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Full Length Research Paper

Distribution of tractor available workdays over the southeastern Anatolia project (GAP) area

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Determination of available workdays of a tractor for field operations is very significant in design, development, and selection of efficient machinery systems for agricultural operations. Available workdays vary and generally based on average daily temperature and amount of precipitation. In this study, an excel program was developed to determine the available workdays of a tractor in field operations. Available workdays of a tractor over the Southeastern Anatolia Project (Turkish: *Güneydoğu Anadolu Projesi*, GAP) region, opened for irrigation in 1995, were calculated with this software by using the meteorological data of the region. Results indicated significant changes in available workdays from east-to-west and north-to-south. Considering the 15 days period, maximum number of work days corresponds only 33% of the total period in April.

Key words: Tractor, workable days, Southeastern Anatolia Project (GAP) area, spatial distribution.

INTRODUCTION

Agricultural operations should efficiently be performed on time and production plans should be carried out properly to increase the quality and quantity of agricultural production. Input optimization and efficient planning can provide the desired increase. Agricultural machinery should be operated with optimum capacity and be utilized efficiently for efficient and quality agricultural production on time. Meteorological factors have significant impacts on workable days over agricultural lands. Considerable loses are observed when the agricultural practices are not able to be performed on time. Therefore, occurrence probabilities of meteoro-logical factors affecting the workability over the land should be determined properly. The available workdays for field operations are an important component in the selection and analysis of machinery systems. The time available within the optimal period for the required operation must be known. It varies considerably from year to year as weather conditions vary. Selection of the optimal machinery set for long-term production on the farm depends upon accurate assess-ment of the days available for performing each field operation (Rotz and Harrigan, 2005). Soil moisture is strongly influenced by rainfall, and a changed climate is expected to include a major change to rainfall patterns (Cooper et al., 1997; Cooper and McGechan, 1996).

Weather conditions may place severe constraints on the time available for carrying out many types of field operations during the agricultural production period, so any change in climate associated with global warming is likely to have a major effect on management planning for such operations, and machines appropriate to carry them out. The concept of “available workdays” has been widely used for planning many types of field operations. Two distinct but similar concepts of soil workability and traffic ability have been used to describe weather conditions suitable for a wheeled machine such as a tractor to work in a field (Cooper et al., 1997). Because of weather uncertainty, setting the levels of time resources in each period is a difficult problem. For example, during planting, the amount of time that a field will be sufficiently dry to operate a tractor is unknown during the planting and, hence, random, due to the randomness of rainfall patterns (Donaldson, 1968). In order to predict the amount of work that can be accomplished, the time available within the optimal period for the required operation must be known which varies considerably from year to year as weather conditions change. Selection of

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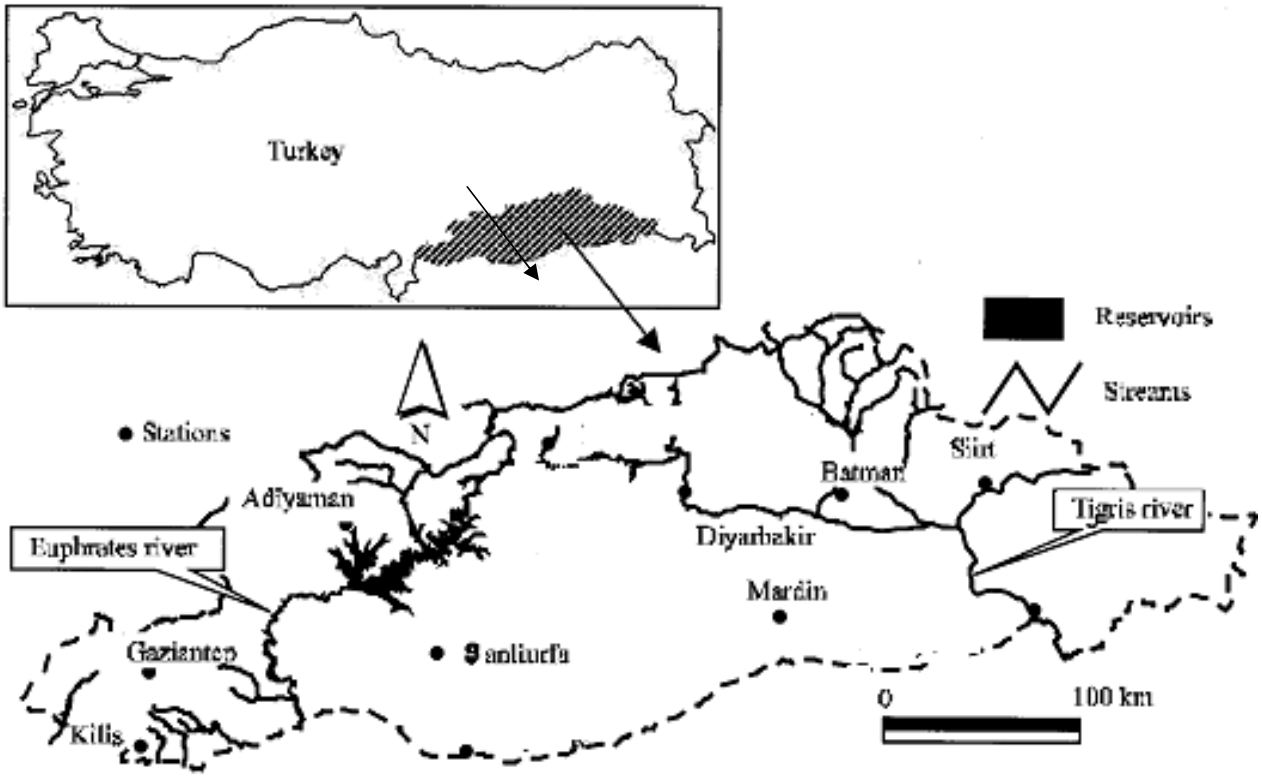


Figure 1. Geographical location of the study areas in Turkey (Tonkaz et al., 2007).

the optimal machinery set for long-term production on the farm depends upon accurate assessment of the days available for performing each field operation (Rotz and Harrigan, 2005).

GAP is a multi-purpose integrated regional development project composed of large dams and hydroelectric power plants to be constructed over Euphrates and Tigris Rivers, irrigation facilities, every kind of infrastructure, transportation, industry, education, health and other facility and services (Isık and Altun, 1998). This project covers about 74000 km^2 land area starting from Provinces of Adıyaman and Gaziantep located at north through the lower sections of Euphrates and Tigris rivers and within the provinces of Şanlıurfa, Mardin, Diyarbakır, Şırnak, Batman ve Siirt at east (almost 1/10 of the entire country). It has 13 sub-projects, 7 of which are over Euphretus and 6 over Tigris River. There are 22 dams and 19 hydroelectric power plants in entire project. Following the full operation of the project, about 1.65 million hectares land area will be irrigated (Anonymous, 1980). There are 22 dams and 19 hydroelectric power plants in entire project. Initially, Şanlıurfa-Harran Plain within Lower Euphretus Project has opened for irrigation. About 30000 ha of the plain opened for irrigation in 1995 and 142 000 ha entire plain is under irrigation by the year until 2005. Capacity and amount of machinary utilization in GAP region has increased with increasing irrigated land area. While the number of tractors in the region was 33101 in 1999, this number reached 50409 with a 52% increase.

Work days of tractor over agricultural lands has also increased with increasing irrigated agriculture. Cropping patterns and cultivated areas forced the effective utilization of tractors and other agricultural machinary during especially the soil tillage and sowing periods to complete the agricultural operations on time within limited production periods. Therefore, tractor working days for the production seasons of the region should properly be determined. Determination of such days will let the agricultural enterprises to plan and optimize the machinary type, capacity and utilization. The objective of this study is to determine the workable days of tractors over the GAP area during the production periods to provide support for producers and enterprises in selecting required machinery type and amount. Long-term daily rainfall, average temperature and snowfall data were used to determine the workable days. A 15 day workable days of a tractor were determined for plant production period of the research area, especially for the limited work periods during soil tillage and sowing periods. Variation in workable days and work periods were calculated for these working periods.

MATERIALS AND METHODS

This research was carried out in GAP area using meteorological parameters of 8 provinces, named, Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt and Şanlıurfa (Figure 1). Long-term climate data taken from provincial meteorological stations (average daily temperature, daily total rainfall and snowfall) were used. Climate data to determine the workable days of tractor were for 32 years. Terrestrial climate with hot-dry summers and warm-precipitated winters is dominant over the research provinces. Precipitations mostly occur during winter and spring months. Average temperature, rainfall and snowfall were taken as the constraining factors to determine the available workdays of tractors. For this purpose, long-term (32 year) climate data were gathered and an excel software was developed to solve the constraint equations involving climate data. Constraint equations for meteorological data to determine the workable hours of a tractor were provided as (Bolukoglu, 1982; Saglam, 2003; Vatandas, 1987):

1. Rainfall at the last day <= 2,5 mm,
2. Rainfall of previous day <= 5,1 mm,
3. Rainfall of two days before <= 7,6 mm,
4. Total rainfall of previous week <=12,7 mm
5. Average daily temperature >= 4℃
6. Snowfall = 0 mm

Meteorological data of the research area between the years 1975 to 2006 to calculate the workable days were taken from General Directorate of State Meteorological Works. Frequency analysis was performed to determine the number of workable days for certain periods at certain probability levels. Some pre-tests were performed before the frequency analysis of workable days and data characteristics were determined.

Descriptive statistics

Some descriptive statistics should be determined before the probability analysis of series. These statistics providing significant information about the characteristics of series are average ($\overline{X}$), median, standard deviation (SD); coefficient of variation (CV), skewness (C_s) and kurtosis (C_k) coefficients.

Trend analysis

Flow data usually presents a distribution around long-term averages and increasing or decreasing trends due to some other factors. Especially the increase in greenhouse gas concentrations during the recent years and human activities cause increase or decrease trends in flow series. Possible trend component can be determined by parametric or non-parametric methods. In this research, successive Mann-Kendall test was used to determine the trend component of series.

Serial correlation coefficient analysis

Successively measured annual flow data does not usually exhibit significant serial correlation. However, recent global warning and human impacts may hinder the randomness of the data. Anderson test was used to determine the significance of serial correlation in workable days (Quimpo, 1967).

Determination of suitable probability distribution model

Random behavior of time series can be modeled with various probability distributions and reoccurrence of a value that can be determined and estimations and also be made for the future events. Extreme value, log-logistic, Pearson, inverse gauss, weibull, normal, and log-normal probability distributions are commonly used for available workday series. Suitability of a model for a data set is tested by Kolmogorov-Smirnov (KS) test at desired probability level (Tulucu, 1996).

Mapping

Inverse distance weighting method and arcview software were employed to spread out point-wise workable days over the project area (Isaaks and Srivistava, 1989; Tonkaz, 2002).

RESULTS AND DISCUSSION

Workable days during the months of March, April and May were determined by using daily values of 8 meteorological station located in GAP area between the years 1975 to 2006. Available workdays rearranged in totals in two groups for a month (1 to 15 and 15 to 30/31). Long-term characteristics of 15 days in total were determined and synthetically derived probable values were distributed over the project area and their spatial distribution was determined.

Descriptive statistics

Some descriptive statistics of total workable days for 15day periods are presented in Table 1. As expected, available workdays increased from east to west, north to south of the region and from spring to summer months. For instance, while the available workdays in Şanlıurfa located in south of the region were 10.3 days (for 0 to15 of May), the value in Siirt located in northeast section of the region was calculated as 6 days for the same period of the year. Workable days over the research area generally had positive skewness coefficients, averages relatively increased in some years due to better weather conditions. Actually, median values generally presents 50% less workable days. Higher coefficient of variation in some stations indicates larger fluctuations among the workable days of the years. That is why it can be said that while there was available time period for soil tillage and sowing in some years, significant losses were seen in tillage and sowing operations in other years, in other words machinery utilization in some years caused labor force losses for farmers.

Results of trend analysis

Before the probability analysis, long-term variation of available workdays was tested by Mann-Kendall trend analysis at 5% significance level (Table 2). Increasing and decreasing trends were observed at some stations and periods. However, these trends were not found to be significant since they have not passed the upper and lower confidence limits of ± 1.98 at 5% significance level. Besides, positive Z-values observed over the entire

Table 1. Some descriptive statistics for available workdays.

Station	Terms	Average	Median	Max	Min	S.D	CV	C_s	C_k
Adıyaman	March 0 to 15	6.0	5	15	0	4.51	75.13	0.50	-0.84
	March 15 to31	6.2	4.5	16	0	5.24	84.67	0.77	-0.73
	April 0 to 15	7.2	7	15	1	4.53	63.06	0.22	-1.19
	April 15 to 30	7.7	8.5	14	0	5.19	67.22	-0.27	-1.57
	May 0 to15	8.9	8	15	0	4.54	51.18	-0.16	-1.19
	May15 to 31	11.5	12.5	16	0	3.94	34.38	-0.83	0.59
Batman	March 0 to 15	5.8	5	15	0	4.36	74.67	0.56	-0.47
	March 15 to 31	5.2	3	16	0	5.19	99.36	0.98	-0.36
	April 0 to 15	6.7	5.5	15	0	4.48	66.69	0.47	-1.02
	April 15 to 30	6.9	5.5	15	0	4.99	72.56	0.28	-1.42
	May 0 to 15	7.1	6.5	15	0	4.90	69.09	0.10	-1.40
	May15 to 31	11.5	14	16	1	5.24	45.66	-0.77	-0.91
Diyarbakır	March 0 to 15	6.1	5	14	0	4.61	75.99	0.52	-1.14
	March 15 to 31	5.9	4.5	16	0	4.82	81.64	0.73	-0.71
	April 0 to 15	7.2	7	15	0	4.43	61.42	0.17	-0.96
	April 15 to 30	7.1	7	15	0	4.90	68.73	0.15	-1.29
	May 0 to 15	8.0	8.5	15	0	4.85	60.66	-0.13	-1.19
	May15 to 31	11.3	14	16	0	5.06	44.82	-0.82	-0.51
Gaziantep	March 0 to 15	6.1	5	15	0	4.06	66.61	0.55	-0.36
	March 15 to 31	6.7	5.5	16	0	4.95	73.72	0.44	-0.77
	April 0 to 15	8.0	7.5	15	1	4.34	54.09	0.30	-1.26
	April 15 to 30	8.3	9	15	0	5.09	61.01	-0.23	-1.41
	May 0 to 15	10.0	10.5	15	1	3.92	39.19	-0.31	-1.03
	May15 to 31	11.9	15	16	1	4.74	39.69	-0.91	-0.45
Kilis	March 0-15	8.2	8.5	15	0	4.43	54.13	-0.37	-0.81
	March 15 to 31	6.6	5.5	16	0	4.83	73.28	0.71	-0.72
	April 0 to 15	8.3	8.5	15	0	4.83	58.58	-0.06	-1.40
	April 15 to 30	9.8	11	15	0	4.68	47.97	-0.53	-0.85
	May 0 to 15	10.9	13	15	2	4.47	41.11	-0.73	-1.05
	May15 to 31	12.9	14.5	16	2	3.80	29.41	-1.50	1.81
Mardin	March 0 to 15	5.2	4.5	15	0	4.06	78.68	0.89	0.26
	March 15 to 31	5.0	3	16	0	4.78	96.25	0.93	-0.30
	April 0 to 15	6.7	6	15	0	4.48	67.36	0.48	-0.98
	April 15 to 30	7.7	7.5	15	0	4.73	61.50	-0.10	-1.43
	May 0 to 15	8.8	9	15	0	4.72	53.36	-0.31	-0.97
	May15 to 31	12.2	14	16	3	4.27	34.95	-0.93	-0.54
Siirt	March 0 to 15	3.7	3	14	0	3.62	97.37	1.26	1.55
	March 15 to 31	3.6	2	15	0	4.51	124.51	1.27	0.36
	April 0 to 15	5.0	4	15	0	4.34	86.81	0.67	-0.60
	April 15 to 30	4.6	3	15	0	4.48	96.97	1.02	0.10
	May 0 to 15	6.0	5	15	0	4.56	75.96	0.52	-0.82
	May15 to 31	10.0	11.5	16	0	5.36	53.78	-0.53	-1.06
Şanlıurfa	March 0 to 15	7.8	7.5	15	0	4.69	59.99	-0.06	-1.21
	March 15 to 31	7.7	5	16	0	6.16	80.42	0.28	-1.68
	April 0 to 15	8.6	8	15	0	4.46	52.14	-0.01	-1.25
	April 15 to 30	9.8	11.5	15	0	4.73	48.53	-0.45	-1.21
	May 0 to 15	10.3	12	15	1	4.75	46.17	-0.53	-1.21
	May15 to 31	13.1	15	16	4	4.04	30.93	-1.25	0.16

Table 2. Results of Mann-Kendall trend analysis (Z-values).

Station	March 0 to 15	March 15 to 30	March 0 to 15	March 15 to 30	March 0 to 15	March 15 to 30
Adıyaman	0.358479	0.244753	-0.29296	1.601259	-0.83201	1.439531
Batman	0.721376	-0.703	-0.30958	0.374757	0.848666	0.066937
Diyarbakır	1.387797	0.114198	-0.66687	0.488835	-0.63512	1.317747
Gaziantep	1.19517	-0.70256	-0.40843	0.814076	0.589057	1.817003
Kilis	1.173514	0	-0.39159	1.1459	-0.39561	0.845317
Mardin	0.538457	0.508447	0.326875	1.367044	-0.61996	0.347499
Siirt	0.180514	-0.81261	-0.24541	-0.01635	0.538553	1.242235
Şanlıurfa	0.879435	1.029793	0.097776	-0.37582	0.181362	1.481329

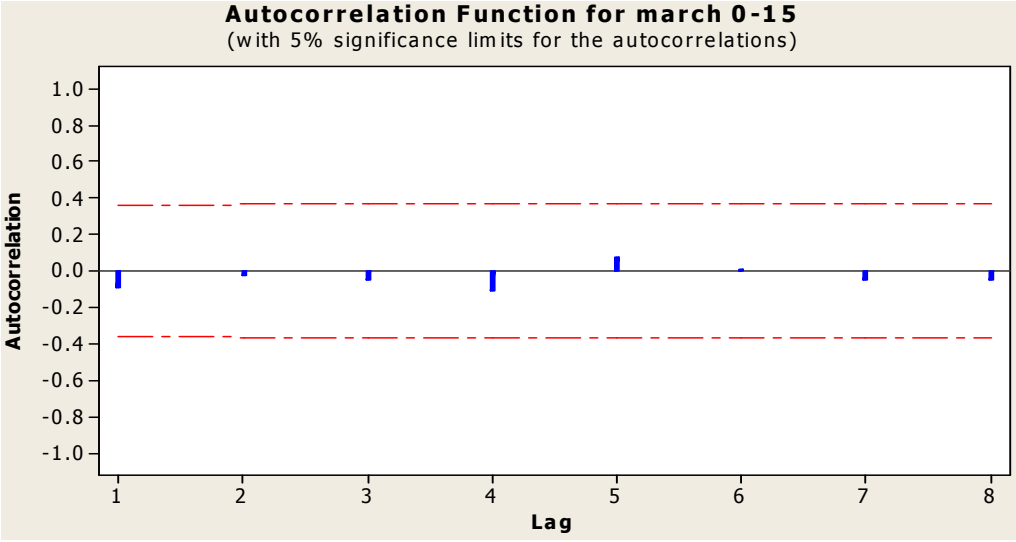


Figure 2. Autocorrelation coefficients and confidence intervals of available workdays for the period of March 0 to15.

region for the periods of March 0 to15 and May 15 to 30 point out the increase trend even the available workdays were not found to be significant. That presents the possible drought risk for the future years. Also, Z-value of 1.81 for Gaziantep station in May 15 to 31 periods should be considered as a significant issue for the optimization of agricultural machinery of the region.

Results of serial correlation analysis

Significance of serial correlation analysis of available workdays was analyzed by Anderson Test and serial correlation was not observed in any of the series. Therefore, it was concluded that workable days in successive years realized independently (Figure 2) from each other and these values were able to be modeled only with probability analysis.

Results of probability analysis

Available work days without trend component and serial correlation, proven with various tests, were modeled with probability analysis and workable days with 80% probability were synthetically derived. Extreme value, log-logistic, Pearson, inverse gauss, weibull, normal and log-normal probability distribution models were tested for available workdays. Suitability of the models for data was tested by KS test at 5% significance level. Several different probability distribution models from train distribution to extreme distribution were found to be suitable for 48 available workdays series. Among these 48 series, 15 best fitted to logistic, 7 to extreme value, 6 to log logistic and Inverse Gauss, 3 to Beta General and normal, 2 to lognormal and Weibull, and the remaining 4 to Raleigh, Triang, Chi-square and exponential probability distribution models (Table 3).

Probability distribution models, of which suitability to available workdays' series tested statistically, since 20% risk is reasonable for agricultural operations in literatures Tonkaz, 2007), available workdays for each station between the period of March 1 to May 31 in 15 days (intervals were derived separately for remaining 80%.

Table 3. Probability distribution models and KS values for available workdays.

Station		March 0 to 15	March 16 to 31	April 0 to 15	April 16 to 30	May 0 to 15	May 16 to 31
Adıyaman	Distribution	Triang	Loglojistik	Loglojistik	Betageneral	Weibull	Logistic
	KS	0.09974	0.09338	0.1049	0.1604	0.1584	0.1485
Batman	Distribution	Invgauss	Lognor2	Weibull	Betageneral	Extvalue	Logistic
	KS	0.1109	0.09584	0.09163	0.1411	0.1337	0.2192
Diyarbakır	Distribution	Invgauss	Invgauss	Logistic	Extvalue	Rayleigh	Logistic
	KS	0.1145	0.1135	0.07913	0.135	0.125	0.207
Gaziantep	Distribution	Extvalue	Loglogistic	Invgauss	Logistic	Extvalue	Logistic
	KS	0.1239	0.1036	0.1622	0.1301	0.1492	0.2434
Kilis	Distribution	Logistic	Invgauss	Loglogistic	Loglogistic	Logistic	Normal
	KS	0.08664	0.08895	0.1526	0.1433	0.2091	0.2094
Mardin	Distribution	Extvalue	Expon	Loglogistic	Betageneral	Logistic	Logistic
	KS	0.07901	0.1263	0.121	0.1032	0.1197	0.2124
Siirt	Distribution	Extvalue	Extvalue	Chisquare	Invgauss	Logistic	Logistic
	KS	0.1251	0.1973	0.1242	0.1347	0.1061	0.1461
Şanlıurfa	Distribution	Normal	Lognor2	Normal	Logistic	Logistic	Logistic
	KS	0.1268	0.1874	0.145	0.1643	0.2006	0.266

Table 4. Distribution of different available workday intervals within total research area (%).

Term	AWD	Total area percentage
March 0 to 15	0--3	81
	3--5	19
March 15 to 31	0--1	29
	1--3	71
April 0 to15	1--3	37
	3--5	63
April 15 to 30	0--2	42
	2--4	37
	4--7	21
May 0 to 15	2--4	42
	4--6	39
May 15 to 31	6--8	34
	8-10	59
	10--11	7

Spatial distribution of point-based derived data was determined with square of inverse distance method by using “Geographical Information Systems, (GIS)”. Spatial distributions determined by using GIS techniques for each period (Rounsevell et al., 2003) (that is, March 1 to15) were questioned and the percentage ratio of desired workable days (that is, 1 to 3 days) to total area was determined (Table 4).

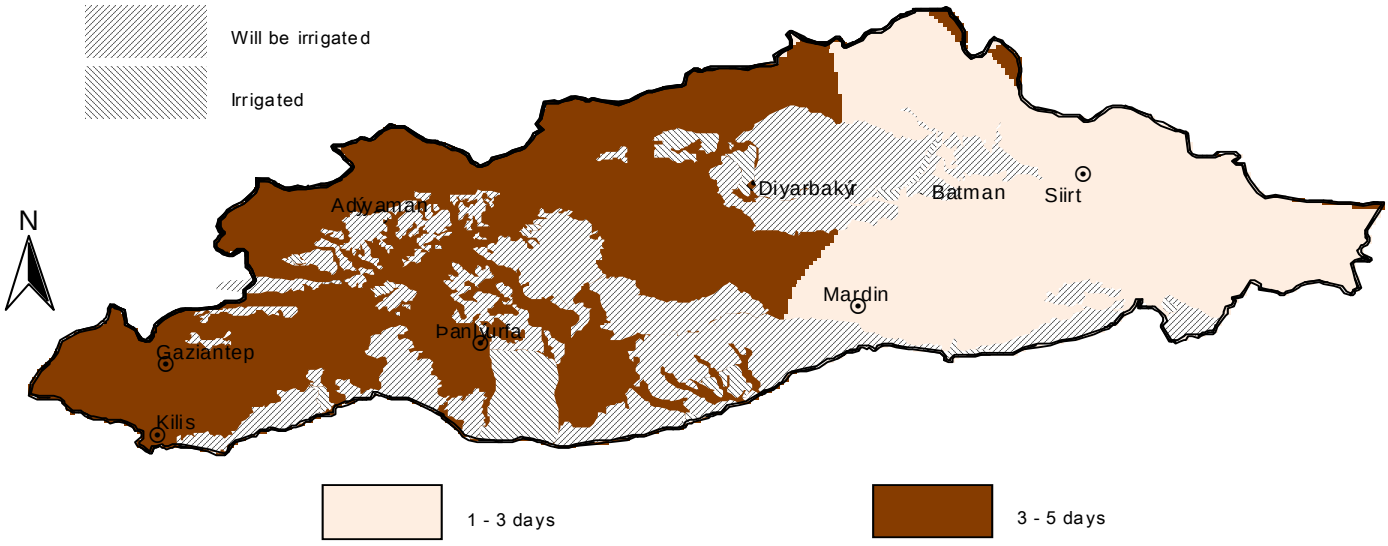


Figure 3. Spatial distribution of AWD for the period of April 0 to 15.

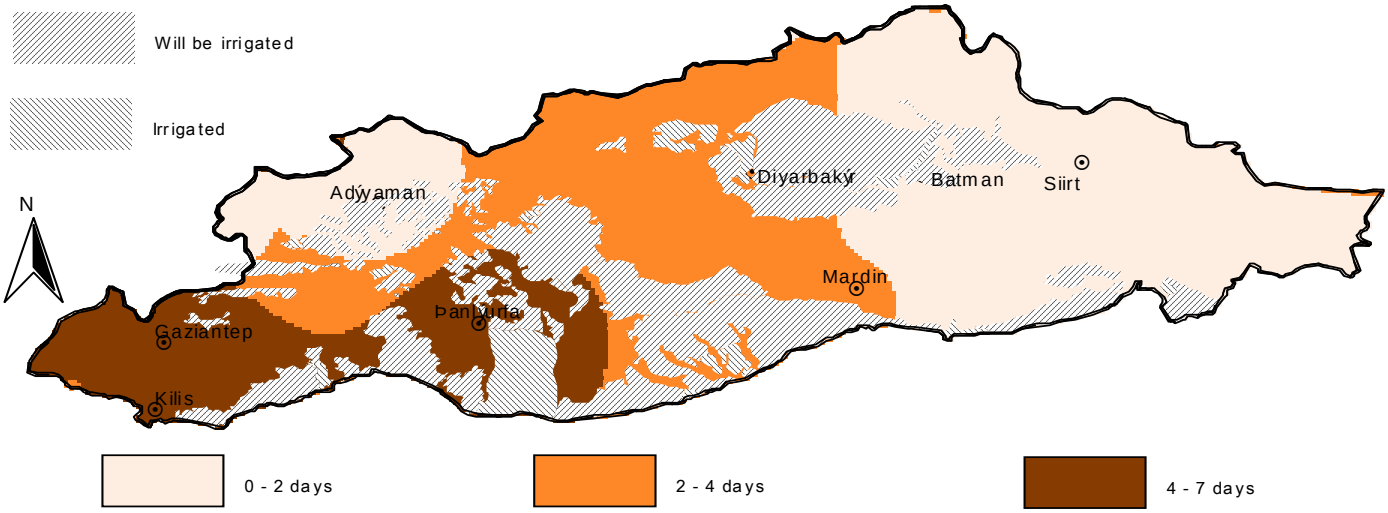


Figure 4. Spatial distribution of AWD for the period of April 16 to 30.

Results of this study indicated significant changes in available workdays over GAP region from east-to-west and north-to-south. For instance, while the available workdays during the first period of April, in which agricultural soil tillage is performed, was 1 to 3 days over the 37% of entire research area, the value was 3 to 5 days in the remaining 63% of the research area (Figure 3). Considering the 15 days period, maximum numbers of available workdays correspond only 33% of the total period in April. During the second half of April (Figure 4), three different available workday intervals stand out. Eastern parts of the region had 0 to 2 available workdays corresponding to 42%, northern parts had 2 to 4 days corresponding to 37% and southern parts had 4 to 7 days corresponding to 21%. Since the land opened to irrigation located in southern sections, lower available workdays may cause significant losses in agricultural machinery organization and work efficiencies. As expected, significant increases were observed in available workdays toward May (Figures 5 and 6) (Toro and Hansson, 2004). Beside this, workability over the land is possible only 66% of the entire area is more than half of

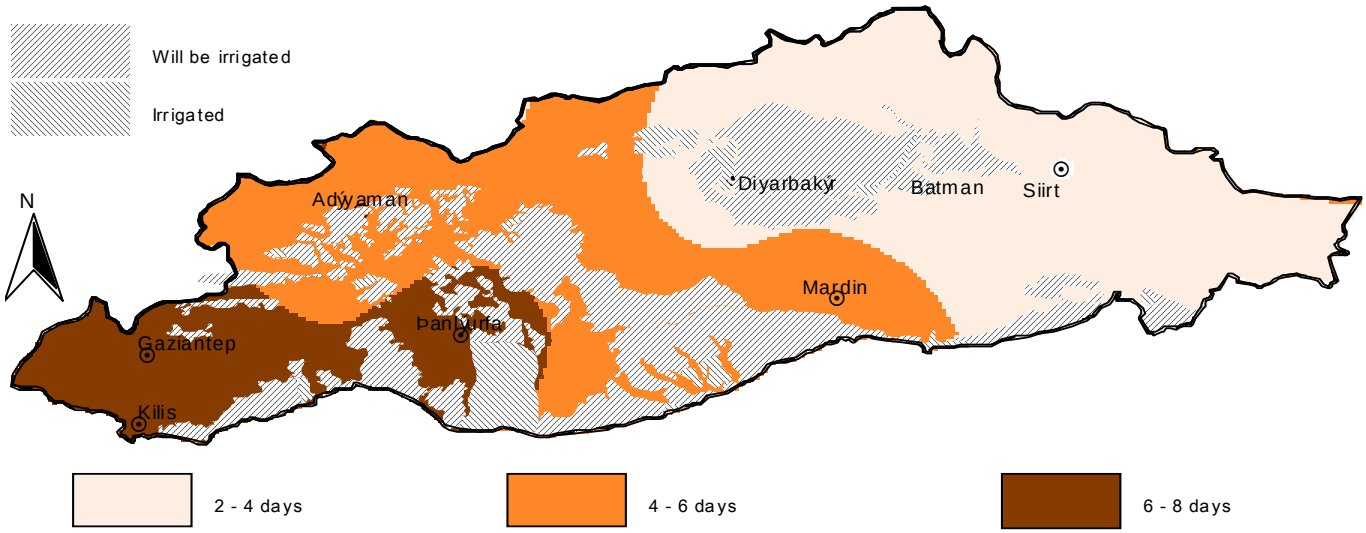


Figure 5. Spatial distribution of AWD for the period of May 0 to15.

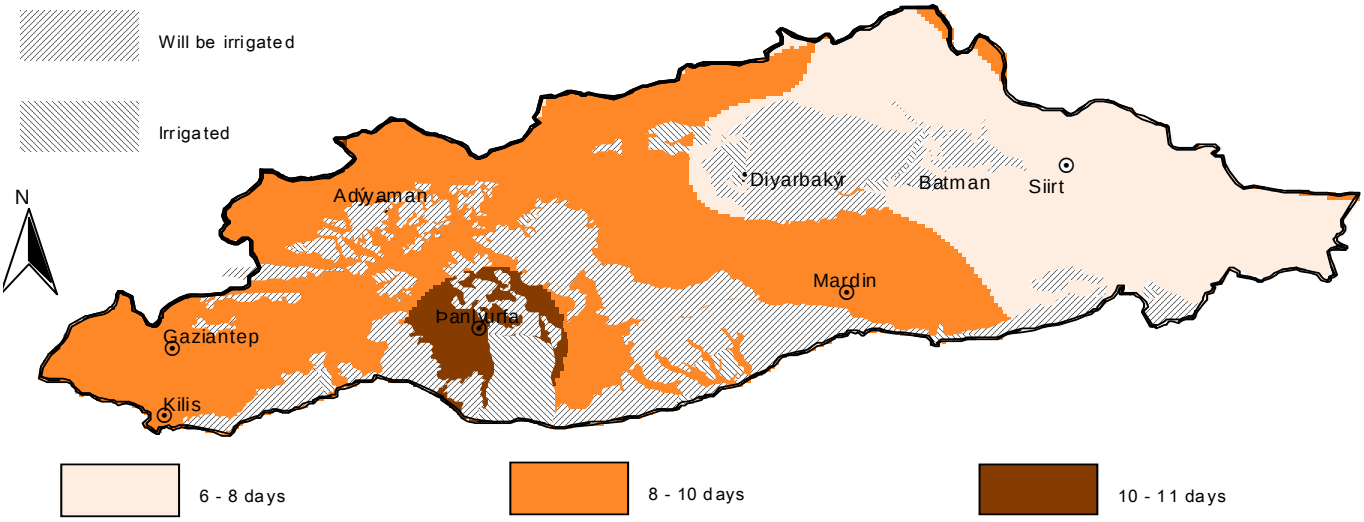


Figure 6. Spatial distribution of AWD for the period of May 16 to 31.

the 15 day period.

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