

# Study on Zones Classification, Management and Control Methods Based on Groundwater Functions

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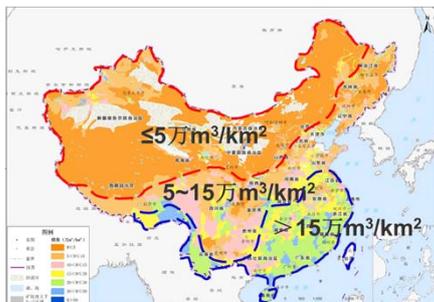
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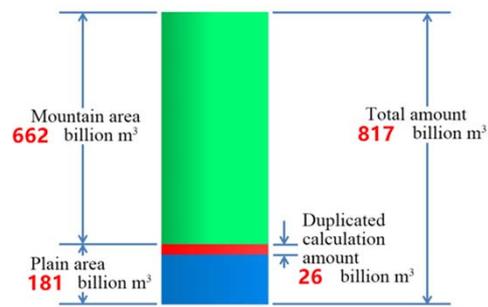


## 1. Background

- ▣ Annual groundwater (GW) resources: 817 billion m<sup>3</sup>, accounting for about 30% of China's total water resources.
- Over 80% of GW resources distribute in mountain area.



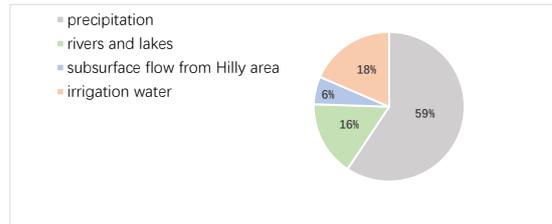
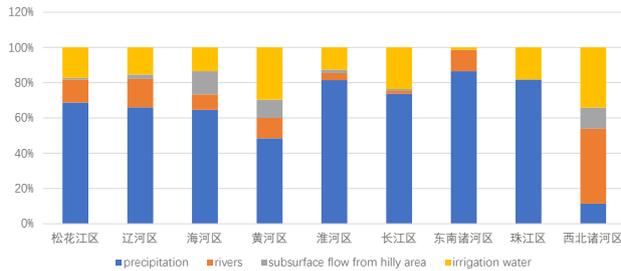
Multi-year average GW resources modulus from 2001 to 2016



Annual average GW resources from 2001 to 2016

# 1. Background

The annual amount of renewable groundwater resources in plain areas of China is 176.5 billion m<sup>3</sup>, of which 59% comes from precipitation infiltration, 16% from the leakage of rivers and lakes, 6% from subsurface flow from hilly areas, and 18% from irrigation infiltration and other water supply sources.

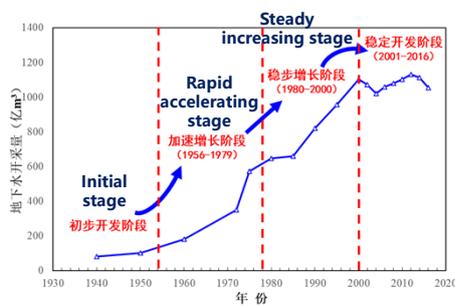


Recharge of Groundwater in Plain Regions

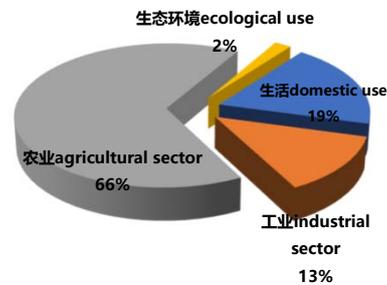
Recharge of Groundwater in Various Plain Regions

# 1. Background

- ❑ The annual GW extraction reached a maximum of 113.4 billion m<sup>3</sup> in 2012, and has been decreasing year by year since then.
- The annual GW extraction reached 93 billion in 2019, accounting for 16% of the total water supply.

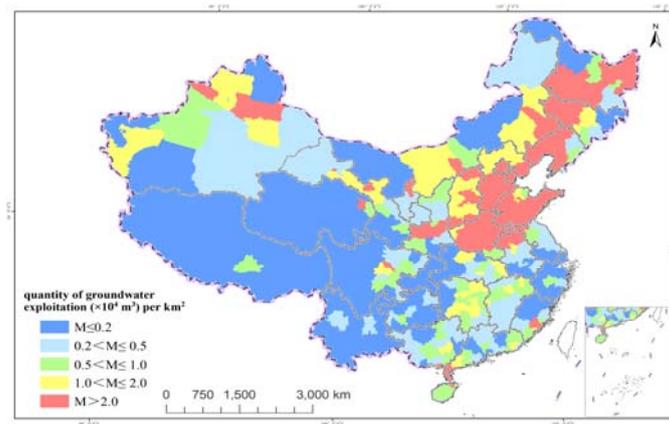


groundwater exploitation



Ratio of groundwater use among different sectors

## 1. Background



The quantity of groundwater exploitation per  $\text{km}^2$  in China

## 2. Groundwater functional zones

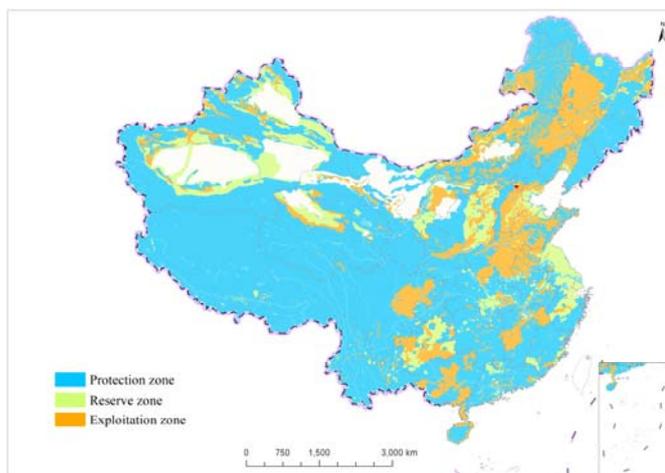
Primary	Secondary	Main Function
Protection Zone	Ecological fragile zone	Ecological maintenance
	Geologically and environmentally sensitive zone	Geology and environment
	Groundwater conservation zone	Circulation and reserve
Exploitation Zone	Centralized water supply zone	Centralized water supply for urban areas
	Distributed exploitation zone	Distributed water supply for rural areas
Reserve Zone	Emergency water supply zone	Emergency water supply
	Water reserve zone	Resources reserve
	Unsuitable exploitation zone	No particular functions

## 2. Groundwater functional zones

The primary groundwater functional zones

The primary groundwater functional zones	Plain area	Hilly area
Exploitation zone	44%	7%
Protection zone	17%	89%
Reserve zone	39%	4%

The Ratio of area of primary groundwater functional zones



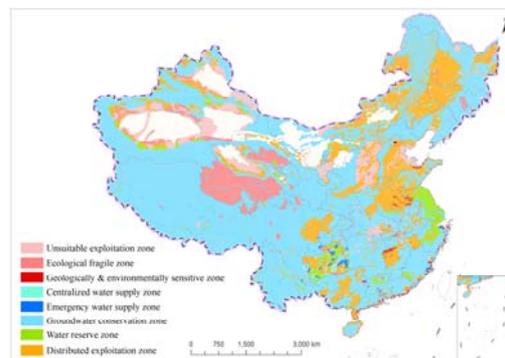
The distribution map of the primary groundwater functional zones in China

## 2. Groundwater functional zones

The secondary groundwater functional zones

The secondary groundwater functional zones	Nationwide					
	Plain area		Hilly area		Total	
	No.	Area	No.	Area	No.	Area
Centralized water supply zone	562	1.3%	312	0.6%	874	0.8%
Distributed exploitation zone	793	42.7%	440	6.4%	1233	17.5%
Ecological fragile zone	181	14.3%	266	15.4%	447	15.1%
Groundwater conservation zone	39	1.9%	1174	73.6%	1213	51.6%
Geologically & environmentally sensitive zone	76	0.9%	103	0.4%	179	0.6%
Unsuitable exploitation zone	354	31.1%	170	1.9%	524	10.8%
Water reserve zone	182	7.5%	135	1.3%	317	3.2%
Emergency water supply zone	44	0.2%	55	0.4%	99	0.3%
<b>Total</b>	<b>2231</b>	<b>100%</b>	<b>2655</b>	<b>100%</b>	<b>4886</b>	<b>100%</b>

The number and ratio of secondary groundwater functional zones



The distribution of the secondary groundwater functional zones

### 3. The management and control of groundwater functional zones

#### Control indicators of groundwater exploitation

stabilizing the balance of groundwater recharge and discharge, meeting the water demand for the natural environment, retaining sufficient strategic reserves.

- ✓ groundwater exploitation for human use should not exceed 90% of the total recharge.
- ✓ the sustainable yield in ecological fragile zones and coastal zones should not exceed 50% of the total recharge.
- ✓ Groundwater exploitation in hilly areas may reduce river baseflows. Thus, groundwater exploitation in hilly areas should also consider surface water exploitation in order not to cause significant decline in surface runoff.

### 3. The management and control of groundwater functional zones

#### Control indicators of groundwater table

Functional Zones		Requirements of Water Table	
		Maximum Depth	Minimum Depth
Exploitation Zone		<ul style="list-style-type: none"> <li>✓No continuous decline in groundwater table</li> <li>✓Effective groundwater supply</li> <li>✓Maintenance of groundwater inflow per unit</li> </ul>	<ul style="list-style-type: none"> <li>✓Reduction in the ineffective phreatic evaporation</li> <li>✓Maintenance of reserve space</li> <li>✓Prevention of groundwater pollution</li> </ul>
Protection Zone	Ecological fragile zone	<ul style="list-style-type: none"> <li>✓Maintenance of the rising height of capillary water to the depth of root system in soil</li> <li>✓Maintenance of surface vegetation</li> </ul>	<ul style="list-style-type: none"> <li>✓Prevention of groundwater pollution</li> </ul>
	Geologically and environmentally sensitive zone	<ul style="list-style-type: none"> <li>✓Prevention and control of land subsidence, seawater intrusion, land subsidence and other environmental geological disasters</li> </ul>	<ul style="list-style-type: none"> <li>✓Prevention of groundwater pollution</li> <li>✓Prevention of soil salinization</li> </ul>
	Groundwater conservation zone	<ul style="list-style-type: none"> <li>✓Maintenance of river base flow and spring discharge, etc.</li> </ul>	<ul style="list-style-type: none"> <li>✓Prevention of groundwater pollution</li> </ul>
Reserve Zone		/	/

## 4. Summary

- ✓ Groundwater management can be based on zonation process. The process geographically separates groundwater resources and the related landscape into 3 primary functional zones (which are protection zone, exploitation zone and reserve zone), and 8 secondary functional zones.
- ✓ The classification of groundwater function is based on the division of a basic unit. Each basic unit could be assigned a certain groundwater function. Sixty-seven percent (67%) of the land is protection zone, 18% is exploitation zone and the remaining 15% is reserve zone.
- ✓ The primary exploitation zones cover about 20% of the country's area and take up about 25% of the country's groundwater resources, but the quantity of exploitation is more than 80%, and its secondary distributed exploitation zones contributes 70%.
- ✓ A set of control indicators of groundwater management in functional zones has been formulated including control indicators of groundwater exploitation and groundwater table. Targeted on the gap between the current status of groundwater system and the protection objectives, optimal and feasible solutions could be proposed and implemented.

