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ESTIMATION AND EXPLOITATION OF WATER RESOURCES IN THE SANJIANG PLAIN

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ABSTRACT: According to practical measurement and related data, the writer discusses the main features of rivers in the Sanjiang Plain and the change of water balance with time and space, and then estimates water resources of five types, namely, runoff, ground water, soil water, and water supplied by three rivers and lakes (or reservoirs).The total volume of the above–mentioned water resources can be up to 31.5 billion m^3. But they are rather unevenly distributed and the annual change is considerable, too. Up to now, only 8.3% of water resources have been utilized. According to a programme, 17.5 billion m^3 will be utilized in the future in the district. Rationally exploiting water resources in the district should be combined with protection and management, and the sole criterion for judging rationality of utilization is that whether it is beneficial to economic, ecologic and social aspects.

KEY WORDS: water resources, the Sanjiang Plain

The district of the Sanjiang Plain is situated in the eastern part of Heilongjiang Province. The district includes the delta region (where three rivers , namely, the Heilong River, the Songhua River and the Wusuli River converge), the Anbang River valley, the Woken River valley, and the Muling River valley. The total area of this district is 103,500 km^2,of which, 43% is the mountainous region, and 57% is the plain and moist low land. It is the largest region of marsh and swamp in our country.

In this paper, the quantity, quality, and rational exploitation and utilization of water resources will be concisely analyzed on the basis of about 5,000 station–year data on precipitation, runoff and evaporation from 204 hydrological and meteorological observatories in this district and the investigation results of the writer.

I. THE MAIN CHARACTERISTICS OF RIVERS

The characteristics of rivers are the product of climate and topography. So the rivers in this district have the following three main characteristics:

1) Affected by the moist and semi–moist continental monsoon climate in temperate zone, the hydrological regime of the rivers belongs to the model of the Songhua River–Heilong River. This model has three types of water sources, namely, rainfall, snow melt and ground water, of which rainfall is the most important one. In the case of water discharge, every year there are four periods, namely, spring freshet, summer median–low water, rain–flood and winter low–water. The rain–flood has not only the highest peak, but also the largest quantity. The winter low–water lasts the longest period of time. Because the discharge of normal year in the river bed is not large, the main channel is narrow(generally about 10–20 meters). But in summer and autumn the flood overflows, and the beach widens from several to more than ten kilometers. Before and after the flood occurs, the hydraulic elements of the widened rivers usually have a sudden change, which should be solved respectively.

2) Because of the influence of topography there are three types of rivers:

(1) Swampy rivers (Their drainage areas occupy 23% of the whole district). The river network is sparse. The gradient of the upper reaches of each river is flat and that of the lower reaches is rather steep. There are many depressions within each drainage area. So the function of accommodation of the river is strong. The rise and drop of water discharge is slow, and therefore the heavy rain and the peak flow usually are not in the same step. In calendar years precipitation and runoff are almost always imbalanced.

(2) Mountainous rivers. The network of waterways is well developed. The gradient of the upper reaches of the water–way is steep and that of the lower reaches is flat. The heavy rain and the peak flow go in the same step. The flood rises and drops rapidly and the peak flow comes frequently. In general, the rain water of a year can flow out of the exit in time.

(3) Mountainous–swampy rivers. Before flowing out of the mountains, such rivers have the characteristics of the mountainous rivers. When they flow into plains, the river network becomes sparse, and most of the tributaries are half rivers, i.e., they have no downstream. Here the function of accommodation is strong. So there may appear the fact that the inflow is heavier than the outflow.

3) Affected by the climate, the freezing period of the rivers is long(generally 130–150 days, from mid–November to mid–April). The largest average thickness of the ice is about 1.0 meter. During the ice–running period in spring, due to the meander narrowness of the river course, the Yilan reach and other places of the Songhua River usually have ice dams and become stuffed, which sometimes results in disasters.

II. THE DISTRIBUTION OF WATER–BALANCE ELEMENTS IN TERMS OF TIME AND SPACE

1. The Regional Distribution of Rainfall, Runoff and Evaporation (d = 20cm)

The distribution of rainfall, runoff and evaporation in this district is uneven (see Tables 1–3). The southeastern slope of the Wanda Mountain and the Xiao Hinggan Mountains are two high–value regions of precipitation and runoff. The average annual precipitation there is 600–620mm, the depth of the average annual runoff is 200–300 mm. The plains of the lower reach of the Songhua River and the upper and middle reaches of the Muling River are two low–value regions of precipitation and runoff. The average annual precipitation there is about 520 mm, and the depth of the average annual runoff is 50–100 mm. Besides, the Fuyuan and Haiqing area in the northeastern part of this district is also a high–value region of precipitation (600–640 mm), but it is a lower middle value region of runoff(only 80–100 mm).

The regional distribution of evaporation capacity is in contrast with that of precipitation and runoff. The southeastern slope of the Wanda Mountain, Luobei and the Xiao Hinggan Mountains are low–value regions, where the evaporation capacity is 1,000–1,100 mm. The plains of the lower reaches of the Songhua River and the upper and middle reaches of the Muling River are high–value regions, where the evaporation capacity is 1,200–1,300mm. The evaporation capacity in Fuyuan and Haiqing in the northeastern part of this district is medium, about 1,100 mm.

2. The Variations of Precipitation, Runoff and Evaporation within a Year and between Years

Because of the influence of monsoon and west wind circulation, the variations of precipitation and runoff are very remarkable. The precipitation from June to September makes up 60–80% of the total of the whole year, and that from December to February of the next year is only about 5% .The amount of runoff from July to September makes up 60–70% of the total of the whole year, and that from May to June is about 20% . In winter (from December to March) the amount of runoff is usually less than 5%, and many medium and small rivers give up flowing. The evaporation capacity is in its maximum from May to July, making up 45–59% of the total of the whole year. The difference of precipitation between the abundant–water year and the low–water year is usually 400 mm. The difference of annual runoff is even more disparate. Cv equals 0.40–1.00 in the whole district, and it is over 0.80 in most cases in plain regions. Such a great difference of water amount makes some year dry and some year wet. In studying the rules of the appearance of abundant–water and low–water, it is also found that not only in large rivers, but also in medium rivers, the abundant and low–water years usually appear alternatively and each may last about three to six years.

Table 1 The eigenvalues of annual precipitation of representative stations in the Sanjiang Plain

Region	Station	County (municipal)	Seiers	Annual precipitation		Annual precipitation of different frequence (mm)			
				Average value (mm)	Cv	20	50	75	95
I	Loubei	Luobei	33	350	0.26	666	539	451	341
	Wangjiadian	Luobei	26	571	0.25	685	560	468	360
	Hegang	Hegang	24	600	0.27	726	588	480	366
	Junchuan	Suibin	14	528	0.26	639	517	433	327
	Farm 290	Suibin	23	525	0.27	635	514	420	320
II	Fuyuan	Fuyuan	20	624	0.19	724	618	543	443
	Bielahong	Fuyuan	24	654	0.17	756	647	576	484
	Tongjiang	Tongjian	26	542	0.26	656	531	444	336
	Qixinggang	Fujin	24	536	0.24	638	525	445	343
III	Raohe	Raohe	33	578	0.18	665	572	509	416
	Caizuizi	Raohe	24	578	0.21	676	566	491	393
	Baoqing	Baoqing	33	537	0.29	661	521	424	311
	Fujin	Fujin	39	527	0.27	638	516	422	321
	Youyi	Jixian	23	499	0.25	599	489	409	314
	Farm 853	Baoqing	23	569	0.20	660	563	489	398
IV	Jiamusi	Jiamusi	33	513	0.27	621	503	410	313
	Fulitun	Jixian	25	506	0.24	602	496	420	324
	Farm 291	Jixian	23	500	0.25	600	490	410	315
V	Yilan	Yilan	51	527	0.25	632	516	432	332
	Huanan	Huanan	30	537	0.27	650	526	430	328
	Boli	Boli	28	529	0.26	640	518	434	328
	Woken	Boli	31	536	0.27	649	525	429	327
VI	Muling	Muling	34	524	0.26	634	514	430	325
	Jixi	Jixi	28	514	0.25	617	504	421	324
	Mishan	Mishan	37	522	0.24	621	512	433	334
	Famuchang	Hulin	22	660	0.23	785	647	554	436
	Hulin	Hulin	35	553	0.21	647	542	470	376
	Farm 856	Hulin	23	542	0.20	629	537	466	379
	Fenghuangdc	Mishan	23	561	0.20	651	555	482	393

Note: The subareas are cited from the results of "the Plan of comprehensive harnessing the Sanjiang Plain".

Table 2 The eigenvalues of annual runoff of representative stations in the Sanjiang Plain

Region	River	Station	Drainage area (km)	Series practical measuring	Years prolonged	Annual runoff (mm): Average value (mm)	Cv	Different frequence (%): 20	50	75	95
I	Yadan	Yadanhe	397	23	24	216	0.65	317	188	112	47.5
	Dulu	Duluhe	1028	14	24	234	0.75	356	192	105	35.2
	Wutong	Wutong	2504	16	24	287	0.58	411	256	164	77.5
	Heli	Xinhua	693	24	24	287	0.50	396	264	184	97.6
	Alingda	Heli	485	19	24	224	0.70	336	191	110	40.4
	Gejin	Huaxing	188	21	24	271	0.65	399	236	141	59.1
II	Bielahong	Bielahong	4340	22	24	95.0	1.00	153	65.6	27.6	4.75
III	Raoli	Baoqing	3689	24	24	172	0.75	269	131	63.7	15.5
	Raoli	plain	13042	22	24	54.4	0.85	84.9	41.9	21.2	5.4
	Qixing	Baoan	1344	23	24	170	0.75	263	136	73.3	22.2
IV	Anbang	Fulitun	579	24	24	171	0.70	256	145	83.7	30.7
V	Nianzi	Boli	142	14	24	144	0.72	218	121	69.3	24.5
	Woken	Taoshan	2148	23	24	153	0.84	238	119	61.1	15.3
	Woken	Woken	4164	24	24	131	0.76	200	106	57.5	18.3
VI	Muling	Muling	2613	18	24	161	0.60	232	143	89.9	41.7
	Muling	Lishu	6600	17	24	148	0.62	215	130	81.4	35.5
	Muling	Yanggang	15337	24	24	136	0.60	196	121	75.6	35.3
	Huangni	Xincheng	678	23	24	136	0.72	206	114	65.5	23.2
	Abuqin	Famuchang	672	22	24	330	0.45	446	308	219	132
	Didao	Tuanshanzi	5559	22	24	160	0.80	247	128	67.3	19.3

Table 3 The annual evaporation of water surface of representative stations in the Sanjiang Plain

Region	Station	County (municipal)	Series	Annual evaporation (mm) E average value	Annual evaporation (mm) E average value	Conversion coefficiet of every year
I	Luobei	Luobei	34	577.1	1041.8	0.55
	Wangjiadian	Luobei	26	595.0	988.3	0.60
	Hegang	Hegang	23	768.8	1284.7	0.60
	Suinin	Suibin	13	751.1	1346.9	0.56
II	Fuyuan	Fuyuan	12	769.7	1256.0	0.61
	Bielahong	Fuyuan	20	547.7	983.0	0.56
	Tongjiang	Tongjiang	13	691.8	1218.9	0.57
III	Raohe	Raohe	17	683.2	1109.6	0.62
	Caizuizi	Baoqing	24	679.4	1119.9	0.61
	Baoqing	Baoqing	35	704.5	1318.0	0.53
	Youyi	Youyi	6	667.5	1246.0	0.54
	Fujin	Fujin	34	654.8	1179.5	0.56
IV	Jiamusi	Jiamusi	34	695.0	1240.0	0.56
	Fulitun	Jixian	24	716.1	1328.9	0.54
	Huachuan	Huachuan	13	770.3	1379.5	0.56
V	Yilan	Yilan	38	736.7	1246.8	0.59
	Huanan	Huanan	13	728.8	1330.0	0.55
	Boli	Boli	21	821.9	1514.8	0.54
	Woken	Boli	31	660.9	1218.5	0.54
VI	Wuling	Wuling	24	657.3	1 83.8	0.61
	Jixi	Jixi	31	734.5	1272.3	0.58
	Mishan	Mishan	30	671.6	1135.3	0.59
	Famuchang	Hulin	11	596.4	979.4	0.61
	Hulin	Hulin	33	697.2	1141.5	0.61
	Hutou	Hulin	12	658.2	1079.0	0.61

III. ESTIMATION OF WATER RESOURCES

From the standpoint of water circulation, the equilibrium equation of average water amount for numerous years in a closed catchment is generally expressed by the formula:

$$\overline{P} = \overline{Rs} + \overline{Rg} + \overline{ETs} + \overline{ETg} + \overline{V} \tag{1}$$

where $\overline{P}$—precipitation

$\overline{Rs}$—the runoff amount on the surface

$\overline{Rg}$—the underground runoff amount discharged through rivers

$\overline{ETs}$—the evapotranspiration of surface, soil and plant

$\overline{ETg}$—the evaporation of phreatic water

$\overline{V}$—the flow amount of phreatic water

According to the principle that supply equals discharge, the supply of precipitation penetrating into phreatic water (P_g) on the condition of perennial average value may be expressed by the formula:

$$\overline{Pg} = \overline{Rg} + \overline{ETg} + \overline{V} \tag{2}$$

At present, the total amount of the water resources of the catchment (R_{total}) is generally defined as the sum of the surface runoff and the underground—water supply, that is:

$$\overline{R}_{(total)} = \overline{Rs} + \overline{Pg} = \overline{Rs} + \overline{Rg} + \overline{ETg} + \overline{V} \tag{3}$$

The writer thinks that soil water is directly absorbed and exploited by plant. If expressed with $\overline{ETg}$, then the formula (3) should be changed into (4)

$$\overline{R}_{(total)} = \overline{Rs} + \overline{Rg} + \overline{ETg} + \overline{V} + \overline{ETs} \tag{4}$$

where $\overline{R}$—surface water

$\overline{Rg} + \overline{ETg} + \overline{V}$—underground water

$\overline{ETs}$—soil water

$\overline{Rs} + \overline{Rg} = \overline{R}$—runoff amount of rivers

$\overline{V}$—flow amount of phreatic water in the catchment

$\overline{ETs} + \overline{ETg}$—the precipitation in the catchment

$\overline{R}_{(total)}$—the precipitation in the catchment

Because ETg and V are not large in mountainous regions, if neglected, then:

$$\overline{R}_{(total)} = \overline{Rs} + \overline{Rg} + \overline{ETs} \tag{5}$$

where $\overline{Rs} + \overline{Rg}$—runoff of rivers

$\overline{ETs}$—soil water

In plain regions:

$$\overline{R}_{(total)} = \overline{R} + \overline{Pg} - \overline{Rg} + \overline{ETs} \tag{6}$$

where $\overline{R}$—runoff of rivers

$\overline{Pg}$—underground water

$\overline{Rg}$—repeating amount

$\overline{ETs}$—soil water

According to formulas (5) and (6) the river runoff, underground water and soil water in each region and in the whole district are estimated, respectively. Meanwhile a general estimation of the water amount conducted or pumped from three rivers (the Heilong River, the Songhua River and the Wusuli River) and that adjusted by lakes and reservoirs is also done (see Table 4).

1. The Amount of River Runoff

There are 31 rainfall stations and 20 discharge stations that can be utilized in the whole district. Through a series of representative analysis, practical measuring series is adopted for precipitation, and a series of 24 years from 1956–1979 is adopted for runoff.

The perennial average precipitation in the whole district is 557mm (57.6 billion m^3), and it is 5–10% higher in mountainous regions than in plain regions. The perennial average runoff in the whole district is 119 mm(12.3 billion m^3) and it is 80% higher in mountainous regions than in plain regions. When the reliable frequency $P = 75\%$, the annual precipitation in the whole district is 467 mm(48.4 billion m^3), and the annual runoff is 63mm (6.52 billion m^3). The results of six regions show that the annual runoff in region(I) is the largest (176 mm), and that in region (IV) is the smallest (73mm).

2. The Underground Water Resource

The estimation is done in two landform units, i.e. mountainous region and plain region. The method of breaking up base flows is mainly adopted in mountainous regions, and the method of comprehensive supplement is mainly adopted in plain regions. On the whole, comparing various ways, the best one is selected. The comprehensive supplement of the underground water in the whole district (It includes the supplement after extraction) is 9.198 billion m^3, of which 18% is in mountainous regions, and 82% in plain regions. The abundant underground water concentrates in plain regions. Among the six regions,the amount of underground water in regions (I) and (IV) is the largest, and in region (III)the smallest.

3. Soil Water Resource

Soil water is an important resource that may be directly used by plant. Its amount varies with climatic conditions, soil characters and soil structures. There are five types of soil

Table 4 The estimation of water resources in the Sanjiang Plain

Items			Regions						
			(I)	(II)	(III)	(VI)	(IV)	(V)	The whole Sanjiang plain
Area	total	(1)	16448	15500	25825	5862	11630	28240	103505
	m.r.	(2)	7158	623	10817	2460	8049	16379	45486
(km²)	plain	(3)	9290	148777	15008	3402	3581	11861	58019
p.(10^8 m³/mm)		(4)	97.2 / 573	92.8 / 599	141 / 548	31.1 / 530	63.4 / 545	154 / 550	576.5 / 557
r.r.	w.d.	(5)	29.2 / 176	14.0 / 90	27.4/ 106	4.3 / 73	14.4 / 124	33.7 / 119	123 / 119
(10^8 m³/mm)	m.r.	(6)	20.1 / 280	0.6 / 97	15.4 / 142	2.3 / 94	11.4 / 142	23.5 / 143	73.3 / 161
	plain	(7)	9.1 / 9.7	13.4 / 90	12.0 / 80	2.0 / 58	3.0 / 84	10.2 / 85	49.7 / 86
u.w.	w.d.	(8)	25.22 / 153	19.81 / 128	6.97 / 27	12.02 / 205	7.90 / 68	20.06 / 71	91.98 / 89
(10^8 m³/mm)	m.r.	(9)	3.59 / 50	0.21 / 34	3.88 / 36	0.74 / 30	3.13 / 39	5.31 / 32	16.86 / 37
	plain	(10)	21.63 / 233	19.60 / 132	3.09 / 21	11.28 / 332	4.77 / 133	14.75 / 125	75.12 / 129
r.w.	m.r.	(11)	3.59	0.21	3.88	0.74	3.13	5.31	16.86
(10^8 m³)	plain	(12)	0.44	0.90	0.23	1.00	0.29	0.77	3.63
s.u.	w.d.	(13)	50.4 / 306	32.7 / 211	30.3 / 117	14.6 / 249	18.9 / 162	47.6 / 168	194.5 / 188
(10^8 m³/mm)	m.r.	(14)	20.1 / 280	0.6 / 97	15.4 / 142	2.3 / 94	11.4 / 142	23.5 / 143	73.3 / 161
	plain	(15)	30.3 / 326	32.1 / 216	14.9 / 99	12.3 / 361	7.5 / 209	24.1 / 203	121.2 / 209
s.(10^8 m³/mm)		(16)	43.8/ 266	60.1/ 388	110.7/ 429	16.5/ 281	44.5/ 383	106.4/ 377	382/ 369
S.J.(10^8 m³)		(17)							100
a.w.(10^8 m³)		(18)	The annual adjusted-water storing capacity of Xingkai Lake (in our country) 6.4+3.3 (of small lake) +7.8 (expoitating capacity of the reservoir) = 17.5						

Notes: 1. Subareas are adopted from "The Plain of Comprehensive Harnessing the Sanjiang Plain".

2. In the table: (14)=(6)=R+R, (15)=(7)+(10)−(12), (16)=(4)−(13)

3. Region (I) is Luobei, (II) is Tongjiang-Fuyuan, (III) is Raolihe, (IV) is Anbanghe, (V) is Wokenhe, and (VI) is Mulinghe.

4. mr = mountainous region p.= precipitation r.r.= river runoff

w.d. = whole district u.w.= underground water r.w.= repeated water

s.u.= the surface and underground water s.= soil water

S.J.= the water conducted and pumped from the Heilong River, the Songhua River and the Wusuli River a. w.= adjusted water in lakes and reservoirs in this district, i.e. burozem, meadow soil, albic soil, black soil, and it is difficult to estimate them respectively. The equilibrium equation of perennial average water amount is adopted in the paper to estimate the soil water resource generally (see Table 4). The soil water in regions (II),(III) and (V) is abundant, and that in regions (I) and (IV) is poor.

4. The Conducted and Pumped Water Amount from the Heilong, Songhua and Wusuli Rivers

The Heilong River is the boundary river between China and the Soviet Union, into which the Songhua River and the Wusuli River enter in this district. The perennial average runoff at the exit cross section of the Heilong River is 273 billion m^3(at Boli Station, $F=1{,}620{,}000\ km^2$), that of the Songhua River is 73.3 billion m^3($F=546{,}000\ km^2$), and that of the Wusuli River is 45.14 billion m^3($F=187{,}000\ km^2$). According to the estimation in various ways, the total amount of water flowing through this district is 218.4 billion m^3, and that conducted and pumped is 10 billion m^3, making up about 4.6% of the total.

5. The Water Resources of Lakes and Reservoirs

Small Xingkai Lake and Xingkai Lake are natural lakes in this district. The drainage area of Small Xingkai Lake is 15,299 km^2, including that of the Muling River. At the normal high water level, the surface area of the lake is 145 km^2, and the storage capacity is 330 million m^3. Through calculation, we found that the supplementary coefficient of the lake is 105, perennial average inflow is 30.5 m^3per second, and the period of exchanging water is 125 days, so the water resources can be exploited sufficiently.

Not including the drainage areas of the small lakes; the drainage area of Xingkai Lake is 22,400 km^2. If they are included, it is 36,400Km^2. At the normal water level, the surface area of the lake is 4,340 Km^2(1,080 $Km^2$is in our country), the storage capacity is 17.5 billion m^3. Through calculation, we found supplementary coefficient of the lake is 8.40, the perennial average inflow is 92.0 m^3per second, and the total period of exchanging water is 2,202 days. If the annual water level fluctuation is 0.6m, the storage capacity is 2.4 billion m^3(640 million m^3 is in our country), the period of exchanging water is 302 days.

Beside lakes, 3 large, 12 medium and 326 small I and II reservoirs and 86 pools and ponds have been built in this district. The total catchment area is 15,734 Km^2. The total storage capacity is 1.42 billion m^3, and the exploitative capacity is 780 million m^3.

The total storage capacity (Here it refers to the exploitative capacity) of the above—mentioned lakes and reservoirs is 1.75 billion m^3, and the water quality is good. It is a great supplementary water resource of this district.

6. The Quality of Natural Water and Its Pollution Conditions

The sand content in revers in this district is not high. The average annual modulus of erosion is 10—20 tons per square kilometer. The character of the surface water and underground water mostly belong to the type of calcium and sodium bicarbonate. The pH value is 7 and its annual change is not great, belonging to weak acidity or weak alkalinity. The total hardness of the surface water is 0.47—1.32 m.e. / L. The total amount of ions is 61.5—195 mg / L. The degree of mineralization of the underground water is less than 0.5 g / L. The content of iron ions ($Fe^{2+}+Fe^{3+}$)is commonly high, and the average content in the whole district approaches 3.53 mg / L. It belongs to low mineralized fresh water, which suits industrial and agricultural production and human living.

Although the water quality of the natural rivers in this district is good, at present the water resources have been severely polluted to some degree by the industrial waste water, the domestic sewage and farm pesticide and chemical fertilizer which are carried into the rivers by overland runoff. According to investigations at four cities of Jiamusi, Jixi, Shuangyashan and Hegang, and Hejiang region, the daily discharge is 410,000, 118,600, 101,700, 42,100 and 98,300 tons, respectively. Among them, the industrial waste water is 331,500, 57,400, 99,100, 30,100 and 58,400 tons, respectively. Through monitoring analysis, it has been found that in the Songhua River from Yilan to its mouth, the organic contamination reaches about degree III and the five poisons (phenol, cyanogen, mercury, arsenic, chromium) contamination is degree II. In the Muling River from Jixi to Tangwang and from Tangwang to its mouth, the organic contamination is degree III and IV, respectively, and the five poisons contamination is degree IV and II, respectively. In addition, the contamination of the Woken River is also relatively serious. Harmful and poisonous matters such as cyanogen and phenol, etc. have also been in the Heilong River and the Wusuli River.

IV. EVALUATION AND EXPLOITATION OF WATER RESOURCES

1. Evaluation of Water Resources

In this district, the river runoff is 12.3 billion m^3, the underground water is 9.2 billion m^3, the soil water is 38.2 billion m^3, the water conducted and pumped from three rivers is 10 billion m^3, the stored water in lakes and reservoirs is 1.75 billion m^3. Deducting repeated water and not including soil water and the water stored in lakes and reservoirs, the total water resources in this district is 29.45 billion m^3. Considering the development hereafter, if the water resources are allocated according to the population of $850 \times 10^4$and the cultivated land of 3.902 million ha., there is 3,465 m^3 of water for each person and 503 $m^3$of water for each mu(1 mu = 1 / 15 ha). It shows that the average water amount each person is higher than that in the whole Heilongjiang Province and the whole country.

In the six subdivided regions, water resources in regions I and IV are comparatively abundant (306 mm and 249 mm). In region III it is the least (117 mm). In every region, the surface water mainly concentrates in the mountainous area, while underground water mainly concentrates in the plain region. Through estimation, we can see that the net water amount conducted and pumped from three rivers and lakes is 5 billion m^3. In the whole district, the net water amount of 5.02 billion m^3 in the rivers can be adjusted and exploited by means of projects. The underground water of 5—7 billion m^3 is exploitable. According to the long-term plan, in regions I and IV , the water quantity is sufficient, while in regions III and V, it is deficient.

Through analyzing the relation of the transformation of the three kinds of water, it can be seen that the atmospheric precipitation is the main supplementary source of surface water and underground water, but in terms of the quantity, the latter only occupies 34% of the former. The soil water which amounts to 66% of the atmospheric precipitation is the water resource that can be used by crops and other plants, and it is a direct resource to the production of agriculture, forestry and animal husbandry. But in most cases, it is difficult to be exploited by people and industry. The study of the supplementary quantity through infiltration and its transformation should be given enough attention to.

Compared with requirement the water resources in this district have the following advantages. The water quality is good. Apart from the atmospheric precipitation, there are still three revers and lakes as supplementary conditions. And the water–storing condition of the water bearing stratum is good. On the other hand, there are some disadvantages. The variation in a year and between years is great. In the period of freezing(half a year), it is difficult to exploit water resources. And the soil texture in the plain is too heavy and the adjusting function of the soil is weak. In the exploitation of water resources, we should accommodate the natural conditions, develop favorable factors and avoid unfavorable factors.

2. The Rational Exploitation of Water Resources

Viewing the exploitation of water resources from various angles. Water as a resource includes water quantity, water quality, water surface and water energy, and can be widely used in industry, agriculture, forestry, animal husbandry, sideline production, fishery, living environment and tourism, etc. All of them can not develop without water. Therefore multipurpose exploitation and repeated exploitation are essential to rationally exploiting water resources.

Taking suitable measures according to local conditions for exploitation. In mountainous areas, growing grass and trees, and developing forestry and sideline production can not only reduce the flood menace, but also conserve water resources. At suitable locations, constructing control works to adjust the runoff may eliminate calamities and develop benefits. The plain regions lack surface water resources, but when precipitation exceeds a certain quantity, the surplus water is usually discharged out in order to prevent flood and waterlog. Suggestion can be made that except developing soil water and underground water, water–storing pits, be excavated to expand breeding industry. According to preliminary estimation, in the plain regions, during dry years (*P* is 80%), the depth of runoff is about 30 mm. In normal years it reaches only 80–100 mm. If we excavate fish pools using 3–5% of the land, it will hold the surplus water of the cultivated land to develop breeding industry. In planning and designing, one may rationally lay out the pools to make them with the channels.

Adjusting the kinds of the crops to suit the natural characteristics. The area of low land in this district is very large and waterlog is frequent. In terms of wheat, due to the spring waterlog, the proper sowing-time is often missed, and the autumn waterlog also affects harvest. It is suggested that the wheat land be changed into paddy field, making use of the surface water and underground water to develop irrigation so as to suit the nature and gain a bumper harvest.

3. Strengthening the Protection and Management of Water Resources

This district is a recently developed region. Here the natural water quality is good, and the exploitation of water resources has great potentiality. According to investigation, in this district, the total water amount used in industry, agriculture and residential living is 2.486 billion m^3(water used in agriculture is 1.632 billion m^3, industry 792 million $m^3$and in residential living 62 million m^3, making up only 8.3% of the total water resources.

In recent years, as the five cities administrated by the province expand, the constructions of counties, small towns and farms are developing rapidly. This results in the constant increase of industrial waste water and sewage in towns. Most of the waste water is directly discharged into rivers without treatment, which severely contaminates the water bodies. Besides, in agricultural areas, the amount of pesticide and chemical fertilizer used is constantly increasing, which intensifies the pollution of water sources. Therefore, some accidents such as the killing of fish, the poisoning of human beings, animals and trees, the decrease in production in some units and the deterioration of product quality happen by degrees. At present, we should lay down the rules of protecting water resources at once, organize well the monitoring of water quality, and take proper measures of prevention and cure.

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