



An advanced tool to determine agriculture groundwater usage for irrigation to greenhouse facilities¹

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Abstract

Introduction: With the development of agricultural technology, it is possible to cultivate crops in winter at the greenhouse facility cultivation complex, and as the crop cultivation period has increased, the use of groundwater has increased. When calculating the amount of groundwater used, the utilization period should be increased according to the cultivation period.

Materials and Methods: As a result, the groundwater use calculated by the conventional method is applied to the annual use period of 270 days for the whole action and 180 days for the answer action, so the value less than the actual groundwater use for the year is inevitably calculated. Therefore, it is necessary to estimate the irrigation water demand for each crop in consideration of the cultivation period when the groundwater use is calculated in the facility cultivation complex that grows the four-season crops. The purpose of this study was to calculate monthly cultivation crops and cultivation periods through Gwang-ju Meteorological Agency's climate data in South Korea, land cover map, field survey, and residents' survey to estimate the irrigation water demand by crops in the area around Yeongsan River where facility cultivation complex is concentrated.

Results: Based on the results of the calculation of crop evaporation (irrigation water demand) using the crop coefficients presented by the Rural Development Administration

1. Received: 2022/07/03; Received in revised form: 2022/08/11; Accepted: 2022/09/02; Published Online: 2022/10/01

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DOI: 10.22034/wpj.2023.388193.1056





and FAO, it was analysed that irrigation water used is $2,114 \times 1000 \text{ m}^3/\text{year}$ for rice, $3,353 \times 1,000 \text{ m}^3/\text{year}$ for field crops, and $6,649 \times 1,000 \text{ m}^3/\text{year}$ for water dropwort. As a result, water dropwort uses irrigation water twice more than field crops. In addition, except for rice, which mainly uses surface water, the difference in usage amount occurred more than twice as compared to the groundwater use calculated by the existing groundwater use method. Therefore, if the facility cultivation complex that grows four seasons of crops water demand calculation method is applied to the irrigation water required by the crops rather than the conventional groundwater usage calculation method, it will not only calculate the exact amount of water but also establish proper water supply measures and facility maintenance. The high agriculture productivity in the command area and poor performance of the irrigation system clearly justifies the role of shallow tubewell has played in the command area. Since the irrigation facility is Agency Managed and O&M of the surface system is carried out by the Government, the investment cost on the tube well and their O&M is entirely contributed by the farmers. The deficit water fulfilled by the tubewell and total cost associated to it is considered to be the total economic loss due to irrigation system inefficiency. Finally, the amount of irrigation water required by the crop during the growth period was calculated by multiplying the monthly crop evaporation amount to the monthly cultivation area. However, it is difficult to calculate the amount of groundwater used as a crop factor by repeating the operation of filling and subtracting water and running water in order to prevent temperature maintenance and dobok (bending) during cultivation. Therefore, in the case of dropwort with a large amount of groundwater, irrigation water demand was separately calculated monthly through field surveys on cultivation area, cultivation period, and cultivation methods and interviews with local residents.

Conclusions: It will be helpful in establishing measures and maintaining water supply facilities. If research on crop factor estimation is activated in the future, it will be possible to more accurately estimate the demand for irrigation water for all crops.

Keywords: Groundwater usage, Irrigation, Greenhouse facilities, South Korea.



1. Introduction

Recently, the agricultural environment has been greatly changed from paddy farming to field farming and facility cultivation. In particular, with the development of alluvial layers, increasing facilities cultivation complexes around rivers rich in groundwater, it is necessary to re-evaluate the demand for irrigation water in these areas. Unlike paddy farming, in the case of facility cultivation complexes where crops can grow in four seasons, it is important to secure warm water and heat sources, so that warm groundwater is pumped and used as a water source. Considering the changing agricultural environment, it is very important to understand the actual use of irrigation water, but there is no observational data on the amount of groundwater used in agricultural areas around the river where the facility cultivation complex is located. The indirect calculation method of multiplying the amount of groundwater use by application is multiplied by the number of days usages of groundwater during the year in accordance with the grounding water usage calculation method (Ministry of Land, Infrastructure and Transport, 2015) prepared through actual measurement by each type of groundwater use.

According to the groundwater usage calculation guidelines presented in the 2015 Groundwater Business Performance Guidelines, there is data that can be used to measure the actual amount of groundwater measurement or to check the actual amount of groundwater usage charges and sewerage charges. If there is a calculation standard, it is recommended to apply the standard first, but in reality, it is almost impossible to determine the actual amount of use by conducting a total survey of the groundwater facilities in the area. The flow meter installation obligation is also limited to licensed facilities, and in the case of the reporting facility, there is no obligation to install the flow meter, which acts as a factor that makes it difficult to accurately calculate the amount of usage. There is a great risk of actual usage and many errors.

For example, if applied according to the groundwater usage calculation method, the daily usage is calculated by multiplying the estimated daily use (applied to 270 days) after calculating the daily use with $4.338 + (\text{pumping capacity} \times 0.041)$ for the total action (in the case of an area exceeding the average precipitation). The annual action is calculated by multiplying the estimated daily use $[0.203 + (\text{pumping capacity} \times 0.047)]$ by the number of days used (applied to 180 days) (Table 1).

**Table 1.** The calculated criteria of agriculture groundwater usage in South Korea

by use	Detailed use	Calculation criteria of Groundwater Usage			Days of use
		Urban	Urban+Rural	Rural	
Agri-culture	Field	6.964+(pumping capacity×0.013)	5.660+(pumping capacity×0.014)	4.338+(pumping capacity×0.041)	270
	Paddy	2.089+(pumping capacity×0.043)	1.980+(pumping capacity×0.044)	0.203+(pumping capacity×0.047)	180
	Gardening	2.789 + (pumping capacity × 0.011)			365
	Living-stock	Beef	3.480 + (breeding number × 0.009)		365
		Pig	4.719 + (breeding number × 0.001)		365
		Poultry	5.492 + (breeding number(thousand) × 0.041)		365
	Etc.	Planned quantity in groundwater development			365

* **Source:** Ministry of Land, Infrastructure and Transport (2015)

However, in the case of facility cultivation complexes, farming technology has greatly improved to the extent of 2 or 3 crops per crop, and at most 5 crops. Since the amount of groundwater is used, it would be desirable to calculate the amount of moisture (required amount) required to grow the crop during the growth period and apply it as the amount of groundwater use in accordance with the changes in the agricultural crop system. Therefore, the area under study was selected as an area with very little slope relief, adjacent to the river, and a lot of groundwater developed and used as an agricultural area with thick developed alluvial aquifer such as sand and gravel. In particular, this area has a dropwort cultivation complex that requires groundwater throughout the year. This study aims to propose an improvement method for the actual calculation of groundwater usage by calculating the required amount of irrigation water for each crop in around the Yeongsan River and comparing it with the existing groundwater usage calculation method.

2. Research Method

Yoon *et al.* (1990), Choi *et al.* (2013), Song *et al.* (2019) conducted research on calculating demand using crop factors to estimate the amount of groundwater use in the past. It is limited to trial application. it is calculated for each land use type, such as arable land, forest land, orchard, there is a limit to applying water use of the actual crop to the amount of groundwater use in farming land under cultivation. Therefore, in order to estimate the amount of irrigation water required in the area where the actual crop is being grown, the



crops and cultivation area of each facility cultivation area in the research area and the amount of demand was calculated by using data from the cultivation period, crop coefficient, potential evaporation amount, land cover, groundwater use status, etc. The cultivation area and cultivation period for each crop of the facility cultivation complex were identified by reflecting the results of interviews with local farmers and the registration information of agricultural management organizations by parcel. The potential evaporation amount was calculated by using climate data from the Gwangju Meteorological Office near the study area, and the area for each land use was calculated by using the 2018 land cover map provided by the Ministry of Environment's 'Environmental Spatial Information Service', and the numerical map provided by the National Geographic Information Institute. The area was corrected by comparing the crop cultivation site with.

Finally, the calculated demand for irrigation water for each crop was compared with the amount of groundwater using the existing method for estimating the amount of groundwater use, which raised the need to improve the method for estimating the amount of groundwater use in a facility cultivation complex that grows four season crops.

2-1. Estimation of crop cultivation area

In recent years, with the development of farming technology, the amount of facility cultivation complex that can grow crops in four seasons has increased. In terms of supply and use of irrigation water, it can be said to be one of the reasons for the increase in the use of groundwater in winter. The reason is that in winter, it is more economical to use groundwater, which maintains a warm water temperature of 14~16°C year-round, as irrigation water, rather than heating with expensive oil in order to adjust the growth temperature of crops. Therefore, if only the groundwater is abundant, crops can be grown in winter to generate additional income, so the amount of underground water use will increase as the planting complex increases and the cropping system changes from 1st to 2nd and 3rd. Therefore, in order to understand the actual amount of groundwater use, it can be said that it is essential to understand the area of crop cultivation and the period of cultivation in winter. In order for farmers to receive some compensation according to the extent of the damage after suffering from typhoons or droughts the agricultural management registration information directly reported by farmers is provided by the Ministry of Food and Agriculture (2019) for the past three years (2017-2019). The cultivation area and cultivation period were partially corrected to reflect the results of



interviews with farmers (Table 2).

Table 2. Registration information of agricultural management

Registration information of agricultural management*			Terms of crop cultivation(The results of field survey)											
PNU	Cultivated area	Cultivated crops	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2920013800 104780002	300	Sweet pepper												
2920013800 104860003	3002	dropwort												
2920013800 104860003	3002	Pumpkin												
2920013800 104860004	3100	dropwort												
2920013800 104860013	2830	Sweet pepper												
2920013800 104860013	2830	Potato												
2920013800 104860019	820	Sweet pepper												
2920013800 104860019	820	Tomato												
:			:					:				:		

* **Source:** Ministry of Agriculture and Forestry (2019), The empty cells of the table is for the results of field survey.

2-2. Estimation of potential evaporation

Potential evaporation (ET₀) was calculated from 2010 to 2018 by the Gwangju Meteorological Agency daily climate data (average temperature, average wind speed, average humidity, sunshine time) by using the FAO Penman-Monteith equation (Allen *et al.*, 1998).

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)} \quad (\text{Eq.1})$$

Here, ET₀ is the potential evaporation amount (mm/day), R_n is the net solar radiation amount on the crop surface (MJ/m²/day), G is the ground heat flow (MJ/m²/day), and T is the average daily temperature of 2 m above the surface (°C), U₂ is the average wind velocity of 2 m above the surface (m/sec), e_s is the saturated water vapor pressure (kPa), Δ is the water vapor pressure curve slope (kPa/°C), γ is the humidity and humidity constant (kPa/°C), P is the atmospheric pressure (kPa) and λ are latent heat (MJ/kg).

1) Water vapor pressure curve (Δ)

$$\Delta = \frac{0.4098e_a}{(T + 237.3)^2}$$

$$e_a = 0.661 \exp\left(\frac{17.27T}{T + 237.3}\right)$$

Where, e_a is the water vapor pressure, T is temperature.

2) Humidity constant (γ)

$$\gamma = 0.00163 \frac{P}{\lambda}$$

$$\lambda = 2.501 - (2.361 \times 10^{-3})T$$

Where, P is atmospheric pressure (kPa), λ is latent heat (MJ/kg)

3) Ground heat flow (G)

$$G = C_s d_s \left(\frac{T_n - T_{n-1}}{\Delta t} \right)$$

Where, G is the amount of heat flow absorbed into the soil

T_n is n -day temperature ($^{\circ}\text{C}$)

T_{n-1} is $n-1$ day temperature, Δt is time (day)

C_s is heat capacity ($\text{MJ/m}^3/^{\circ}\text{C}$)

d_s is estimated soil depth (m)

Since the potential evaporation amount changes every day due to the presence of rain or irrigation, the potential evaporation amount is calculated from the daily climate data, and then it is summed up monthly.

2-3. Estimation of crop evaporation

The amount of crop evaporation is the sum of the amount of crop production and the amount of evaporation from the land. If the crop covers all of the soil, the amount of evaporation from the land can be neglected, but the amount of evaporation varies depending on the land cover area by growth stage, so, in this case, the crop factor (K_c) is used to simplify. Crop evaporation amount was calculated by multiplying the crop factor for each crop by multiplying the potential evaporation amount calculated by the above four climatic factors and this is equivalent to the minimum irrigation water demand required by the actual crop.

$$ET_c = E_t \times K_c \times A_m \quad (\text{Eq.2})$$

Where, ET_c is the amount of crop evaporation (mm), E_t is the amount of potential evaporation (mm), K_s is the crop coefficient, and a_m is the monthly

crop cultivation area (m^2).

The crop factor is a concept that includes the multiplication of crop evaporation and soil evaporation, and the difference in the amount of evaporation during the entire growth period of crops, such as early growth, elongation, mid-term, and late, is expressed as a ratio compared to the reference crop (crop factor 1.0).

Recently, in the FAO, dual crop factors that applied hydrological relations of soil were presented in addition to the existing crop factors. In this study, the crop factors suggested by the existing FAO were applied for convenience (Fig. 1).

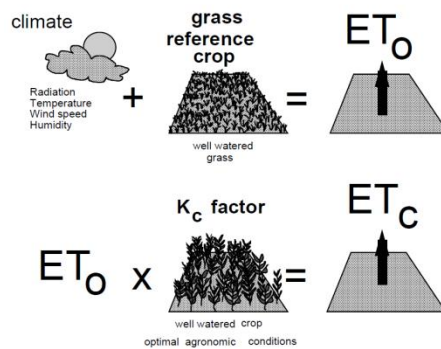


Fig.1. Reference (ET₀), crop evapotranspiration under standard (ET_c)

In addition, among the crop yield factors suggested by the Rural Development Administration, the value of the southern region where the study area is located was applied preferentially. If the crop factor is not applicable, the crop factor suggested by FAO in 1998 was applied or replaced by the same crop (Table 3).

Table 3. Monthly crop coefficient in study area

Monthly	Tomato	Yeolmu	Pumpkin	Sweet pepper	Water melon	Eggplant	Cucumber	Allium	Perilla	Strawberry	Etc
Jan.	0.90	1.20	0.50	0.82	-	0.90	0.75	1.28	0.35	0.40	0.70
Feb.	0.90	1.11	1.00	-	-	0.90	-	1.28	1.10	0.85	1.05
Mar.	0.90	0.58	0.80	-	-	0.90	-	0.64	0.25	0.75	0.95
Apr.	0.90	1.20	0.50	-	0.50	0.60	0.60	1.08	0.35	0.40	0.70
May	0.50	1.11	1.00	0.53	0.80	0.60	0.60	1.28	1.10	0.85	1.05
Jun.	0.80	0.58	0.80	0.96	0.98	1.05	1.00	1.28	0.25	0.75	0.95
Jul.	1.20	1.20	0.50	1.06	0.88	1.05	1.00	1.28	0.35	-	0.70



Monthly	Tomato	Yeolmu	Pumpkin	Sweet pepper	Water melon	Eggplant	Cucumber	Allium	Perilla	Straw-berry	Etc
Aug.	0.90	1.11	1.00	1.06	-	1.05	0.75	1.28	1.10	-	1.05
Sep.	0.90	0.58	0.80	0.82	-	0.90	0.60	1.28	0.25	0.40	0.95
Oct.	0.90	1.20	0.50	0.53	-	0.90	0.60	1.28	0.35	0.85	0.70
Nov.	0.90	1.11	1.00	0.96	-	0.90	1.00	1.28	1.10	0.75	1.05
Dec.	0.90	0.58	0.80	1.06	-	0.90	1.00	1.28	0.25	-	0.95

* Except water dropwort area

In the case of paddy irrigation water, the required amount of rice was calculated by using the HOMWRS (Repair Facility Simulation System) used by the Korea Rural Community Corporation (Table 4).

Table 4. Crop coefficient of the rice planting

Division	Apr.		May			Jun.			Jul.			Aug.			Sep.
	mid	end	Ini.	mid	end	Ini.	mid	end	Ini.	mid	end	Ini.	mid	end	Ini.
Planting	0.56	0.56	0.56	0.56	0.56	0.75	0.95	1.06	1.09	1.17	1.39	1.53	1.58	1.47	1.42
Direct sowing	0.56	0.56	0.56	0.56	0.56	0.75	0.95	1.06	1.09	1.17	1.39	1.53	1.58	1.47	1.42

* **Source:** Korea Rural Community, Hydrological Operation Model for Water Resource System (2019)

Finally, the amount of irrigation water required by the crop during the growth period was calculated by multiplying the monthly crop evaporation amount to the monthly cultivation area.

However, it is difficult to calculate the amount of groundwater used as a crop factor by repeating the operation of filling and subtracting water and running water in order to prevent temperature maintenance and dobok (bending) during cultivation. Therefore, in the case of dropwort with a large amount of groundwater, irrigation water demand was separately calculated monthly through field surveys on cultivation area, cultivation period, and cultivation methods and interviews with local residents. To briefly explain how to grow dropwort, in general, there are spring cultivation, summer cultivation, and fall cultivation. In this study area, the market price is high for evaluating irrigation water demand.

Young seedlings are cultivated from late March to early April to the end of August, and settled in early September, and can be harvested from 45 days to March the following year. In the case of young seedlings (hereinafter referred to as seedlings), seedlings should be cultivated at 1/4 of the cultivation area,

and groundwater should be continuously supplied to a height of 5-7 cm to prevent spoilage of the seedlings and maintain stable temperature due to the lack of circulation in the summer. In addition, during the official planting in early September to early October, the water level is watered as low as 2 cm for 5 to 6 days so that the roots can be planted. After filling the water to the height of 1/3 of the crop size (45-70 cm), water is continuously supplied. From November, to prevent the frost damage, the groundwater flows at night to supply water without freezing, and the temperature rises with sunlight during the day, so you must repeat the stoppage. At this time, when filling with water, it is necessary to fill it with a small amount from 1/3 of the crop size to the tip of the leaf to withstand the cold winter. Therefore, the actual amount of groundwater used in winter is much higher than in summer, so the annual groundwater usage pattern is referred to as the seasonal pattern of groundwater use (Table 5).

Table 5. Cultivation term of water dropwort

Cultivation method	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Fall												
Spring												
Summer												

— Croe cultivation period ■ Harvest ● Seedlings ○ Planting

* **Source:** Rural Development Administration (2019)

3. Research Results

3-1. Crop cultivation area

As a result of investigating the area of each land use type extracted from the land cover map by cultivation crops by plant farming lot provided by the Ministry of Agriculture and Forestry, cultivation area, and field surveys and interviews with residents, crop cultivation in the study area was carried out by using rice (371 ha), which is a field crop excluding dropwort, tomato, pumpkin, radish, pepper, eggplant, cucumber, Allium etc.

In particular, among the 134ha of facility cultivation complexes, 34.8ha (26%) were the most common dropwort that were easier to cultivate than other crops if only abundant groundwater was secured. 7%), and 4.8 ha (4%) of zucchini in order, accounting for more than 60% of the total. Other plant-growing crops such as eggplant, cucumber, and leek are grown in about 1 to 2% (Table 6, Fig. 2).

Table 6. Monthly crop cultivation area in study area (Unit: ha)

Division	Water dropwort	Tomato	Yeolmu	Pumpkin	Sweet pepper	Water melon	Eggplant	Cucumber	Allium	Perilla	Strawberry	Etc
Jan.	49.30	10.29	-	4.76	18.40	-	4.41	-	2.07	-	44.41	44.41
Feb.	49.30	23.72	-	4.76	18.40	-	3.72	-	1.80	-	31.95	31.95
Mar.	49.17	29.36	-	8.40	10.37	-	0.58	3.83	0.88	-	31.06	31.06
Apr.	37.11	35.92	-	5.25	8.40	9.24	-	4.98	1.16	0.59	31.00	31.00
May	17.09	35.92	24.92	5.25	1.86	9.24	4.10	4.98	1.35	1.65	27.28	27.28
Jun.	17.09	35.92	30.49	5.03	1.86	9.24	4.10	4.98	1.35	1.65	22.53	22.53
Jul.	17.09	35.92	33.85	5.03	1.86	8.21	4.10	4.46	1.90	1.65	19.56	19.56
Aug.	17.09	15.05	13.81	5.03	1.86	-	5.39	0.86	1.90	1.16	71.49	71.49
Sep.	16.55	9.88	8.24	0.83	3.49	-	8.83	1.44	2.07	-	82.31	82.31
Oct.	49.30	10.29	4.88	3.33	18.40	-	5.30	1.14	2.07	-	38.93	38.93
Nov.	49.30	10.29	-	4.54	18.40	-	5.30	1.14	2.07	-	42.60	42.60
Dec.	49.30	10.29	-	4.76	18.40	-	5.30	1.14	2.07	-	42.38	42.38
Ave.	34.81	21.90	9.68	4.75	10.14	2.99	4.26	2.41	1.72	0.56	40.46	40.46

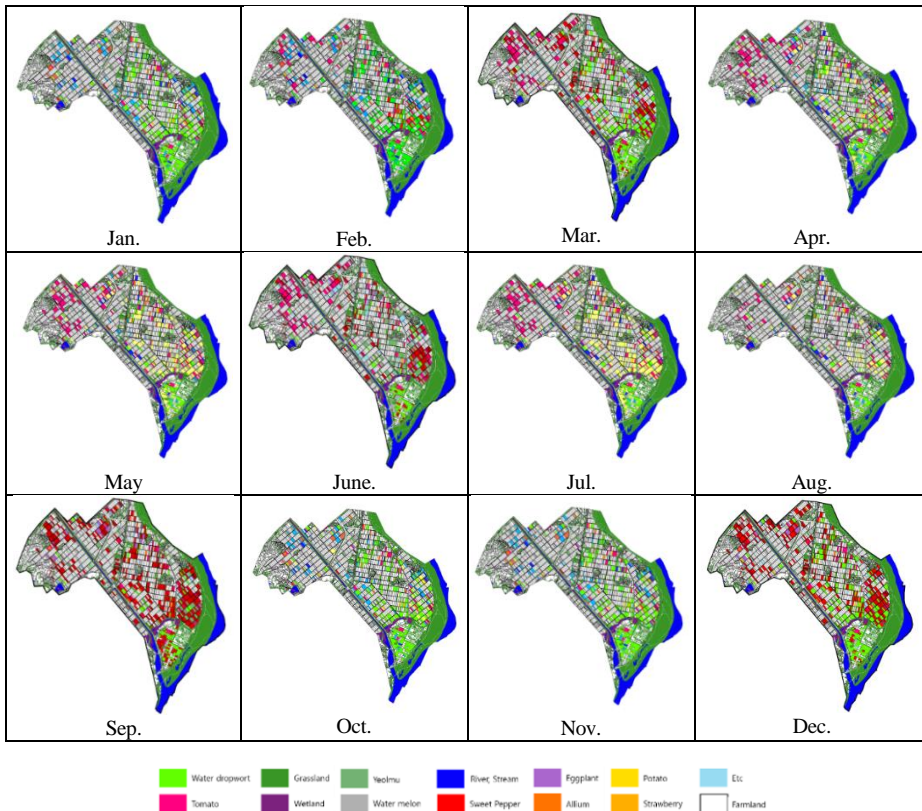


Fig.2. Monthly distribution of crop cultivation in study area



3-2. Potential evaporation amount.

Since the potential evaporation amount can vary greatly depending on climate change, the daily evaporation amount was calculated by using the FAO Penman-Monteith formula from the Gwangju Meteorological Agency's 2010-2018 weather data (Table 7).

Looking at the monthly average potential evaporation from 2010 to 2018, there is no significant difference by year, and it is similar to the period of spring drought that is experienced in Korea every year (Fig. 3).

Table 7. Monthly potential evapotranspiration in study area (unit: mm)

Division	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	ETo
2010	25.9	34.7	58.1	83.1	113.7	116.3	106.5	108.5	92.0	65.6	40.3	28.8	873.57
2011	24.7	34.6	0.0	89.9	113.3	114.7	113.7	97.3	97.2	65.8	38.4	27.8	817.49
2012	28.8	34.2	0.0	94.4	127.4	125.3	122.2	130.1	92.3	71.5	41.8	23.8	891.81
2013	26.1	37.3	0.0	90.2	123.9	120.9	133.3	148.4	99.4	73.0	37.3	26.7	916.50
2014	31.1	41.4	0.0	93.8	139.2	125.6	124.7	100.3	96.8	71.6	37.4	23.8	885.80
2015	27.1	36.2	0.0	86.1	132.0	115.0	113.0	112.6	94.7	67.5	29.0	23.8	837.08
2016	25.0	37.6	0.0	90.6	124.6	103.8	125.7	132.4	80.0	53.4	37.9	25.3	836.25
2017	27.2	36.4	0.0	100.6	126.6	125.9	106.4	117.4	89.4	62.3	37.5	24.5	854.07
2018	24.2	35.6	0.0	91.5	105.4	121.2	143.7	136.0	82.2	59.6	34.3	27.9	861.64

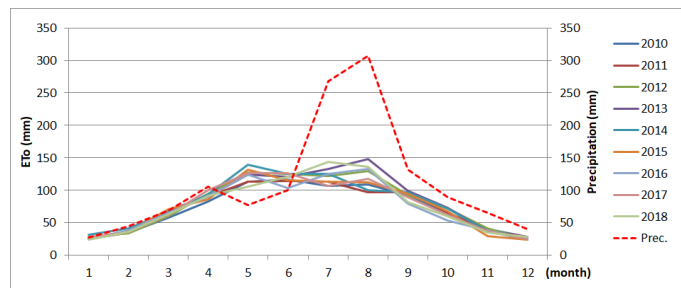


Fig. 3. The graph of Monthly Potential Evapotranspiration and Precipitation

3-3. Crop evaporation.

It can be said that the crop evaporation amount, calculated by multiplying the potential evaporation amount by the crop factor suggested by the Rural Development Administration and FAO, is the amount of irrigation water that is required as crops grow. Demand for irrigation water was calculated by dividing the field crops and field crops grown in the facility cultivation



complex. The demand for irrigation water in the study area was estimated to be 5,964 thousand m^3/year , among which 3,847 thousand m^3/year of rice, 1,245 thousand m^3/year of dropwort, and 873 thousand m^3/year of field crops. When converted to the same area of paddy fields or fields, it was analyzed that irrigation water was used 3.4 times more than field crops and 2.4 times more than rice (Table 8).

In addition, it was analyzed that the difference in the amount of irrigation water (2,118 thousand m^3/d) excluding rice, which mainly uses surface water, compared to the amount of ground water use (1,069 thousand m^3/d) calculated by using the existing groundwater capacity calculation method, was found to be approximately twice the difference.

Table 8. Crop evapotranspiration in study area (unit: m^3)

Division	Tomato	Yeolmu	Pumpkin	Sweet pepper	Water melon	Eggplant	Cucumber	Allium	Perilla	Straw- berry	Etc.	Total
Jan.	2,239	-	575	3,646	-	960	-	641	-	58	7,514	15,633
Feb.	7,610	-	1,697	-	-	1,193	-	819	-	182	11,958	23,459
Mar.	16,760	-	4,265	-	-	330	-	357	-	285	18,715	40,712
Apr.	29,592	-	2,403	-	4,227	-	2,736	1,148	189	220	19,860	60,375
May	18,934	29,164	5,536	1,041	7,789	2,597	3,152	1,820	1,915	538	30,195	102,681
Jun.	34,837	21,439	4,878	2,168	10,972	5,225	6,040	2,093	500	-	25,942	114,094
Jul.	61,954	58,381	3,615	2,838	10,383	6,195	6,410	3,503	830	-	19,680	173,789
Aug.	18,423	20,844	6,840	2,686	-	7,696	873	3,314	1,742	-	102,075	164,493
Sep.	7,310	3,926	547	2,353	-	6,531	709	2,178	-	197	64,257	88,008
Oct.	5,517	3,487	993	5,807	-	2,843	406	1,578	-	304	16,230	37,165
Nov.	3,179	-	1,559	6,061	-	1,638	390	910	-	154	15,354	29,245
Dec.	2,580	-	1,061	5,432	-	1,330	317	738	-	-	11,218	22,676
Total	208,935	137,241	33,969	32,032	33,371	36,538	21,033	19,099	5,176	1,938	342,998	872,330

4. Conclusion

As a result of calculating the demand for irrigation water, the use of groundwater increased significantly as the cultivation period for each crop increased, and especially dropwort used groundwater much more than other crops. Therefore, the calculation of the amount of groundwater uses in the facility cultivation complex for cultivating the four season's crops is more accurate than the existing method. It will be helpful in establishing measures and maintaining water supply facilities. If research on crop factor estimation is



activated in the future, it will be possible to more accurately estimate the demand for irrigation water for all crops.

5. Acknowledgement

This study was supported by Korea Institute of Planning and Evaluation for Technology in Food, Agriculture and Forestry (IPET) through Agricultural Facilities and Disaster Management Technology Development Program, funded by Ministry of Agriculture, Food and Rural Affairs (MAFRA) (grant number 320052-3).



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