate to population growth rate ;
- Urb<sub>t</sub>(t+n): Total areal extent of the urban agglomeration in km<sup>2</sup> for current year ;
- Urb<sub>t</sub>(t): Total areal extent of the urban agglomeration in km<sup>2</sup> for past/initial year ;
- Pop<sub>t</sub>(t+n): Total population within the city in the current/final year ;
- Pop<sub>t</sub>(t): Total population within the city in the past/initial year ;
- γ : The number of years between the two measurement periods

#### Estimate land use efficiency from the social side

- $R < 0$ , Population presents negative growth.
- $1 > \text{LCRPGR} > 0$ , Population growth is faster than land consumption.
- $\text{LCRPGR} > 1$ , land consumption is faster than Population growth.

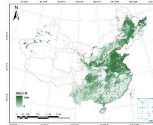
## Multi-scale measurement

Global



The world

National



China

Local



Deqing County

## Content

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**Multi-scale measurement**

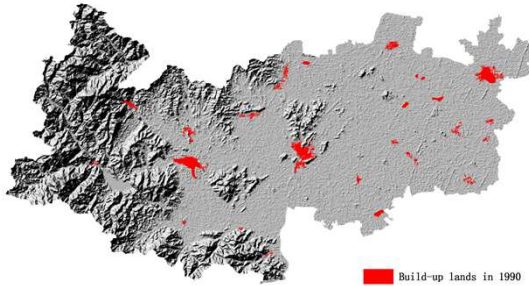
Preliminary analysis

Extend the indicator?

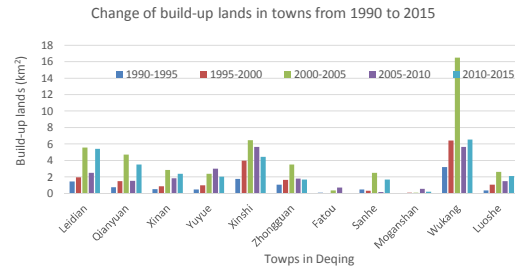
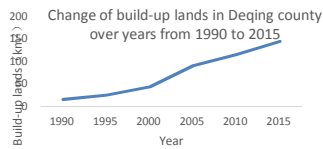
Summary

## 2.1 Deqing

Authorized higher resolution land cover maps and time series of satellite images were used to derive changes of built-up areas in Deqing, with help of other complementary data (such as Globeland30).

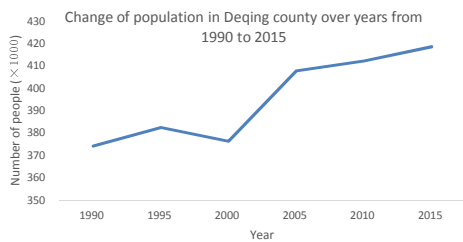


Build-up areas increased 129 km<sup>2</sup> during 1990-2015

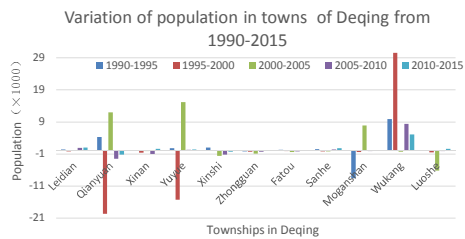


- Wukang, the county capital, and Xinshi, an ancient town, grows faster
- Fatou, Moganshan and Sanhe presents a small increase.

## Deqing' s population



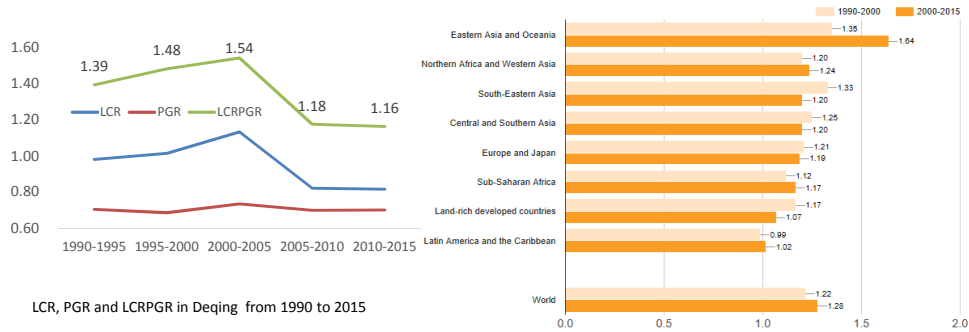
•Household registered population : increased 50,000 during 1990-2015.



- Population in different towns has a vibration , except Wukang having increased population from1990 to 2015.
- Due to re-division of administrative districts, large number of people from Qianyua and Yuyue immigrated to Wukang during 1995-2000, and changed back from 2000 to 2005

## Quantified 11.3.1 in Deqing

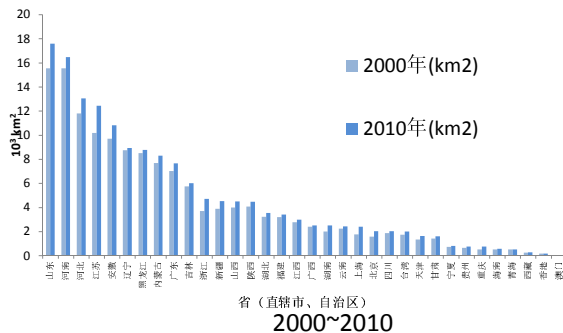
The value of indicator 11.3.1 changes over the years



values are less the average value in Eastern Asia and Oceania, while after 2005, the LCRPGR values is less than the average value in the world. This means that the land use efficiency has been improved since 2005.

## 2.2 China

The class Artificial Surface of GlobeLand30 was used as a proxy for deriving land consumption



• Total increase: 16,000km<sup>2</sup>;

- High increase in Shandong and Jiangsu(25%).
- Low consumption in Northwest and southwest

Table 1. Top 10 provinces of land consumption

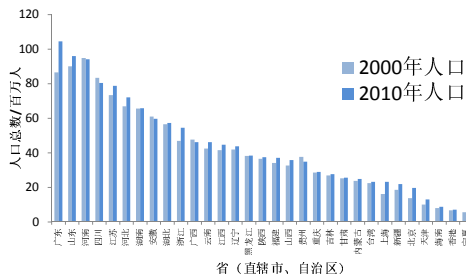
Provinces (municipalities, autonomous regions)	Land consumption in 2000 (km <sup>2</sup> )	Land consumption in 2010 (km <sup>2</sup> )	Increase area (km <sup>2</sup> )
Jiangsu	10175.91	12444.59	2268.68
Shandong	15545.90	17586.96	2041.06
Hebei	11800.55	13033.06	1232.51
Anhui	9687.31	10814.46	1127.15
Zhejiang	3697.12	4696.38	999.26
Henan	15536.25	16458.46	922.21
Shanghai	1764.21	2408.65	644.44
Guangdong	7014.64	7646.55	631.91
Xinjiang	3896.69	4528.45	631.76
Inner Mongolia	7670.79	8299.19	628.4
Shanxi	3979.14	4493.52	514.38
Hunan	1999.8	2504.68	504.88
Beijing	1574.11	2034.16	460.05

• City: built-up area

Here Urban and rural construction land

# China- Population

The population has increased 7,390,000 from 2000-2010



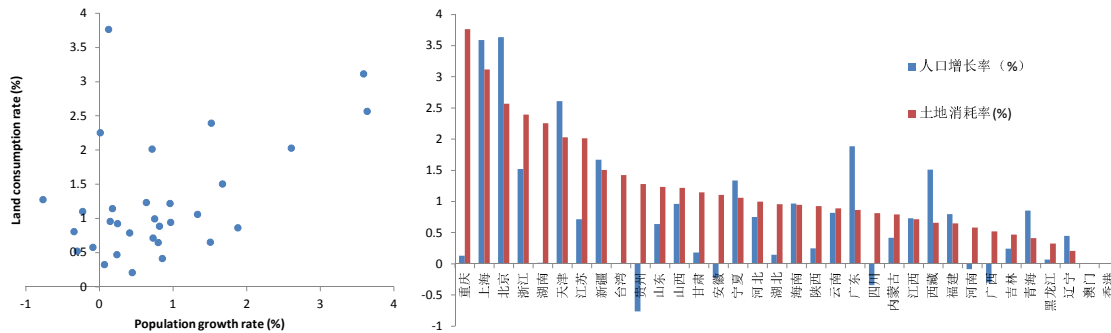
•2/3 of the population concentrated in North, East and Southeast China collect

Table 1. Top 10 provinces of population growth

Provinces (municipalities, autonomous regions)	Population in 2000 (10000 person)	Population in 2010 (10000 person)	Increase population (10000 person)
Shandong	8650	10441	1791
Zhejiang	4680	5447	767
Shanghai	1609	2303	694
Beijing	1364	1962	598
Shandong	8998	9588	590
Jiangsu	7327	7869	542
Hebei	6674	7194	520
Yunnan	4241	4602	361
Xinjiang	1849	2185	336
Shanxi	3247	3574	327
Jiangxi	4149	4462	313
Tianjin	1001	1299	298
Fujian	3410	3693	283

# China- Indicator 11.3.1

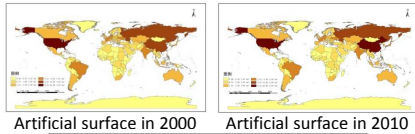
Relatively low in the East and high in the northwest.



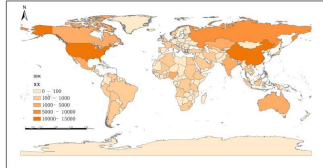
- $R < 0$ , Negative population growth in Henan, Anhui, Guangxi, Guizhou, Sichuan provinces. (5)
- $1 > R > 0$ , Population growth is larger than land consumption: the south east provinces of China, Beijing, and Shanghai, etc. (12)
- $2 > R > 1$ , North China and East China.
- $R > 2$ , In Northeast, northwest and southwest. (7)

## 2.3 Global

149 countries were considered taking into the consideration of the 30-m resolution



Artificial surface in 2000      Artificial surface in 2010



Increased artificial surface during 2000 to 2010

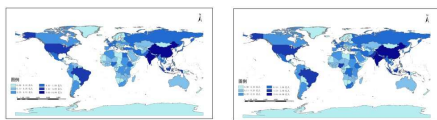
- Land consumed: 57,400 km<sup>2</sup>;
- Low : developed countries in Western Europe ;
- High: developing countries in Asia and Africa
- About 50% increase come from China and US

Table 1. Top 10 countries of land consumption

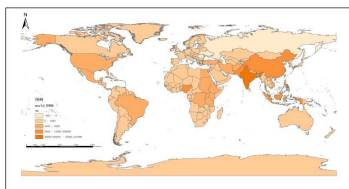
Country	Land consumption in 2000 (km <sup>2</sup> )	Land consumption in 2010 (km <sup>2</sup> )	Increase area (km <sup>2</sup> )
USA	22.38	23.56	1.18
CHN	14.49	16.1	1.61
RUS	9.5	9.83	0.33
IND	4.9	4.99	0.09
BRA	3.18	3.24	0.06
DEU	3.02	3.0201	0.0001
FRA	2.86	2.9	0.04
JAN	2.5	2.54	0.04
MEX	2.32	2.5	0.18
CAN	2.25	2.38	0.13
ITA	1.7	1.73	0.03
GBR	1.65	1.7	0.05
AUS	1.44	1.53	0.09
UKR	4.09	4.0907	0.0007

## Global Population Data

Population increased in most countries , but some countries had decreased



Population in 2000      Population in 2010



Increased population during 2000 to 2010

- Increased 800 million during 2000 to 2010.
- India and China take 30%.
- Some European countries have negative growth.

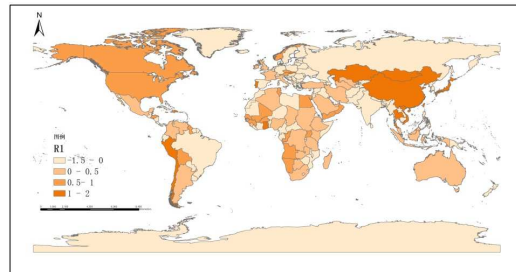
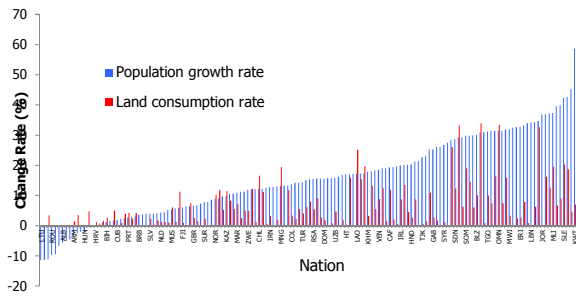
Table 1 Population change in typical country

Country	Population in 2000 (10000 person)	Population in 2010 (10000 person)	Increased population (10000 person)
USA	28216.24	30934.69	2718.445
CHN	126264.5	133770.5	7506
RUS	14659.66	14284.94	-374.711
IND	105348.1	123098.5	17750.34
BRA	17578.64	19861.42	2282.777
GEN	8221.151	8177.693	-43.4578
FRA	6091.25	6502.751	411.5014
JAN	12684.3	12807	122.7
MEX	10280.86	11861.75	1580.895
CAN	3076.97	3400.527	323.5574
ITA	5694.211	5927.742	233.5309
GBR	5889.251	6276.637	387.3851
AUS	1915.3	2203.175	287.875
UKR	4917.585	4587.07	-330.51

## Indicator 11.3.1 at Global Scale

Average is 0.31.; minimum is -1.31(RUS); maximum is 1.72(MNG).

- Negative in 18 countries, mainly due to negative population growth in Europe ;
- High ratios occurred in developing countries, such as MNG, CHN, BRA, etc.



Distribution of ratio of Land consumption rate to population growth rate

- **Land consumption rate** (0.001~2.876), 1>rates in 115 countries ;
- **Population growth rate** (-1.221~10.902) , 1>rates in 52 countries ;
- The land consumption rate of each country is positive.

## Content

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Multi-scale measurement

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**Preliminary analysis**

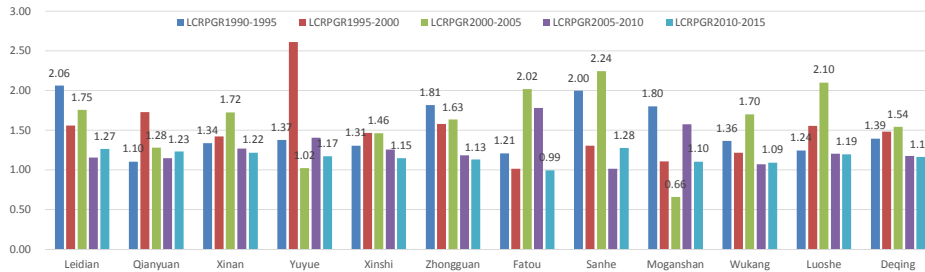
Extend the indicator?

Summary



## Results in Deqing

The average R in the townships of Deqing is 1.4, meaning land consumption is 1.4 times as quick as people growth, less than 1.5 regarded as the average ratio around the world.

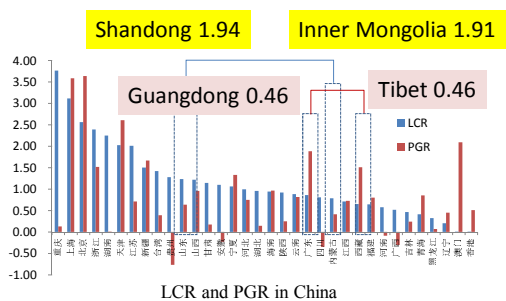


R values in different towns in Deqing

The maximum LCRPRG is 2.61 in Yuyue from 1995 to 2000. There is a lower PGR (0.40) and higher LCR (1.02) during this period indicating an inefficiency land use. While the minimum LCRPGR is 0.66 which is happened in Moganshan from 2000 to 2010 with a higher PGR of 1.1 and a lower LCR of 0.74 suggesting an shortage in build-up lands.

## Problems found at National Scale

Same ratios occur when both LCR and PGR being higher or lower.



- Shandong (1.94) -- Inner Mongolia(1.91)
- Guangdong (0.46) -- Tibet (0.43).
- Not all are compared as some take negative values

Num	Provinces (municipalities, autonomous regions)	LCR	PGR	R
1	北京(Beijing)	2.56	3.64	0.71
2	天津(Tianjin)	2.03	2.61	0.78
3	河北(Hebei)	0.99	0.75	1.32
4	山西(Shanxi)	1.22	0.96	1.27
5	内蒙古(Inner Mongolia)	0.79	0.41	1.91
6	辽宁(Liaoning)	0.21	0.45	0.46
7	吉林(Jilin)	0.47	0.24	1.96
8	黑龙江(Heilongjiang)	0.32	0.07	4.77
9	上海(Shanghai)	3.11	3.59	0.87
10	江苏(Jiangsu)	2.01	0.71	2.82
11	浙江(Zhejiang)	2.39	1.52	1.58
12	安徽(Anhui)	1.10	-0.23	-4.88
13	福建(Fujian)	0.65	0.80	0.81
14	江西(Jiangxi)	0.71	0.73	0.98
15	山东(Shandong)	1.23	0.64	1.94
16	河南(Henan)	0.58	-0.09	-6.56
17	湖北(Hubei)	0.95	0.14	6.62
18	湖南(Hunan)	2.25	0.01	184.76
19	广东(Guangdong)	0.86	1.88	0.46
20	广西(Guangxi)	0.52	-0.30	-1.72
21	海南(Hainan)	0.94	0.97	0.98
22	重庆(Chongqing)	3.76	0.13	29.97
23	四川(Sichuan)	0.81	-0.35	-2.33
24	贵州(Guizhou)	1.28	-0.77	-1.66
25	云南(Yunnan)	0.89	0.82	1.08
26	西藏(Tibet)	0.65	1.51	0.43
27	陕西(Shanxi)	0.92	0.25	3.74
28	甘肃(Gansu)	1.14	0.18	6.46
29	青海(Qinghai)	0.41	0.85	0.48
30	宁夏(Ningxia)	1.06	1.33	0.79
31	新疆(Xinjiang)	1.50	1.67	0.90
32	台湾(Taiwan)	1.42	0.39	3.67
33	香港(hongkong)	0.00	0.51	0.01
34	澳门(Macao)	0.01	2.09	0.00

## Problems found at Global Scale

Same ratio, but actual land use efficiency is different

Num	Country	Urb.t (10 <sup>2</sup> km <sup>2</sup> )	Urb.(t+n) (10 <sup>2</sup> km <sup>2</sup> )	LCR (%)	Pop.t (万人)	Pop.(t+n) (万人)	PGR (%)	R
1	KOR	35.00	35.10	0.03	4700.81	4941.04	0.50	0.06
	LAO	10.00	10.10	0.10	534.29	626.05	1.59	0.06
	CHE	18.00	18.10	0.06	718.42	782.49	0.85	0.06
2	FRA	286.10	290.00	0.14	6091.25	6502.75	0.65	0.21
	COD	40.00	50.00	0.69	4804.86	6593.87	3.17	0.22
	GBR	164.90	170.00	0.30	5889.25	6276.63	0.64	0.47
3	DZA	28.00	30.00	0.69	3118.36	3603.61	1.45	0.48
	NGA	74.00	84.00	1.27	12287.67	15942.47	2.60	0.49
	BWA	12.00	13.00	0.80	173.66	204.78	1.65	0.49
4	CZE	51.00	52.00	0.19	1025.51	1047.44	0.21	0.92
	NAM	7.00	8.00	1.34	189.79	219.36	1.45	0.92
	HND	5.90	7.10	1.71	624.31	750.38	1.84	0.93
5	NOR	24.00	26.00	0.80	449.09	488.92	0.85	0.94
	PER	20.00	23.00	1.40	2591.49	2937.36	1.25	1.12
	THA	42.00	45.00	0.69	6269.33	6669.20	0.62	1.12
6	GHA	21.00	28.00	2.88	1882.50	2431.77	2.56	1.12
	JAN	250.00	254.00	0.16	12684.30	12807.00	0.10	1.65
	CHN	1451.00	1600.00	0.98	126264.50	133770.50	0.58	1.69

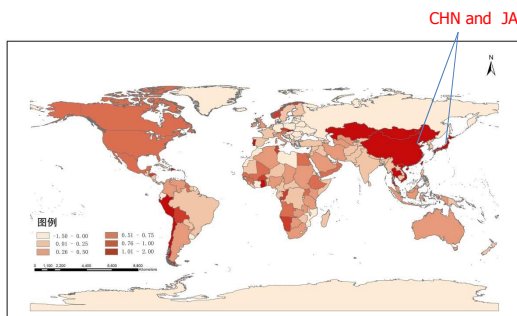
GBR: low LCR and LPR;  
BWA, NGA: high LCR  
and LPR.

Ratio=1.12 ,  
GHA: high LCR and LPR

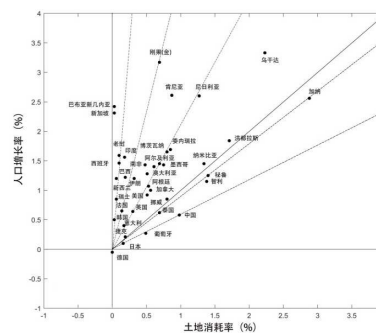
JAN and CHN  
have similar ratios.

## Problems found at Global Scale

- Same ratio: high LCR / high PGR  $\approx$  low LCR / low PGR



Distribution of ratio of land consumption rate to population growth rate



Typical countries of ratio of land consumption rate to population growth rate

# Content

Introduction

Multi-scale measurement



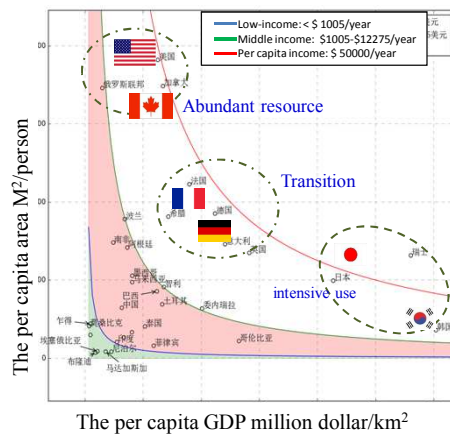
Preliminary analysis

**Extend the indicator?**

Summary

## Taking Ecomic Dimension into Consideration?

**Land consumption in different countries is related to the level of economic development, showing obvious differences. (Li et al., 2016)**



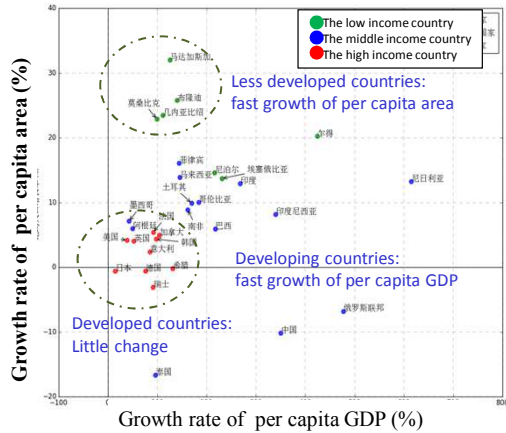
Structural difference of resource allocation and utilization of land consumption can be observed

- Abundant resource (the USA, Canada, Russia.)
- Transition
- Intensive use type (Japan, Swiss, Korea, et al.)

Li R, Kuang, Chen et al. Spatio-temporal pattern analysis of artificial surface use efficiency based on Globeland30 (in Chinese). Scientia Sinica Terrae, 46, 1-10.

## Taking Economic Dimension into Consideration?

Land consumption in different countries is related to the level of economic development, showing obvious differences. (Li et al., 2016)



Structural difference of resource allocation and utilization of land consumption can be observed

- Developed countries are relatively stable in land use efficiency.
- Developing countries have faster growth of per capita area and per GDP area.
- More fast growth of per capita area in less developed countries is obvious.

Li R, Kuang, Chen et al. Spatio-temporal pattern analysis of artificial surface use efficiency based on Globeland30 (in Chinese). *Scientia Sinica Terrae*, 46, 1-10.

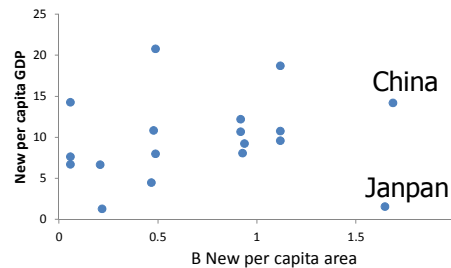
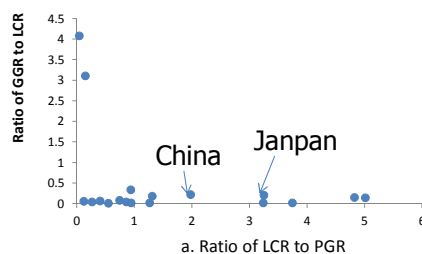
## GDP and Land Consumption at Global Scale

A. Ratio of newly increased per capita GDP to the new per capita area

$$R_r = \frac{(GDP_{(t+n)}/GDP_t)/(Urb_{(t+n)}/Urb_t)}{(Urb_{(t+n)}/Urb_t)/(Pop_{(t+n)}/Pop_t)}$$

B. Ratio of GDP growth rate to land consumption rate

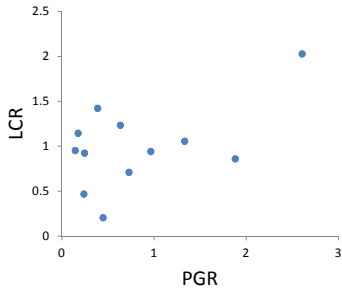
$$R_{GDP} = \frac{\langle LN(Urb_{(t+n)}/Urb_t) \rangle / \langle j-i \rangle}{\langle LN(GDP_{(t+n)}/GDP_t) \rangle / \langle j-i \rangle}$$



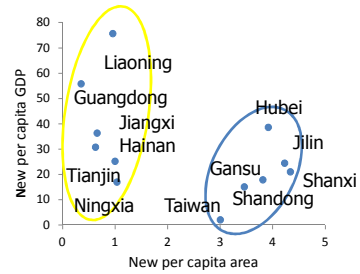
By introducing the economic dimension (GDP growth rate / new GDP), most of the problems found before can be solved

## GDP and Land Consumption in China

Well differentiated but not well clustered.



Provinces )	R
Hubei	6.60
Gansu	6.48
Shanxi	3.74
Taiwan	3.67
Jilin	1.95
Shandong	1.94
Jiangxi	0.97
Hainan	0.97
Ningxia	0.79
Tianjin	0.77
Liaoning	0.46
Guangdong	0.45



- Yellow - high increased per capita GDP , low new per capita area  
- Ningxia, Tianjin, Liaoning, Jiangxi, Hainan, Guangzhou;
- Blue -low increased per capita GDP , high new per capita area :  
-Shanxi, Jilin, Hubei, Gansu, Shandong, Taiwan.

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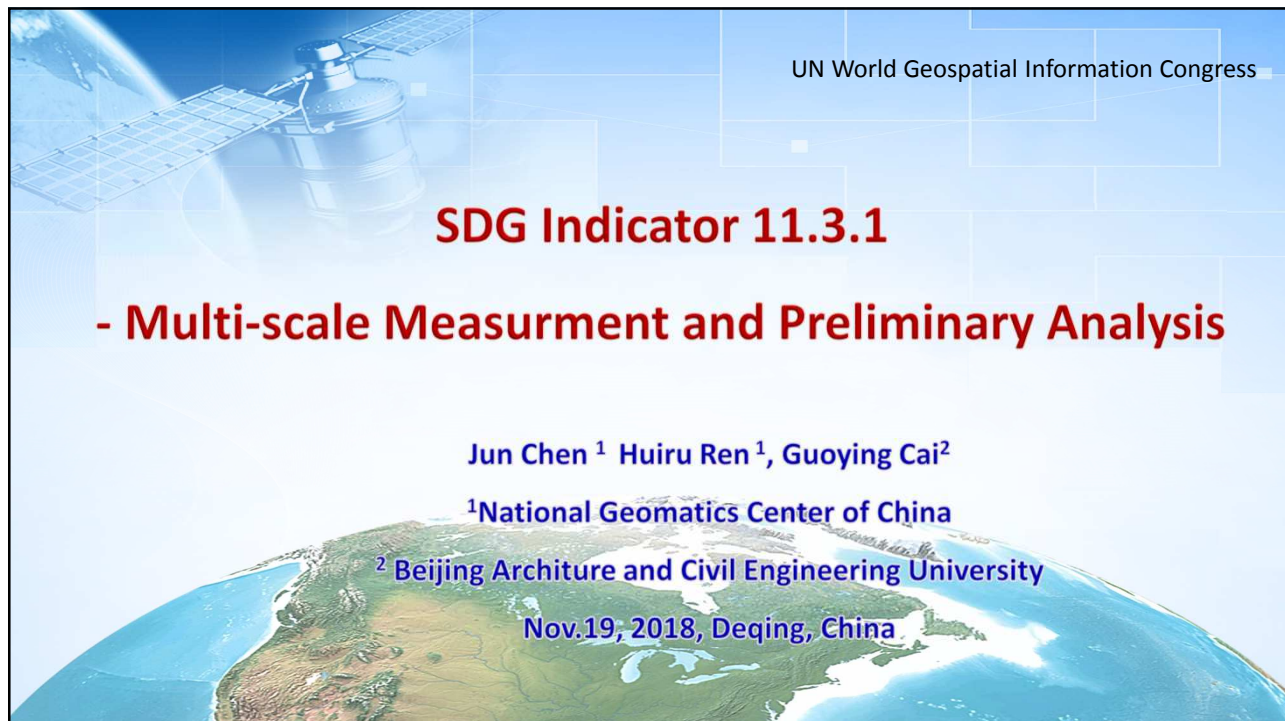
Preliminary analysis

Extend the indicator?

**Summary**

## Summary

- During 2000 to 2010, average ratio of LCR(Urban and rural construction land) to PGR in the world is 0.31, 1.77 for China, . 1.28 for Deqing.
- Indicator 11.3.1 provides reasonable results at local scale , but presents anomalies or problems at larger areas (such as China and the globe)national scale. The reason behind might be the missing of economic dimension.
- Thanking GDP into consideration, Indicator 11.3.1 can be extended by introducing the ratio of economic growth rate to land consumption rate. Preliminary results show that countries and regions with different economic development levels can be better distinguished.



UN World Geospatial Information Congress

**SDG Indicator 11.3.1**

**- Multi-scale Measurement and Preliminary Analysis**

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Nov.19, 2018, Deqing, China

The slide features a background image of a satellite in orbit above a globe, with a grid overlay. The text is centered and uses a mix of red and blue colors for emphasis.



**Thank you for your attention !**

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