IMPACT OF CLIMATE CHANGE ON WATER REQUIREMENT OF AIDOGHMOUSH IRRIGATION NETWORK

IMPACT DES CHANGEMENTS CLIMATIQUES SUR LES BESOINS EN EAU DU RESEAU D'IRRIGATION AIDOGHMOUSH

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ABSTRACT

This research work is aimed to investigate agricultural water requirement in Aidoghmoush irrigation network at time period 2026-2039 under climate change scenario, vis-à-vis the uncertainty of seven Genaral Circulation Models (GCMs). The monthly temperature and precipitation data of AOGCM models including HadCM3, CCSR, CGCM2, CSIRO- MK2, ECHAM4, GFDL- R30, NCAR- DOE PCM were provided in the baseline period (1987-2000) and the target period (2026-2039) under the SRES emission scenario, namely A2. Then, these data were downscaled spatially and temporally to Aidoghmoush irrigation network. Results showed that the temperature increased (Between 0.1 to 3.10C) and precipitation varied (-60 to 139 percent) in 2026-2039 compared to baseline period. By weighting AOGCM models, the 14-year mean monthly probability distribution function (pdf) of temperature and precipitation of the network were produced. Using Monte-Carlo approach, 1000 samples from each pdf were taken and introduced to the calibrated water requirement model of the network. Finally the risk of increasing crop water demands in the network in the future compared to the baseline was evaluated. In this regard, assuming 25 and 50% probability, the crop water requirement of the network will increase by 11 and 9 per cent, respectively, compared to the baseline crop water requirement. The sensitivity of the crops reaction to climate change was not similar. Wheat and barley showed the least reaction among other crops in the network.

Key words: *Climate change, Water requirement, A2 scenario, Aidoghmoush Basin (Iran).*

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RESUME ET CONCLUSIONS

Il est de notoriété publique que l'activité humaine et de la population croissante ont modifié le climat et la biosphère terrestre. La tendance linéaire de ce réchauffement au cours des 50 dernières années (0,13 ° C [0,10 ° C à 0,16 ° C] par décennie) est presque deux fois plus que pendant les 100 dernières années. Le changement climatique anthropique a non seulement eu une incidence sur les variables climatiques, mais aussi les ressources en eau et l'agriculture. Par ailleurs, en Iran, l'agriculture est le principal consommateur d'eau, il est donc très efficace qu'il puisse être étudié et évalué en vue de réduire les effets négatifs du changement climatique. Pour évaluer l'ampleur probable des changements climatiques dans l'avenir et ses retombées sur les besoins en eau des cultures, les scientifiques s'appuient sur des simulations de MCG, entraînée par des scénarios plausibles des futures émissions provenant des activités humaines.

Le champ d'application principal de cette étude est d'évaluer l'impact des incertitudes du changement climatique sur le réseau d'irrigation Aidoghmoush. Dans un premier temps, de température et de scénarios de précipitations ont été générés à partir de 7 MCG dans le scénario d'émissions A2 en 2026-2039 et à échelle réduite à l'échelle du réseau. pdf Ces données pondérées et mensuelles de la température et les précipitations ont été produites pour l'avenir. Ensuite, ces fichiers PDF servi comme entrée à un modèle des besoins en eau pour générer des fichiers PDF des besoins en eau agricole pour le réseau étudié à l'avenir.

Afin d'évaluer l'impact du changement climatique, six grandes étapes ont été suivies:

- *Une relation conceptuelle entre la température et l'évapotranspiration de référence (ET0) a été déterminé (pour l'année 1987 - 2000).*
- *scénarios de changement climatique ont été construits pour le réseau en 2026-2039 en utilisant les résultats du 7 MCG dans le scénario A2.*
- *pdfs température discrets et les précipitations ont été construits en utilisant une méthode MCG-pondération.*
- *méthode de Monte-Carlo a été effectuée pour l'échantillon (1000 échantillons) de la pdfs.*
- *Les échantillons scénarios de changement climatique ont été introduits pour modéliser des besoins en eau afin de déterminer les changements des besoins en eau pour l'agriculture dans le réseau étudié.*
- *La moyenne condition des 14 ans de l'eau mensuel a été simulé dans 2026-2039 en vertu de A2, en comparant les résultats de référence.*

Pour évaluer les besoins en eau du réseau à l'avenir, discrète pdfs mensuelles de température et les précipitations dans les scénarios de changement 2026-2039 ont été construits sous A2 à l'aide des MCG pondérée. Ensuite, méthode de Monte Carlo a été réalisée pour simuler 1000 échantillons de chaque pdf mois. Ensuite, chaque ensemble de séries temporelles de température de 2026-2039 période introduits individuellement au modèle des besoins en eau et de 1000 échantillons de 14 - année ET0 mensuelle du réseau ont été produites. Utilisation appropriée des cultures coefficient précipitations et efficace, les besoins en eau nets ont été calculés. Enfin, la moyenne mensuelle de 1000 le nombre de 14 - les besoins en eau pour un an pour l'avenir ont été comparés à l'exigence d'eau moyen mensuel net pour

la période de référence. Les résultats ont montré qu'à l'avenir, le risque d'augmentation des besoins en eau, principalement dans la région. Comme, cette augmentation sera de 9% et 11% pour la probabilité de 50% et 25%, respectivement. Considérant les domaines actuelle de la production de certaines cultures et de leurs exigences augmenté, le volume de 2,5 à 6 MCM / an pour 2026-2039 période (pour la probabilité de 50% et 25%) sera nécessaire pour répondre à la demande. Il est constaté que les réponses des cultures sont différentes, où le blé et l'orge ont montré moins de réaction aux effets du changement climatique.

Il peut être conclu que pour fournir des conseils à base scientifique aux décideurs, il est essentiel que les études d'impact sur le changement climatique envisager un éventail de scénarios climatiques pondérée des différents MCG. La méthodologie et les résultats finaux de cette recherche peuvent jouer le rôle de base pour d'autres disciplines telles que les politiques d'adaptation qui sont grandement affectées par des changements dans la demande en eau agricole. Il convient de noter que, bien que l'application des incertitudes dues à la simulation de GCM dans les études d'impact peuvent améliorer les résultats définitifs, il faut utiliser la méthode qui s'applique d'autres incertitudes.

Mots clés: *Changement climatique, besoins en eau, scénario A2, bassin d'Aidoghmoush (Iran).*

(Traduction française telle que fournie par les auteurs)

1. INTRODUCTION

The atmospheric average temperature has been increasing due to emission of greenhouse gasses and the Intergovernmental Panel of Climate Change (IPCC) reported that the mean temperature of the atmosphere was increased by 0.76^{0}C in 20th century and will increase up to 6.4^{0}C by the end of current century (IPCC, 2007). This change is called "global warming" or "climate change" that has a lot of impacts on different systems such as water resources and agriculture. Since climate change can have some negative impacts in future, some study has been done to assess its impacts. On the other hand, since agriculture consumes maximum water among all the water users (over 90%), any change in water requirement of this section due to climate change will decrease the availability of water for other sectors. Massah Bavani and Morid (2005) evaluated the impact of climate change on main crops of ZayandehRud basin in Iran. HadCM3 data under A2 and B2 emission scenario were used in 2010-2039 and 2070-2099 periods. Results showed that crop yield of the basin will decreased in future. To tackle the negative changes in crop yield, changing crop pattern especially cultivating wheat instead of rice was recommended. Joyce *et al*. (2006) investigated the impact of climate change on inflow to the reservoirs, changes in the time of runoff, and drought situation of California basin. The adaptation strategies were also evaluated to cope with negative impacts on these variables. WEAP model (Raskin *et al., 2001*) was used to evaluate the effect of changing crop patterns and irrigation efficiency as adaptation strategies on water supply. The results showed that these strategies will reduce crop water requirements from 639 Acre-Ft in baseline period to 616 Acre-Ft in 2075-2099. Knox *et al*. (2009) investigated the impact of climate change on water requirement and yield of cane in Switzerland. They used HadCM3 data under A2 and B2 emission scenario in 1997-1980 and 2040-2069 period. For estimating water requirement CANEGRO model was used. Results showed that water requirement increased by 20 to 22%. In another research, the impact of climate change on yield of barley of China was investigated by Liu *et al* (2010). Temperature would increase 2 to 5^{0}C and precipitation varied -30 to 15% in future. On the other hand, yield will change -18.5 to 22.8% for 2^{0}C and -2.3 to 13.2% for 5^{0}C. same results were obtained by Payne *et al* (2004), Rosenweig *et al* (2004) and Xiong *et al*. (2009).

Although the previous researches about impact of climate change on water requirement attempted to manage uncertainty of AOGCM model in the study, the AOGCMs data were applied with the same likelihood of occurrence in the future. On the other hand in simulating the water requirements only the models with temperature as input data were applied in the study. So in this research we aim to investigate the impact of climate change on water requirement of Aidoghmoush plain, north east of Iran, in 2026-2039 period, considering uncertainty of AOGCMs by Monte-Carlo approach and also using water requirement model with temperature and precipitation as input data.

2. STUDY AREA AND DATA SETS

The 80 km long Aidoghmoush River is the largest river in the Aidoghmoush Basin. It originates in the north- west of Iran and flows eastward. The area of the irrigation network is about 13500 km^2 (Figure 1). Wheat, barley, soya, alfalfa, seed corn, forage maize, potato and walnut are the main staple crops in the basin. The monthly precipitation (from 10 stations), temperature (from 2 stations) are available for the baseline period 1987–2000. These data were obtained from the Meteorological Institute and Ministry of Energy of Iran.

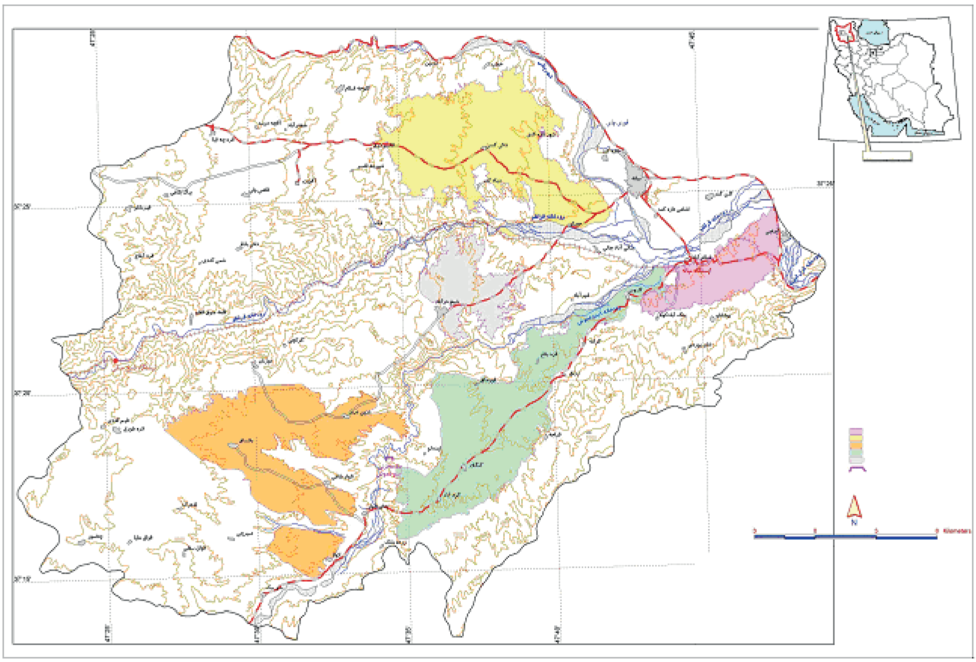


Fig. 1. Location of Aidoghmoush irrigation network in East Azerbaijan (réseau d'irrigation Situation Aidoghmoush en Azerbaïdjan de l'Est)

Seven GCM configurations are considered in this study; CCSR: Japanese Centre for Climate Research Studies model, CGCM2: Canadian Centre for Climate Modeling and Analysis GCM, CSIRO-Mk2: Australian Commonwealth Scientific and Industrial Research Organization, ECHAM4 – OPYC3: German Climate Research Centre, European Centre/Hamburg, GFDL-R30: US Geophysical Fluid Dynamics Laboratory, HadCM3: UK Hadley Centre for Climate Prediction and Research Coupled and NCAR-DOE–PCM: US National Centre for Atmospheric Research model, DOE version (Carter 2007). For each configuration four runs were considered, one for the control period 1987–2000 and remains for the periods 2026-2039, based on the SRES-scenario A2.

3. CONSTRUCTION OF CLIMATE SCENARIOS

To better estimate crop water requirements considering the direct relationship between temperature and potential evapotranspiration (ETc), different temperature and rainfall scenarios should be evaluated as a first step.

AOGCMs Scenarios. Atmospheric- Ocean General Circulation Models (AOGCMs) are the most comprehensive tools for estimating the response of climate to radiative forcing. The basis of these models consists of describing the physical process taking place in the climate system and the dynamics of climate variables as a function of different internal or external changes.

Emission Scenarios. In 1996, a new set of emission scenarios that called Special Report on Emission Scenario (SRES) was presented by IPCC. Each one sub-scenarios of SRES, belongs to one of A1, A2, B1 and B2 families. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other storylines.

In this research, Because of more production of CO_2 gas in A2 scenario, we used this scenario.

Construction of climate change scenarios. A simple downscaling approach, the ‘change fields’ procedure was applied to derive the monthly climate change scenarios for the basin. The climate change scenarios were obtained by computing the differences (or ratio) between the averages of the AOGCMs dataset for the future period (2026-2039) and the corresponding averages of the models simulated for the baseline period (here, 1987-2000). The changes for temperature are usually presented based on the differences (e.g. 2026- 2039 minus 1987-2000), while for precipitation change, ratios are commonly used (e.g. 2026-2039 divided by 1987-2000) (Carter 2007; Diaz-Nieto and Wilby and Harris 2006).

4. CALCULATION OF MAXIMUM WATER REQUIRMENT

For calculating crop evapotranspiration (ET), the crop coefficient approach was used (FAO Irrigation and Drainage Paper 24; Doorenbos and Pruitt, 1984). In this approach, ET_C, is calculated by multiplying the reference crop ET (ET_O), by a crop coefficient, K_C. Most of the effects of the various weather conditions are incorporated into the ET_O estimate. Therefore, as ET_O represents an index of climatic demand, K_C varies predominately with specific crop characteristics and only to a limited extent with climate. This enables the transfer of standard values for K_C between locations and between climates. Calculation of ET_O has been done by FAO Penman- Monteith equation (Doorenbos and Pruitt, 1984) for base period but, as producing all of the necessary inputs of this equation weren't possible for future period, the relationship between temperature and reference ET that has been earned from base period data was used in that time.

The crop coefficient, K_C, is the ratio of the crop ET_C to the reference ET_O, and it represents an integration of the effects of four primary characteristics (crop height, albedo (reflectance) of the crop- soil surface, canopy resistance and evaporation from soil) that distinguish the crop from reference grass. As the K_C for a given crop depends on the growing period, the crop coefficient curves for the initial, mid and late seasons were calculated for every crop.

5. UNCERTAINTY AND ASSESSMENT

Climate change assessment is dominated by uncertainty, affecting the choice of method and the confidence that can be attached to the results. We applied the uncertainties due to different simulations of GCMs in impact assessment studies.

Weighting GCMs. Single forecasts of the climate response to increasing greenhouse gas levels, are far more useful to policy makers when they are accompanied by some measure of the associated uncertainty [Schneider, 2001]. In ensemble forecasting, it is customary to take the arithmetic ensemble mean as a prediction quantity and in most cases this already provides a better skill than any of the ensemble members alone. The term “Multi-model ensemble” indicates a set of simulations from various climate models with different structures. The use of such ensembles allows assessing the structural uncertainty included in model output. The simplest way of presenting climate change scenarios from different GCMs is with no weighting estimates. On the other hand by this approach all models take account the same weights. However, this does not take any account of differences in GCM model performance for the present day. Ensemble weights are calculated by comparing model output for the present month with observed data. Accordingly we will evaluate the sensitivity of the expose unit to a multi-model probabilistic prediction by using the following equation:

$$R_i = \frac{\frac{1}{B_{x,i}}}{\sum_{i=1}^{N} \frac{1}{B_{x,i}}} \qquad (1)$$

where R_i is a measure of the model reliability in terms of the model bias in simulating present month temperature/precipitation and $B_{x,j}$ is the model bias that defined as the difference between simulated and observed monthly mean temperature/precipitation for the baseline period (here 1987-2000). It is obvious that the higher the bias, the lower the model reliability. On the other hand, models with more ability are assigned higher weights and hence given more emphasis. The results of this process are shown in Figure 2 and 3.

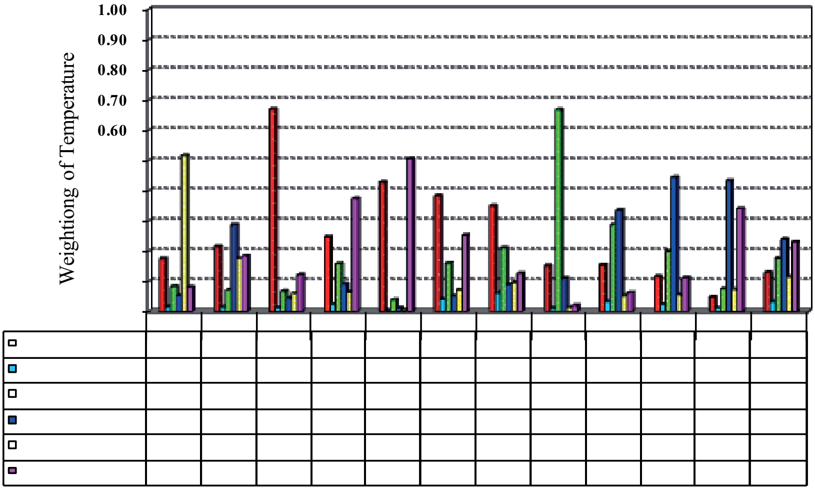


Fig. 2. Monthly weights of GCMs in simulating temperature for A2 scenario of Aidoghmoush basin

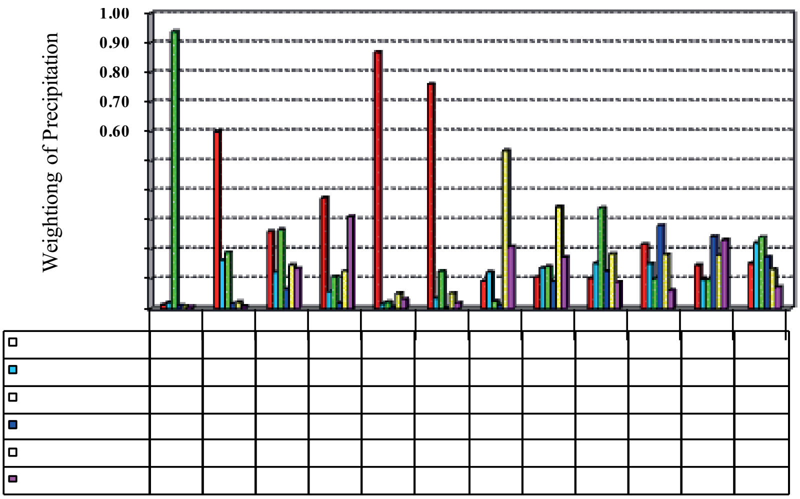


Fig. 3. Monthly weights of GCMs in simulating precipitation for A2 scenario of Aidoghmoush basin

Risk can be defined in several ways, but is broadly defined as a combination of the likelihood of an outcome or event. Many analyses of risk consider a simple product of probability and consequence and in that sense are used broadly in decision making for environmental and other issues (Manning et al., 2004). Haimes (2004) has defined risk as an amalgamation of two constructs: one, probability, is a mental, man- made construct that has no physical existence peruse; and the other is severity of adverse effects. Risk evaluation relates to the following triplet risk assessment questions posed by Kaplan and Garrick (1981): (i) What can go wrong?; (ii) What is the likelihood that it would go wrong?; (iii) What are the consequences?

6. RESULTS

Risk analysis of ET_o)nd (K_c). Calculation of ET_o has been done by FAO Penman- Monteith equation (Doorenbos and Pruitt, 1984) for base period but, as producing all of the necessary inputs of this equation weren't possible for future period, the relationship between temperature and reference evapotranspiration that has been earned from base period data was used in that time. In this regard, after necessary considerations, regression relationship with $R^2 = 0.93$ was accepted. Figure 4 and 5 shows the monthly average of reference evapotranspiration and temperature for the base and the future periods.

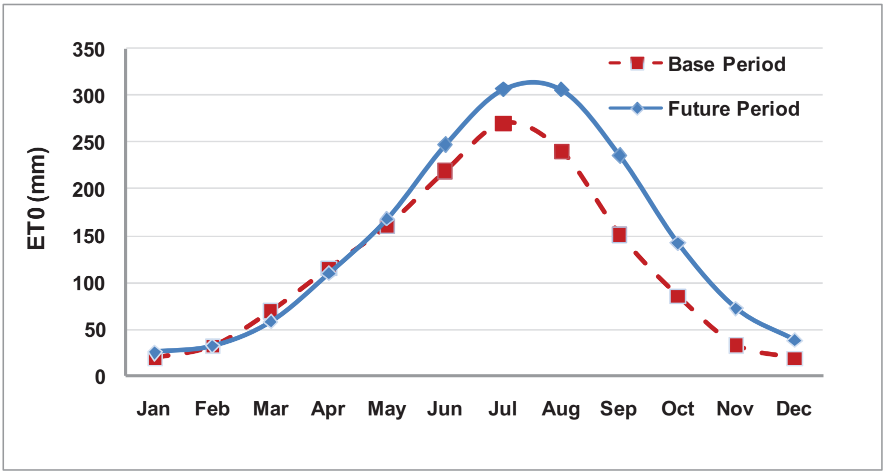


Fig. 4. Monthly average of reference evapotranspiration of the Aidoghmoush basin for base and future periods (Moyenne mensuelle de l'évapotranspiration de référence du bassin Aidoghmoush de base et des périodes futures)

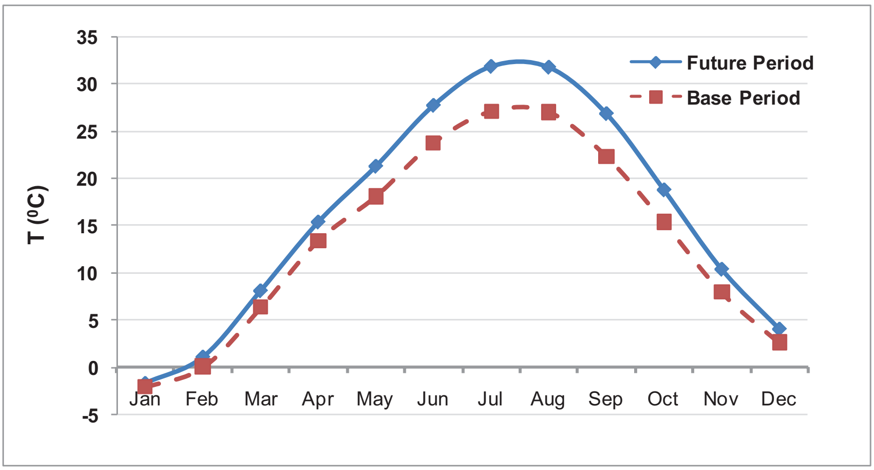


Fig. 5. Monthly average of temperature of the Aidoghmoush basin for base and future periods (Moyenne mensuelle de la température du bassin Aidoghmoush de base et des périodes futures)

Then, with Monte Carlo methods (repeated random sampling) were employed to stochastically generate probabilistic estimates of future temperature change and its impacts on reference evapotranspiration increase. By using SIMLAB software (Giglioli and Saltelli, 2003), long-term monthly average temperature change (ΔT) ($\Delta T = \overline{T}_{GCM,fut,i} - \overline{T}_{GCM,base,i}$) were randomly sampled and repeated 1000 times by distribution for 2026-2039 to get an adequate sampling density over the projected range of uncertainty. Then by using available equation ($T = T_{obs} + \Delta T$), simulations samples were used to calculate monthly temperature time series samples that were used as inputs of crop water requirement model to calculate monthly evaporation reference evapotranspiration changes in periods of 2026-2039. Also, (ΔP) were randomly sampled and repeated 1000 times by distribution for future period. Then by using available equations ($\Delta P_i = \overline{P}_{GCM,fut,i} / \overline{P}_{GCM,base,i}$) and ($P = P_{obs} + \Delta P$), 1000 time series of monthly water requirement for future period of the network were produced. Having calculated the cumulative probability distributions for ET_0, discrete probability (25% and 50%) of ET_0 was used to calculate K_C. For obtaining relative humidity, its regression relationship with ET_0 in base period was used. Also, for wind speed its amounts in base period were considered. The value of K_C for every crop used in this study and every month in future periods was calculated (Table 1).

Table 1. K_C values according the 50% cumulative probability in the period of 2026-2039 (KC valeurs en fonction de la probabilité cumulative de 50% dans la période de 2026-2039

Month/ Crop	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wheat	0.36	0.31	0.28	0.27	0.30	0.52	1.05	1.07	0.79			0.34
Barley	0.36	0.16	0.13	0.12	0.30	0.51	1.05	1.07	0.76			
Alfalfa	0.92							0.93	0.98	1.05	1.05	0.95
Soya								0.42	0.90	1.01	1.05	0.65
Feed Corn								0.52	0.64	0.92	1.10	1.02
Forage Maize	0.61							0.42	0.64	1.01	1.09	0.99
Potato	0.72							0.43	0.53	1.01	1.08	0.96
Walnut	0.63						0.30	0.45	0.63	0.76	0.92	0.81

Risk of change in water requirement. By using the results of ET_O and K_C, evapotranspiration of dominant crops (ET_C) of the basin was calculated for the risk 25% and 50% probabilities for the future periods as well as the base period. The yearly evapotranspiration of crops for the future period are presented in Table 2. According to these results, for the risk of 50%, the average increase of 1-12% is expected in evapotranspiration for all of crops except wheat, barley and walnut (10, 14 and 3% decrease, respectively) during the period 2026-2039. For the risk of 25%, this increase would be 4-13% except wheat and barley (2 and 6%, respectively).

Table 2. Yearly crop evapotranspiration in future period (mm) with the cumulative probability of 25%, 50% (l'évapotranspiration des cultures annuelles dans la période à venir (mm) avec la probabilité cumulative de 25%, 50%)

	ETc_{base} (mm)	ETc_{fut} (mm)		ETc_{fut}/ETc_{base} (mm)	
		25%	50%	25%	50%
Wheat	696.56	683.08	626.68	0.98	0.90
Barley	617.64	578.23	528.71	0.94	0.86
Alfalfa	1187.72	1333.46	1251.21	1.12	1.05
Soya	947.54	1021.17	960.73	1.08	1.01
Seed Corn	956.72	1052.68	992.44	1.10	1.04
Forage Maize	1018.11	1137.12	1137.12	1.12	1.12
Potato	989.14	1116.10	1051.41	1.13	1.06
Walnut	977.46	1011.85	950.14	1.04	0.97

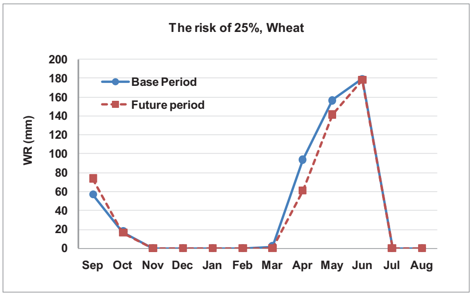
After determination of effective rainfall for the risk of 25% and 50% probabilities by using equations (2) and (3) and crop evapotranspiration (previous section), water requirement of crops of the basin (WR) was calculated ($WR = ET_C - P_{eff}$). The results of this process are shown in Figure 6. The yearly water requirements for the future period are presented in Table 3. According to these results, for the risk of 50%, the average increase of 3-9% is expected for different crops except wheat, barley and walnut (8, 12 and 1% decrease, respectively) during the period 2026-2039. For the risk of 25%, this increase would be 2-11% for future period except wheat and barley (7 and 12% decrease, respectively).

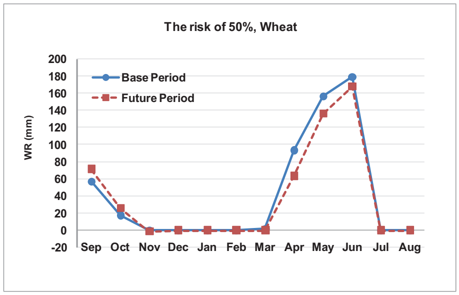
$$P_{eff} = P/125 \times (125 - 0.2P) \quad P \leq 250mm \qquad (2)$$

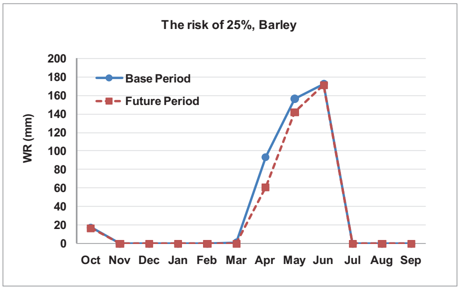
$$P_{eff} = 125 + 0.1 \times P \quad P > 250mm \qquad (3)$$

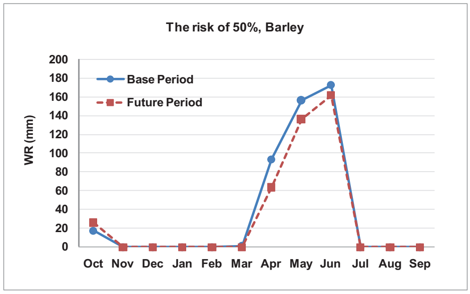
Where P_{eff} is effective rainfall average monthly and P is rainfall average monthly.

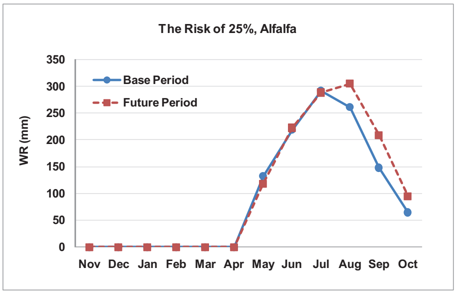
In some studies, such as the one by Steinemann and Cavalcanti (2006), an increase of 10% in demand has been introduced as a trigger for system stress. If this trigger were to be accepted here, for the probability of 50%, for potato there would be stress regarding water requirement increase in the period 2026-2039 in the system and so for the probability of 25 crops such as alfalfa, seed corn, forage maize and potato would face the risk of increase of 10% in demand (wheat and barley would face with decrease of water stress). Climate change causes an increase in water requirement of alfalfa and potato for 2026-2039 by about 1.32-2 MCM/year and 1.30-1.70 MCM/year based on the present irrigation area for the probability of 25% and 50%, respectively (Table 4). This will necessitate use of adaptation strategies.

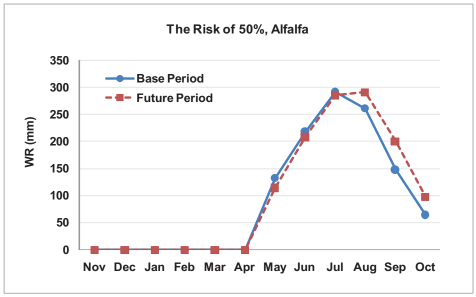

The risk of 25%, Wheat
WR (mm)
Base Period
Future period
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

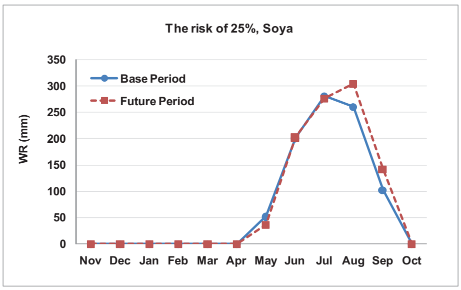

The risk of 50%, Wheat
WR (mm)
Base Period
Future Period
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug

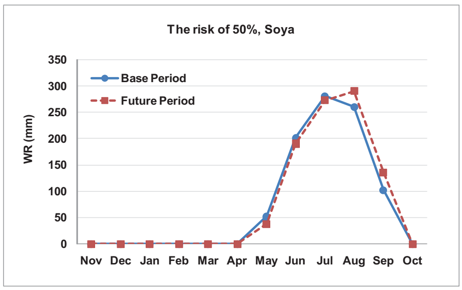

The risk of 25%, Barley
WR (mm)
Base Period
Future Period
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep

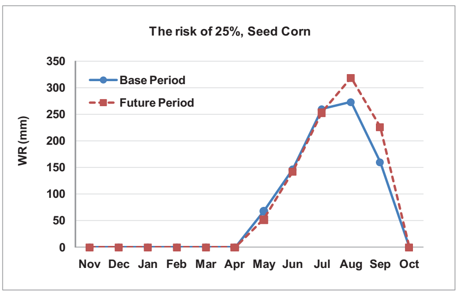

The risk of 50%, Barley
WR (mm)
Base Period
Future Period
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep

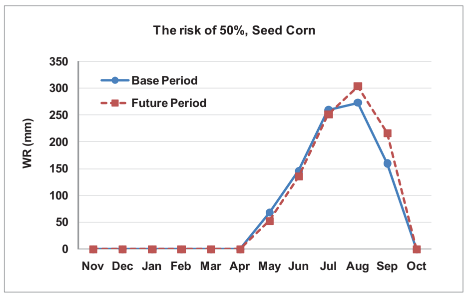

The Risk of 25%, Alfalfa
WR (mm)
Base Period
Future Period
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


The Risk of 50%, Alfalfa
WR (mm)
Base Period
Future Period
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


The risk of 25%, Soya
WR (mm)
Base Period
Future Period
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


The risk of 50%, Soya
WR (mm)
Base Period
Future Period
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


The risk of 25%, Seed Corn
WR (mm)
Base Period
Future Period
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


The risk of 50%, Seed Corn
WR (mm)
Base Period
Future Period
Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct

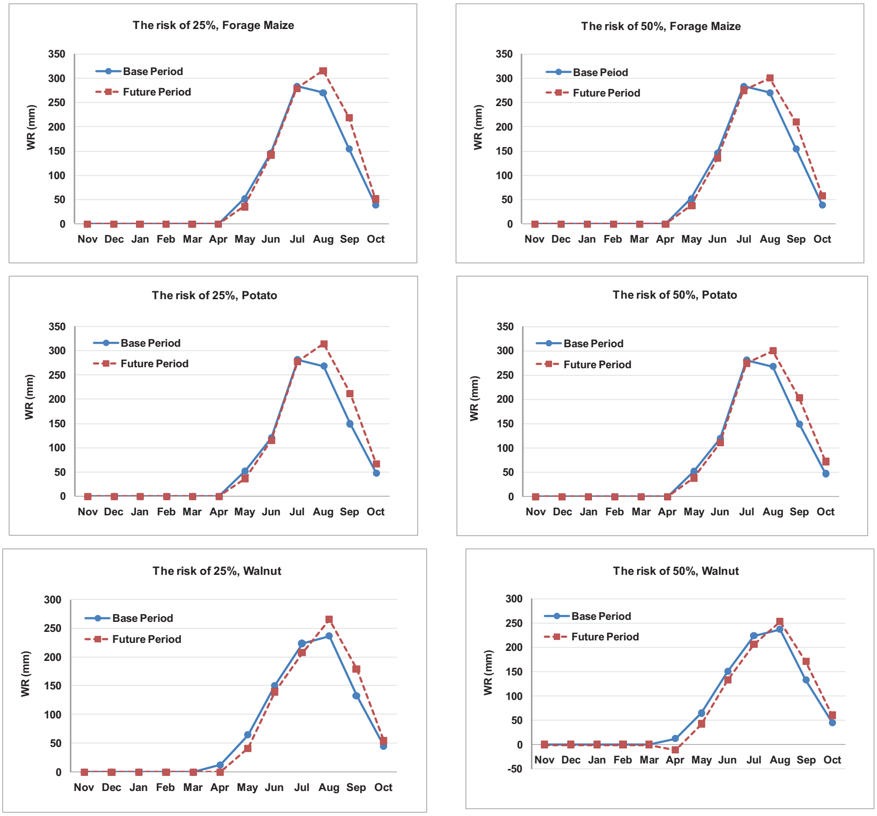


Fig. 6. Water requirement in future in comparison with baseline period with the cumulative probability of 25% and 50% (Besoins en eau pour la période à venir en comparaison avec la période de référence à la probabilité cumulative de 25% et 50%)

Table 3. Yearly water requirement in future period with the cumulative probability of 25%, 50% (besoins en eau annuelle dans la période à venir avec la probabilité cumulative de 25%, 50%)

	WR_{base} (mm)	WR_{fut} (mm)		WR_{fut}/WR_{base} (mm)	
		25%	50%	25%	50%
Wheat	505.53	471.30	464.52	0.93	0.92
Barley	441.50	390.32	387.45	0.88	0.88
Alfalfa	1115.99	1239.65	1197.28	1.11	1.07
Soya	896.86	960.82	926.70	1.07	1.03
Feed Corn	906.04	992.33	958.41	1.10	1.06
Forage Maize	946.38	1043.30	1016.75	1.10	1.07
Potato	917.41	1022.29	997.47	1.11	1.09
Walnut	866.03	886.05	855.80	1.02	0.99

Table 4. Water demand volume in future period for the risk of 25% and 50% (volume de la demande en eau en période future du risque de 25% et 50%)

	V_{base} (MCM)	V_{fut} (MCM)		ΔV_{fut} (MCM)	
		25%	50%	25%	50%
Wheat	8.19	7.63	7.53	-0.55	-0.66
Barley	4.77	4.22	4.18	-0.55	-0.58
Alfalfa	18.08	20.08	19.40	2.00	1.32
Soya	9.69	10.38	10.01	0.69	0.32
Feed Corn	6.12	6.70	6.47	0.58	0.35
Forage Maize	10.22	11.27	10.98	1.05	0.76
Potato	14.86	16.56	16.16	1.70	1.30
Walnut	40.92	41.87	40.44	0.95	-0.48

7. CONCLUSIONS

The aim of this study was to quantify the impact of climate change on water requirement and productivity and to better understand the uncertainty and risk involved in using several Atmospheric- Ocean General Circulation Models (AOGCMs) to predict future temperature and water requirement of Aidoghmoush irrigation network in Iran. The following key inferences can be drawn from this study:

- Considerations of precipitation and temperature climate change scenarios (of AOGCM models) show temperature increase of 0.1 to 3.1^{O}C in 2026-2039 (for A2 scenario) relative to the baseline period. On the other hand, in 2026-2039 precipitation shows substantial increase in autumn and decrease in summer relative to the baseline and also precipitation varied (-60 to 139 percent) in 2026-2039 compared with baseline period (1971-2000).
- Weighting of AOGCMs shows that, among the seven models considered, HadCM3 has the maximum for simulating temperature and precipitation for A2 scenario.
- The probability of water requirement will be increased when approaching the end of this century. This increase would be 9% and 11% for the risk of 50 and 25%, respectively. Based on the current areas of basin's irrigation networks, this increase can cause an increase of water demand volume for the crops considered by about 2.5 and 6 MCM/year for the risk of 50 and 25%, respectively.
- There is also a high risk of reduction of the streamflow in the Aidoghmoush River (Ashofteh and Massah, 2008). Therefore, both demand increase and supply decrease would be expected in the basin, which would lead to a high stress in the basin.
- Results showed that wheat and especially barley could have more resistance to climate change, and so, changes in crop patterns, change of planning date and reservoir operation management can be considered as useful adaptation strategies to climate change.

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