Precipitation Resource Potential in Mountainous Areas in Hebei Province Analysis

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Abstract. The climatic conditions of Hebei Province cause this area shortage of water resources, man-made factors lead it more serious. In March 2007 in Hebei , 37 mountain counties got samples of soil and corn, conducted indoor tests, through analyzing Hebei rainfall and soil moisture and corn yield in mountains, using potential resource calculated model to precipitation, they analyzed and evaluated precipitation resource potential in mountainous areas in Hebei , concluded that precipitation is the important factor affecting the soil moisture content and maize yield. The development of storage-volume of precipitation resource potential is less than half, the theoretical storage-volume set of the potential development is lower, so that it is expected to improve the potential of development through technological improvements; Hebei runoff harvesting project should take rural residential areas as its core region; the precipitation of mountainous areas in Hebei Province is dominant factor affecting the amount of runoff harvesting.

Keywords: Hebei mountain; precipitation; precipitation resources; potential analysis

Precipitation resource potential is such a process that through people's controlling of precipitation in the spatial and temporal on underlying surfaces to promote more parts to form the available resources[1]. Hebei province takes rainwater as one of the main sources of water resources, with climate rainy in hot summer, less snowy in dry winter，windy in dry spring , less rainy in autumn, causing the shortage of water supply. This article analyzes the relationship between the corn yield and precipitation, estimates and evaluates rainfall resource potential, to analyze the precipitation resource potential and the using measures in Hebei mountains.

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1 Data sources

1.1 Field sampling and determination of characteristic parameters

Group conducted soil sampling of 37 mountainous counties in Hebei Province in March 2007, sampling points chosen had 74 various typical mountain soil, at the same time collected corn seed of samples, recorded samples terrain, altitude, slope, vegetation, irrigation, fertilization, and collect relevant information from relevant departments. Experimented the soil parameters in laboratory: soil moisture, soil bulk density, organic matter, pH, total nitrogen, total phosphorus, available phosphorus, total kalium, available kalium; corn seed parameters are: total nitrogen, total phosphorus and total kalium.

1.2 Other statistics

Totally, counted the soil nutrient content, nutrient content of maize seed and maize yield in Handan, Xingtai, Shijiazhuang, Baoding, Zhangjiakou, Chengde, Qinhuangdao, Tangshan 8 counties, 66 cities (county-level cities, districts), which dam highland grassland owns 6 areas, Hebei Northwest Rocky Mountain 10 areas, Taihang Rocky mountainous 26 areas , Yanshan Rocky Mountainous 24 areas . Statistical characteristics of rainfall and the soil moisture in Hebei Province mountainous area is shown in Table 1. Statistical characteristics of rainfall and the soil moisture in Hebei Province each mountainous area in Table 2.

Table 1. Rainfall and soil moisture data describing characteristics statistics table

Index	Mean	Standard deviation	Variation Coefficient（%）
Rainfall	549.019mm	111.420 mm	20.294
Soil moisture	7.047%	4.680%	66.411

Table 2. Rainfall and soil moisture of sampling sites regional tables

Index	Dam Highland Grassland Area	Hebei Northwest Rocky Mountainous area	Yanshan Rocky Mountainous area	Taihang Rocky mountainous area
Rainfall（mm）	395.7	397.69	646.17	566.69
Soil moisture（%）	5.354	5.178	9.326	7.088

Table 2 shows that in the mountains of Hebei Province, Yanshan Rocky mountainous area is the most abundant in rainfall, followed by Northwest Hebei and Taihang mountainous Rocky Mountain area,   Dam Highland Grassland Area has least precipitation of all.

2 Mountain precipitation Resource potential calculation and its evaluation methods [2]

2.1Precipitation Resource potential calculation formula

Resource potential in mountain precipitation calculation can be divided into three levels: first, The theory potential of precipitation resource ; second, precipitation of the set of storage capacity that can be realized; three, the actual set of precipitation storage capacity.

(1) The theory potential of precipitation resource

Calculated as:

$$R_t = P \times A \times 10^3 \tag{1}$$

Type in: R_t——Theory of precipitation potential (m^3); P—— precipitation (mm); A——area (km^2).

(2) Precipitation set of storage capacity that can be realized

Based on the precipitation of storage capacity, it can be set to achieve understanding, and build the following expression:

$$R_a = \lambda_R \times P \times A \times 10^3 \tag{2}$$

$$\text{Or} \quad R_a = P-(1-\lambda_{1R})\, R-(1-\lambda_{2R})\, E_0 \tag{3}$$

The formula: R_a——precipitation set of storage capacity can be achieved (m^3); P——precipitation (mm); A - area (km^2); R——surface runoff; E_0——evaporation; λ_R——possible controlling coefficient achieving the maximum precipitation $\lambda_R \times P$——the largest amount of precipitation can be regulated; λ_{1R}—— maximum controlling surface runoff coefficient; $(1-\lambda_{1R})$ R—— the minimum controlling of surface runoff; λ_{2R}——maximum controlling evaporation coefficient; $(1-\lambda_{2R})$ E_0—— minimum difficult controlling evaporation loss.

(3) The actual set of precipitation storage capacity

It refers to the precipitation on the current use patterns and techniques, amount of resources, set realistic storage capacity R_r is consistent with achievable storage capacity R_a set formula, r is on behalf of mountain precipitation realistic level.

$$R_r = \lambda_r \times P \times A \times 10^3 \tag{4}$$

$$\text{Or } R_r = P-(1-\lambda_{1r})\, R-(1-\lambda_{2r})\, E_0 \tag{5}$$

The formula: R_r —— the actual set of precipitation storage capacity (m^3); p —— precipitation (mm); A - drainage area (km^2); R—— surface runoff; λ_r —— reality level of drainage precipitation controlling ability; λ_{1r}—— runoff controlling coefficient; $(1-\lambda_{1r})$ R—— difficult controlling surface runoff; λ_{2r} —— evaporation controlling coefficient; $(1-\lambda_{2r})$ E_0 ——the difficult controlling evaporation loss; λ_r, λ_{1r}, λ_{2r} concern with technology and the economic level.

In theory, λ_{1R}, λ_{2R} → 1, R_a → R_t, with runoff control, and evaporation suppression technology improved, λ_{1r} → λ_{2r}, λ_{2r} → λ_{2R}, R_r → R_a. With the drainage technological progress and economic development, precipitation set of storage capacity can be realized and the actual set of storage capacity will rise.

2.2 Precipitation potential assessment methods [3-5]

For a specific mountain, if the precipitation, infiltration, topography, soil information of the mountain and existing use and area of precipitation can be mastered, only through some tests on precipitation runoff, the precipitation potential can be calculated. Combined with the needs of mountainous water conditions, it can evaluate precipitation development and utilization of resources.

WD_{max} precipitation resource potential theory development degree:

$$WD_{max} = (R_a / R_t) \times 100\% \tag{6}$$

WD_{real1} precipitation resource realistic storage development degree:

$$WD_{real1} = (R_r / R_t) \times 100\% \tag{7}$$

WD_{rea12} precipitation enables capacity development degree:

$$WD_{rea12} = (R_r / R_a) \times 100\% \tag{8}$$

W_d, R_d actual water demand degree, the actual water demand:

$$W_d = (R_d / R_t) \times 100\% \tag{9}$$

Precipitation resources development must adhere to principles of the sustainable use and sustainable development. On one hand, precipitation should meet the needs of certain areas of water demand; on the other hand, precipitation can not be unlimited to develop, the scale of development should correspond with the existing conditions of precipitation, it must not exceed the carrying capacity of precipitation.

In general, development of precipitation in mountainous areas will appear the following situations:

(1) $WD_{max} > W_d > WD_{real1}$, shows that mountain precipitation resources development scale is more realistic, although precipitation resources in the development and utilization can not meet the requirements of the regional water demand, but you can set store by increasing flow works or other measures to enhance the potential for the development level.

(2) $W_d > WD_{max} > WD_{real1}$, shows that developed mountain precipitation use scale is beyond the maximum level of precipitation development, it needs to reduce the development of scale and optimize water usage of the business, otherwise it will lead to environmental degradation, or drought intensified.

(3) $WD_{max} > WD_{real1} > W_d$, shows that developed mountain precipitation use scale is not very good , for the play to precipitation potential, water consumption should adjust the ratio or the appropriate use of expanding the scale of precipitation.

(4) $WD_{max} = W_d = WD_{real1}$, shows that mountain precipitation set development scale and resources utilization had reached the maximum precipitation development potential, and the practical development ability can also meet the requirements of the

development scale, to realize the efficient use of precipitation , in reality, such opportunities rarely arise.

(5) WD_{real2} always greater than Wdrea11, the higher WD_{real2} shows that precipitation potential can be achieved higher, all taken by the water runoff and storage projects and technology should be more advanced.

3 Estimation and evaluation of runoff collection

By precipitation resource potential calculation and evaluation means, results of precipitation resource potential calculation and store to the arable land in Hebei Province mountainous is in Table 3-6. Results of potential development degree to the arable land in Hebei Province mountains is in Table 7.

Table 3. The theory potential precipitation resource in Hebei Province mountainous area （10^7m^3）

Area	Rural Settlements	Highway	Rural road	Sum
Hebei Province mountainous area	126.2	11.4	22.7	160.3
Dam Highland Grassland area	40.0	3.7	1.6	45.3
Hebei Northwest Rocky Mountain area	20.9	2.2	8.3	31.4
Yanshan Rocky Mountainous area	40.9	3.5	8.2	52.6
Taihang Rocky mountainous area	24.4	2.0	4.6	31

Table 4. The theory potential store Rt to the arable land in Hebei Province mountainous areas （m^3/mu）

Area	Rural Settlements	Highway	Rural road	Sum
Hebei Province mountainous area	514.3	229.9	598.5	1342.7
Dam Highland Grassland area	56.2	25.7	102.6	184.5
Hebei Northwest Rocky Mountain area	61.5	35.3	118.4	215.2
Yanshan Rocky Mountainous area	228.6	100.3	221.1	550
Taihang Rocky mountainous area	168.0	68.6	156.4	393

Table 5. The realized storage capacity Ra to the arable land in Hebei Province mountainous areas（m^3/mu）

Area	Rural Settlements	Highway	Rural road	Sum
Hebei Province mountainous area	226.8	106.8	89.9	423.5
Dam Highland Grassland area	24.8	12.3	15.4	52.5
Hebei Northwest Rocky Mountain area	27.1	13.5	17.8	58.4
Yanshan Rocky Mountainous area	100.8	48.1	33.2	182.1
Taihang Rocky mountainous area	74.1	32.9	23.5	130.5

Table 6. The actual storage capacity Rr to the arable land in Hebei Province mountainous areas （m^3/mu）

Area	Rural Settlements	Highway	Rural road	Sum
Hebei Province mountainous area	128.6	27.5	18	174.1
Dam Highland Grassland area	14.1	3.1	3.1	20.3
Hebei Northwest Rocky Mountain area	15.4	4.2	3.6	23.2
Yanshan Rocky Mountainous area	57.1	12.0	6.6	75.7
Taihang Rocky mountainous area	42.0	8.2	4.7	54.9

Table 7. The potential development degree to the arable land in Hebei Province mountainous areas（%）

Area	The theory development degree （R_a /R_t）	The actual development degree （R_r /R_t）	The realized development degree （R_r /R_a）
Hebei Province mountainous area	31.54	12.97	41.11
Dam Highland Grassland area	28.46	11.00	38.67
Hebei Northwest Rocky Mountain area	27.14	10.78	39.73
Yanshan Rocky Mountainous area	33.11	13.76	41.57
Taihang Rocky mountainous area	33.21	13.97	42.07

The results show that:
(1) In the current runoff collection and storage, rural settlements as courtyard, roof, and scene construction are the key runoff construction areas. In Hebei Province mountains, the percentage of rural settlements area in total runoff area is 74.59%, rural settlements runoff realized potential percentage of store runoff realized potential account is 78.73%, Highways and rural roads in runoff area is 25.41%, realized potential store percentage of runoff to arable land realized potential is 21.27%. Therefore, runoff harvesting project in Hebei Province should take the rural settlements as the core region [6-8].
(2) The theory potential, achieved potential, reality collection and storage of runoff to land is the quite different. Storage capacity to land achieved potential in Hebei Province mountain runoff on average is 423.5m3/mu, accounting for 31.54% in the theory potential storage capacity, the reality storage capacity is 174.1m3/mu, accounting for 41.11% in the achieved potential storage capacity. However, two matters must be focused on, first is in rural settlements, only land near highway and rural roads, runoff collected area are facilitated by supplementary irrigation, which is part of the farmland less than 10% of the total cultivated area; the second is above 85% of construction cellar located in rural settlements, the main problem is to solve drinking water of human beings and animals, cellar in highways and near rural roads runoff is few, and quite a few road away from the field, most of the rural road with narrow surface, not yet hardened, low efficiency of runoff , runoff containing large sediment. Therefore, runoff surface construction should be strengthened, rational planning and layout of cellars, to make the planting area and runoff collection area and storage containers is matching [9-10].
(3)It can be analyzed and calculated through precipitation data collected by district,

runoff area ratio (the ratio of runoff area and the arable land), and runoff to land collection and storage

① In Hebei Mountain 4 regions, annual rainfall, wet season rainfall, runoff area ratio, runoff collection and storage to land are significantly different, the double impact of runoff collection and storage are rainfall and runoff area ratio, precipitation is the dominant factor of runoff store. The order of regional reality storage capacity of runoff to the land (m3/mu) is shown in Table 6: Yanshan Rocky Mountainous area (75.7)> Taihang Rocky mountainous area (54.9)> Hebei Northwest Rocky Mountain area (23.2)> Dam Highland Grassland area (20.3). In comparison, the average rainfall in Yanshan Rocky Mountainous area about 646m, runoff collection and storage to land significantly higher than other regions, is relatively easy to collect and store runoff; Dam Highland Grassland area annual precipitation around 396m, runoff to the land saving is very low, runoff development to irrigation farmland need to build up a larger runoff.

② According to the precipitation resource potential assessment indicators and calculation methods, different regions of Hebei Province mountain runoff to collect and store to land of theory potential development degree is 28-32% (table 7), achieved storage capacity potential development degree is 38-43%, there are about 60% untapped potential, and realistic storage capacity is only a 10-13% development. So the less precipitation, the lower the development; in the existing topography, land use and agricultural technology conditions, the realistic precipitation storage capacity development potential is less than half, the theory development potential is lower, the potential to be developed by improving the degree of technological progress [11].

4 Conclusion

(1) In Hebei Province, the rainfall amount is an important factor affecting soil moisture content and corn yield. In Hebei Province mountains, Yanshan Rocky Mountainous area is most abundant in precipitation, followed by Taihang Rocky mountainous area and Hebei Northwest Rocky Mountain area, precipitation in Dam Highland Grassland area is least. Mountain soil moisture content in Hebei Province, Yanshan Rocky Mountainous area is the most abundant in precipitation, followed by Taihang Rocky mountainous area, Dam Highland Grassland area and Hebei Northwest Rocky Mountain area.

(2) In Hebei Province mountains, precipitation resource realized potential development storage capacity is less than half, the theory storage capacity potential development is lower, the potential to be developed by improving technological. Runoff harvesting project in Hebei Province take rural settlements as the core region. Runoff surface construction should be strengthened, rational planning and layout of cellars, make planting area and runoff collection area and storage containers is matching. In Hebei Mountains, precipitation is the dominant factor of runoff storage. Annual rainfall, wet season rainfall, runoff area ratio, runoff collection and storage to land are significantly different. In comparison, Yanshan Rocky Mountainous area runoff collection and storage to land significantly higher than other

regions, is relatively easy to collect and store runoff. Runoff of Dam Highland Grassland to the land saving is very low, runoff development to irrigation farmland need to build up a larger runoff.

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