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ORIGINAL ARTICLE

Stress and Scarcity of Water Resources in the Drought-prone Areas of Jalgaon District in Maharashtra State: A Geographical Perspective

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ABSTRACT

Water scarcity is one of the most important concerns of the present day of geographers; Water is the central subject of all kinds of developmental activities. In the present study, water availability, stress and water scarcity in the drought - prone tahsils of Jalgaon district have been analyzed. Two indices are used to identify of water scarcity at the scale of tahsil level; water stress index (i.e. consumption to availability ratio) and water shortage index (i.e. water availability per capita). It is found that water stress has the dominant type of water scarcity in the study region. Over 80 % of the total study area, population lives in the areas that suffer from water stress. An half of total population lives in the area that suffers from shortage of water resources. Present study shows that the per capita availability of utilizable water in the study region in 1981 was 1638 m^3*; in 2001 it came down to 1,212 m*^{3}*. It will be decreasing by 894 m*^{3} *per person in 2041. This means that the scarcity of water is about 85% in this region and the severity is about 26%. Finally, the conclusion is that, at present all the tahsils under this zone are under high water stress. Inverting virtual water flows could be one solution for alleviating water scarcity in study region, along with the more traditional measures of e.g. reducing water use intensity and increasing water use efficiency.*

Keywords: *Anthropogenic, hydrometeorology, socio-economic development, water scarcity, water stress.*

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INTRODUCTION

Both population and fresh water resources are distributed very unevenly over the globe (Kummu & Varis, 2011) and water is considered a scarce resource in many regions (Ohlsson & Turton, 1999; Vörösmarty, 2000; Oki & Kanae, 2006; Alcamo *et al*, 2007). Water can be scarce either physically (Falkenmark *et al*, 1989) or socially, induced by political power, policies and/or socio-economic relations (Ohlsson & Turton, 1999). Physical water scarcity can be roughly divided into two main categories: population-driven water shortage and demand-driven water stress (Falkenmark *et al*, 2007). Population-driven water shortage occurs in areas where a large population has to depend on a limited resource while demand-driven water stress is related to the excessive use of otherwise sufficient water resources (Falkenmark *et al*, 2007).

The semi –arid drought- prone is the most water–scarce region of the world. Home to 17.0 percent of the world's population, the region contains only 1.4 percent of the world's renewable fresh water. A major study, the Comprehensive Assessment of Water Management in Agriculture, reveals that one in three people today face water shortages (CA, 2007). Around 1.2 billion people, or almost one-fifth of the world's population, live in areas of physical scarcity, and 500 million people are approaching this situation. Another 1.6 billion people, or almost one quarter of the world's population, face economic water shortage (where countries lack the necessary infrastructure to take water from rivers and aquifers). Both freshwater resources are vital for maintaining human life, health, agricultural production, economic activities as well as the ecosystem functions. With the increase in world's population, demand for water is also increasing very rapidly. But the water resources are not increasing. About one-third of the world's population lacks sufficient access to safe drinking water (UNWWDR, 2007). More than 1.2 billion people have lack of access to clean drinking water. The world's population is growing by about 80 million people per year (USCB, 2012) and is predicted to reach 9.1 billion by 2050, with 1.69 million people living in India (UNDESA, 2013a). The mean value of renewable global water resources is estimated at 42,700 km³ per year, and they are extremely variable in space and time. In absolute values, the largest volume of water resources is those of Asia and South America (13,500 and 12,000 km³ per year, respectively). The smallest are typically those for Europe and Australia with Oceania (2900 and 2400 km³year). For individual years, the extent of water resources can vary 15-25% of their average values. Indeed, absolute values do not fully reflect water availability within the continents as they differ so much in area and population numbers. The rapid population growth between 1970 to I994 has resulted in the potential water availability for the Earth's population decreasing from 12.9 down to 7.6 thousand cubic meters per year per person. The greatest reduction in population water supply took place in Africa (by 2.8 times), in Asia (by two times), and in South America (by 1.7 times).Water resources availability is declining with each passing day. The international yardstick of 1700 m^3 per capita availability of water is taken as a criterion. With this reference, the whole country became "Water stressed" in the year 2007 with per capita water availability declining to 1656 m^3 from 5200 m^3 in 1951. The reported per capita availability of water was 1545 m^3 in 2011. It is estimated that the per capita availability of water is likely to reach a level of around 1100 m^3 in 2050 but in reality we may reach this threshold much earlier considering the wasteful ways of water usage. In the context of water demand as the population increased the pressure has been increasing rapidly on the water resources as seen from these figures. In 2010 the global water demand was 4550 BCM (Igor. A. Shiklomanav, 2005). Out of which water demand from agricultural sector was 66 %, domestic sector occupied 18%, industrial sector 11% and remaining sector covered 5 % respectively. The projected water demand by 2025 will reach 5400 BCM. Out of which the demand from agricultural sector decreased 57% while industrial sector increased 15%, domestic sector covered 22% and remaining sector covered 6%.

In 2010, India water demand compared with globe was 18%. Out of which agricultural sector covered85% and remaining sectors covered 15%. The CGWB, (2010) projected water demand by 2025 will reach 1093 BCM. It was 20 % of the world. Out of which agricultural sector slightly decreased 74%, domestic sector covered 12%, industrial sector occupied 11% and other sector covered 3%. Water stress" refers to the ability, or lack thereof, to meet human and ecological demand for fresh water. Compared to scarcity, "water stress" is a more inclusive and broader concept. It considers several physical aspects related to water resources, including water availability, water quality, and the accessibility of water, which is often a function of the sufficiency of infrastructure and the affordability of water. Among other things, both water consumption and water withdrawals provide useful information that offers insight into relative water stress. Water stress has subjective elements and is assessed differently depending on societal values. For example, societies may have different water stress and thus assess stress differently. So it is very essential to identify the causes of water scarcity of the study region which is totally dependent on rural economy for the socio-economic development of the study region, as water plays a significant role in economic and human development. 70% of the earth surface is covered with water, which amounts to 1400 million km^3. However, 97.5% of this water being sea water, it is salty. Fresh water availability is only

35 million km^3. Out of the total fresh water, 68.7% is frozen in ice caps, 30% is stored underground and only 0.3% water is available on the surface of the earth. Out of the surface water, 87% is stored in lakes, 11% in swamp and 2% in rivers. As all the sweet water is not extractable, only 1% of the total water can be used by human beings (Anon, 2006). The situations will be exacerbated as rapidly growing urban areas place heavy pressure on neighboring water resources (UN-WATER, 2006). This is done by comparing the amount of total available water resources per year to the population of a country or region. A popular approach to measuring water scarcity has been to rank countries according to the amount of below 1,000 m^3 per person per year, the country faces "water scarcity" and below 500 m^3, "absolute scarcity" (Larsen and Samuel, 2009.

THE STATEMENT OF THE PROBLEM

Water resources are rapidly declining due to human growth and development. The quality and quantity of water resources is badly affected by human beings.

objective

Examine the water availability in different tahsils of the study region. Searching of the water use, availability and balance in various tahsils of drought-prone areas as well as the stress and scarcity of water in the study area.

STUDY AREA

The region selected for the study is the drought-prone tahsils located in the Jalgaon district of Maharashtra State. There are 09 drought-prone tahsils identified by V. Subramaniam, a Review Committee appointed by the State Government of Maharashtra in 1987 (Fig. 1). These tahsils are Amalner, Dharangaon, Parola, Erandol, Chalisgaon, Bhadgaon, Pachora, Jamner and Muktainagar. These tahsils are selected for the present study. It covers an area of about 6994.54 km^2. It lies between 20^{o}11′ to 21^{o}13′ North latitudes and 74^{o}46′ to 76^{o}24′ East longitudes. Average rainfall is 682.8 mm in the said area. Also, temperature and relative humidity varies 18^{o}C to 35^{o}C and 45 % to 72 % over the years respectively.

Main water resources of the study region are shallow water levels, within 5 to10 m bgl are seen in the study area during pre monsoon period. In Amalner, Parola, Bhadgaon, chalisgaon and Erandol tahsils deep tube wells ranging from 25 to 50 m bgl in depth. The depth to water levels during post monsoon ranges from 0.80 to 27.1 m bgl (CGWB &GSDA, 2000). Seasonal water level fluctuation more than 4 m is observed. Water harvesting ponds and discharge from small streams. The monsoon rainfall, which contributes about 89 % of the total annual rainfall, extends from June to September. Rainfall is erratic as per space and time in short area. The climate of the study area is featured by a hot summer and general dryness during all seasons, except a few weeks in the South-West monsoon season.

MATERIALS AND METHODOLOGY

The analysis of water availability and scarcity of the present study was based on the primary and secondary sources. Monthly rainfall and temperature data for nine tahsils during (1980-2010) collected from IMD, Pune and HDUG, Nasik (Government of Maharashtra Agency). All other information like area and population data collected from Census handbook of Jalgaon district (1981-2011).

For the assessment of water availability, the researcher applied the ministry of water resources formula (T. N. Narasimhan and V. K. Gaur, 2009): A Framework for India's Water Policy, National Institute for Advanced Studies, Bangalore). For ~~the~~ calculation of water scarcity and stress, two indices were used i.e. the water crowding index (WCI), Falkenmark, (1997) and the water stress index (WSI), Vorosmarty, (2000).

In this study, researcher used the ratio of annual water consumption to available water resources for calculating WCI and WSI. We believe that using water consumption rather than withdrawals is more appropriate because of the reported importance of downstream reuse of flows of irrigation water withdrawals. Tornqvist & Jarsjo, 2011; Ausder Beek *et al*, 2011). Water scarcity refers here to both water shortage and water stress. Researcher followed the thresholds and definitions of different levels of water scarcity defined by Falkenmark, *et. al,* (2007).

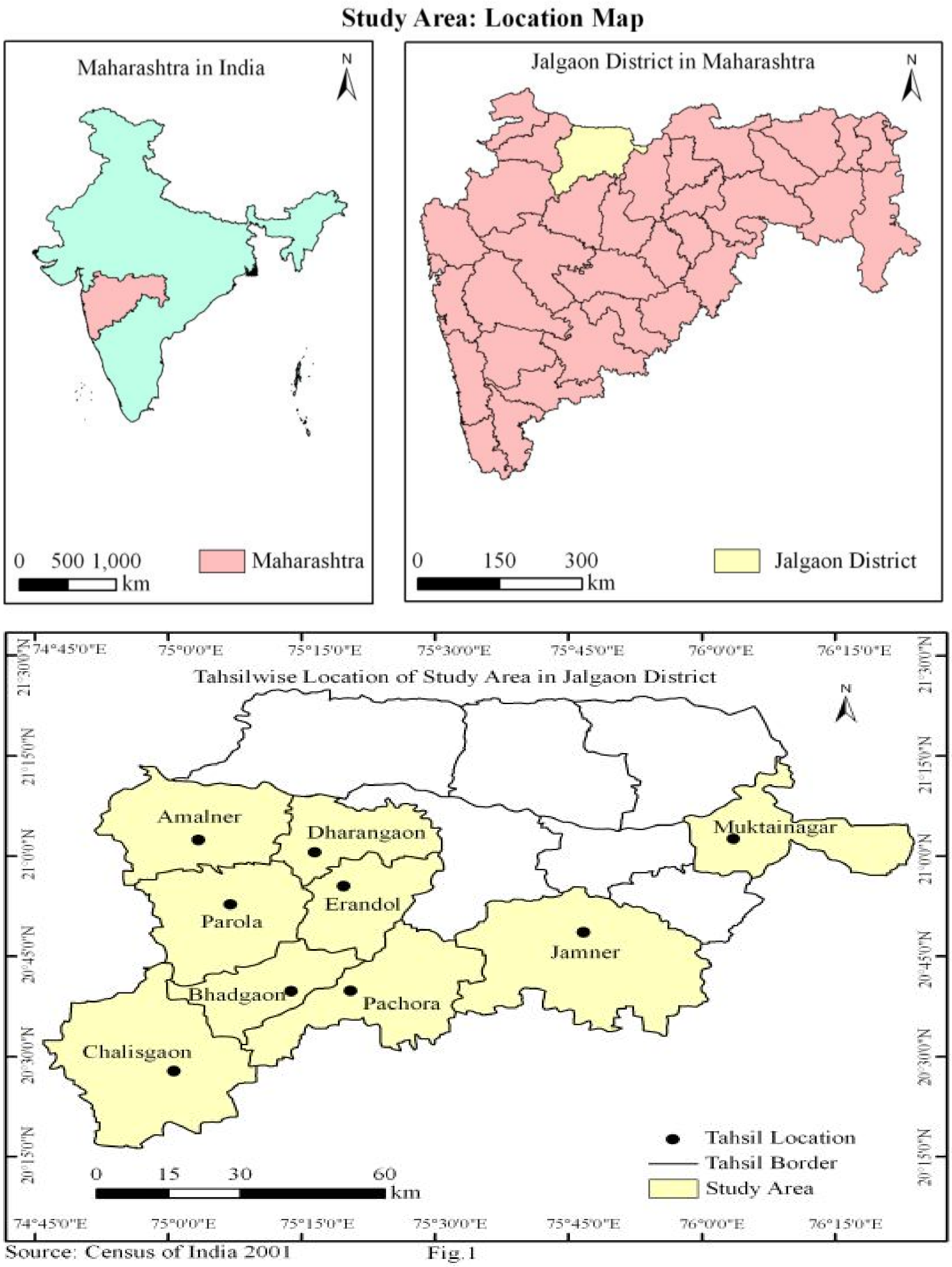

Fig. 1: Study Area: Location Map

WCI:

Moderate water shortage: per capita water availability is 1000 -1700 m^3/ yr.

Chronic water shortage: Per capita water availability is < 1000 m^3/yr.

WSI

Moderate water stress: Consumption of 20-40 % of available water resources.
High water stress: Consumption of over 40 % of available water resources
The analysis of water scarcity and water stress is worked out by Falkenmark water Stress IndicatorAccording to the Falkenmark Water Stress Indicator, a country or region is said to experience 'water stress' when annual water supplies drop below 1,700 m^3 per person per year. At the levels between 1,700 and 1,000 m^3 per person per year, periodic or limited water shortages can be expected (Falkenmark and Lindh, 1976). When water supply drops below 1,000 m^3 per person per year, the country faces water scarcity and when water supply drops below 500 m^3, per person per year, the country faces absolute scarcity (Larsen and Samuel, 2009).

Results and Discussion

Surface Runoff Water Resources:

Table 1 & Fig.2 shows run-off water resources in the drought-prone tahsils are not evenly distributed. Southern parts have more water availability because Ajanta and Hatti ranges lie in its surrounding areas. Meanwhile, northern and western parts have less water resources. The reason is that the northern and western parts lie in leeward direction. Hence, these areas suffer from water scarcity. After accounting for the losses due to evaporation, the total average annual water availability for the study region has been estimated as 2,326 million m^3. In total water volume, the average freshwater resources of the region are 2,326 million m^3. This is only 0.12 % of the Indian supply.

Table 1: Surface Run- off water resources (MCM)

Tahsil	**1980**	**1990**	**2001**	**2010**	**1980-2010**
Chalisgaon	415	643	197	425	409
Bhadgaon	61	87	32	66	66
Pachora	248	248	248	248	208
Erandol	132	262	75	209	153
Parola	221	339	126	367	208
Amalner	209	285	122	263	240
Dharangaon	211	194	83	83	159
Jamner	847	847	847	847	696
Muktainagar	172	201	96	240	187
Region	2416	3069	1115	2664	2326
Source: India Meteorological Department , Pune 1980-2010					

Table 2: Utilizable (Surface and ground) water resources (MCM)

Tahsil	1980		1990		2001		2010		1980-2010	
	Surface	Ground	Surface	Ground	Surface	Ground	Surface	Ground	Surface	Ground
Chalisgaon	153	96	237	149	72	46	157	99	169	106
Bhadgaon	78	14	110	20	40	7	83	15	84	15
Pachora	91	57	120	75	48	30	107	68	95	60
Erandol	49	31	97	61	28	17	77	49	56	35
Parola	82	51	125	79	46	29	135	85	95	60
Amalner	77	48	105	66	45	28	97	61	88	56
Dharangaon	72	45	71	45	31	19	31	19	59	37
Jamner	312	197	246	155	74	47	192	121	180	114
Muktainagar	63	40	74	47	35	22	89	56	69	43
Region	890	561	1130	712	411	259	981	618	857	540

Source: India Meteorological Department, Pune 1980-2010

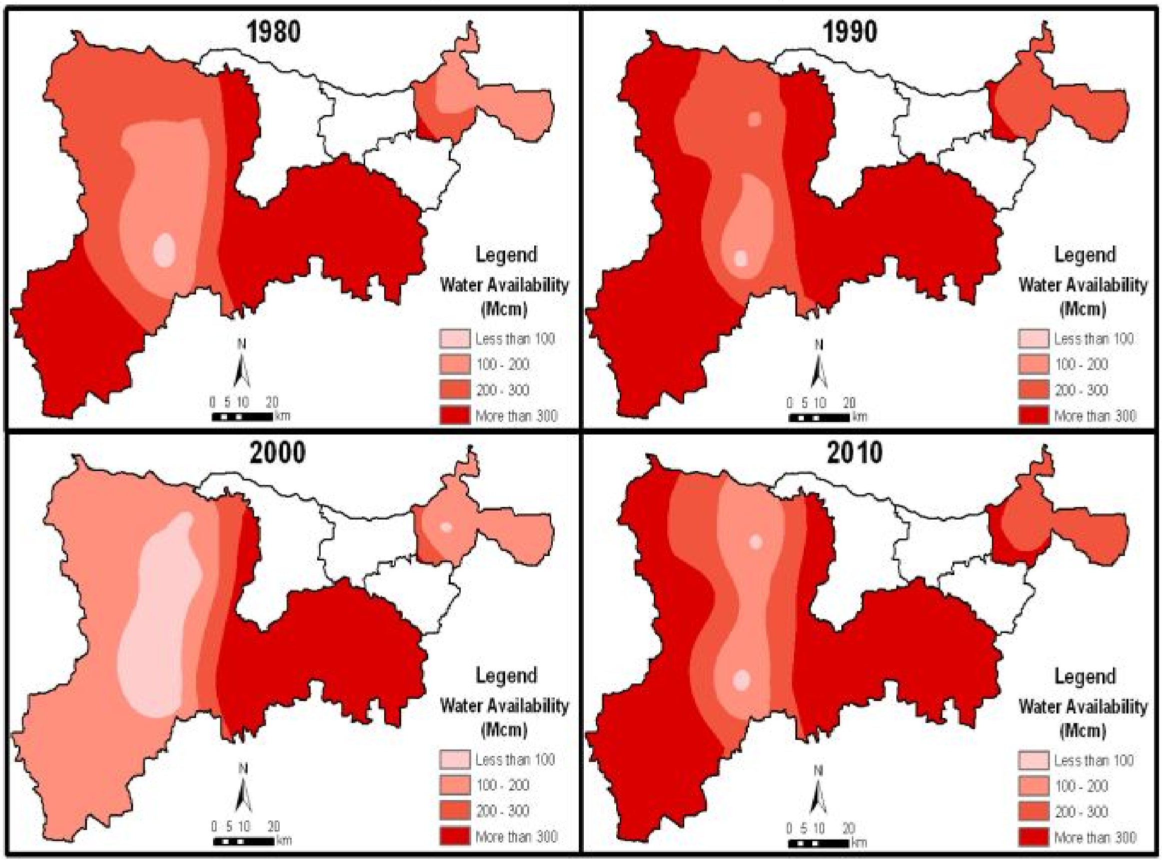

Fig. 2: Study Area: Water Availability

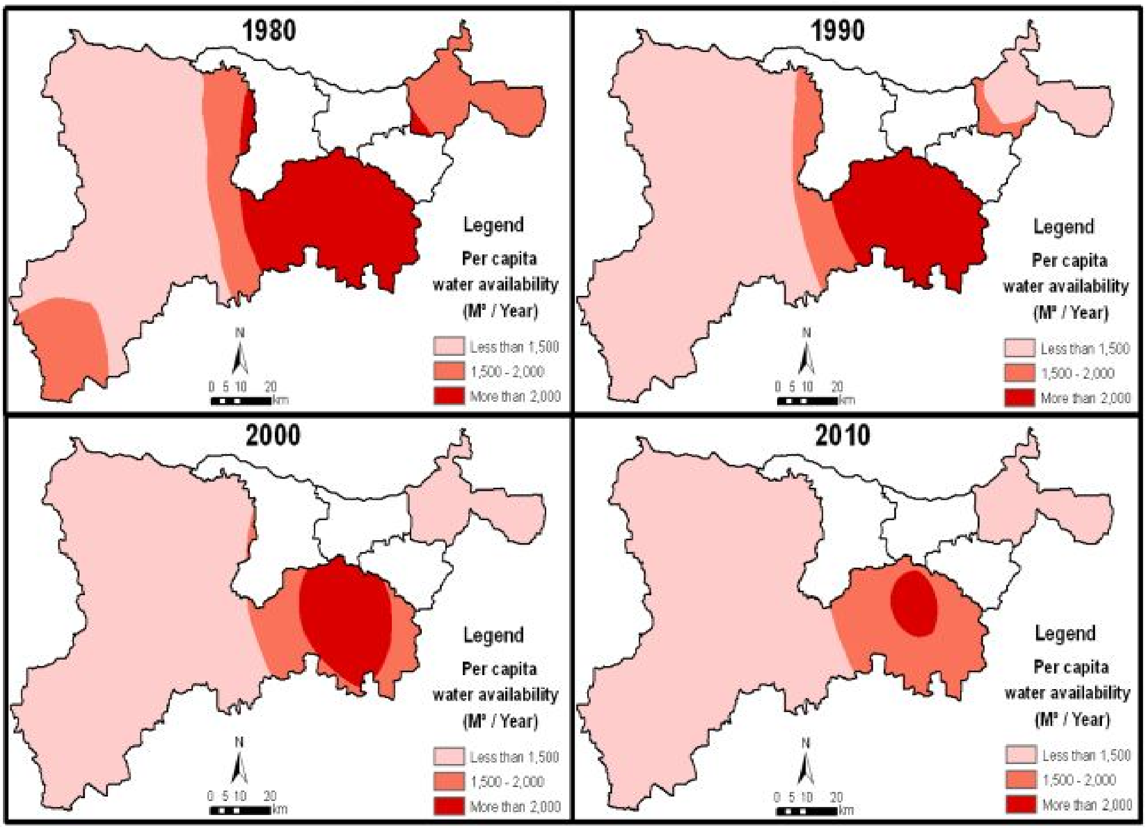

Fig. 3: Study Area: Per Capita Water Availability

Due to hydrological characteristics and topographical constraints, the utilizable water works out to be only 1,397 million m^3, out of which about 857 million m^3 is from surface water and about 540 million m^3 is through depleting ground water. However, there are considerable spatial and temporal variations in availability of water as in case of rainfall. Table-1 indicates the average annual water availability is more which 1005 million m^3 in Jamner tahsil followed by 840 million m^3 in Chalisgaon tahsil. While least average annual water availability is 314 million m^3 in Erandol tahsil 326 million m^3 Dharangaon tahsil. Whereas, remaining tahsils having annual average water availability ranges between 385 million m^3 to 530 million m^3.Utilizable water resource is the quantum of withdrawal water from its place of natural occurrence. Within the limitations of physiographic conditions and socio-political environment, legal and constitutional constraints and the technology of development available at present, utilizable quantity of water from the surface flow has been assessed by various authorities differently. The utilizable annual surface water of the region is 1,396 million m^3 (Table- 2 & Fig.3). There is considerable scope for increasing the utilization of water in the Girna, Waghur and Bori basins by construction of storages at suitable locations in neighboring regions. The annual potential natural groundwater recharge from rainfall in the study region is about 540 million m^3, which is 11.31% of total annual rainfall of the study region. The annual potential groundwater recharge augmentation from canal irrigation system is about 35 million m^3. Thus, total replenish able groundwater resource of the study region is assessed as 431.89%. After allotting 15% of this quantity for drinking, and 5 million m^3, for industrial purposes, the remaining can be utilized for irrigation purposes. Thus, the available groundwater resource for irrigation is 361 million m^3 of which utilizable quantity (90%) is 325 million m^3. The estimates by the Central Groundwater Board, Nagpur (CGWB) of total replenish able groundwater resource, provision for domestic, industrial and irrigation uses and utilizable groundwater resources for future use.

PER CAPITA WATER AVAILABILITY

In the view of growing population, per capita water availability is getting reduced year after year. Growing population, increased demand for water for both urban and agricultural uses, and economic development are putting pressure on limited water resources. In 1981 the per capita availability of water in the study region was about 1638 m^3. This has now reduced to about 1,096 m^3 in 2011. Recently the gap between demand and supply of water is widening day by day due to rapid growth of population. The demand for water in the study region is steeply increasing. During the period 1981 to 2011 the per capita availability of water is found at the trace level. The projected per capita availability of water in 2041 will be 894 M^3only. It means that during these decades the population will suffer from water scarcity (Table- 3). It is observed that, Bhadgaon, Parola and Amalner tahsils suffers a lot from water scarcity.

WATER SCARCITY

Demand-driven water stress has the dominant type of water scarcity in the study region. Most of tahsils had sufficient water resources in relation to their population. The areas that experienced some form of water scarcity suffered from either water stress alone high (WSI value) or both water stress and water shortage (high WSI and low WCI value) (Fig. 4 & Table 4a & 4b).

The few areas where population-driven water shortage occurred along with water stress, however, hold almost a half (0.7099435 million) of the total population of the study area. Thus, water shortage is also significant in the study region, despite this seemingly plentiful per capita water resources (Table 2) .According to the calculations 85% (1.629883 million) of in the study area population lived under some level of water scarcity. About a half of them lived in areas that suffered from severe water scarcity in the sense that both high water stress and chronic water shortage occurred (Figure 4, Table 4a & 4b). 60% of the population experienced high water stress, with majority of them living in areas with less than 985 m^3 of water per capita per year. Water scarcity occurred mainly in all tahsils (Fig. 4, & Table 4a & 4b) except in Jamner tahsil. Scarcity was particularly serious in Pachora, Bhadgaon, and Dharangaon where 13% and 6% and 8% of population respectively are classified as being under severe water scarcity (Table 4a & 4b).In Jamner tahsil all of this population lived not under water scarcity, while remaining tahsils population lived under extreme water shortage with a WCI value of less than 900 m^3 per capita per year.

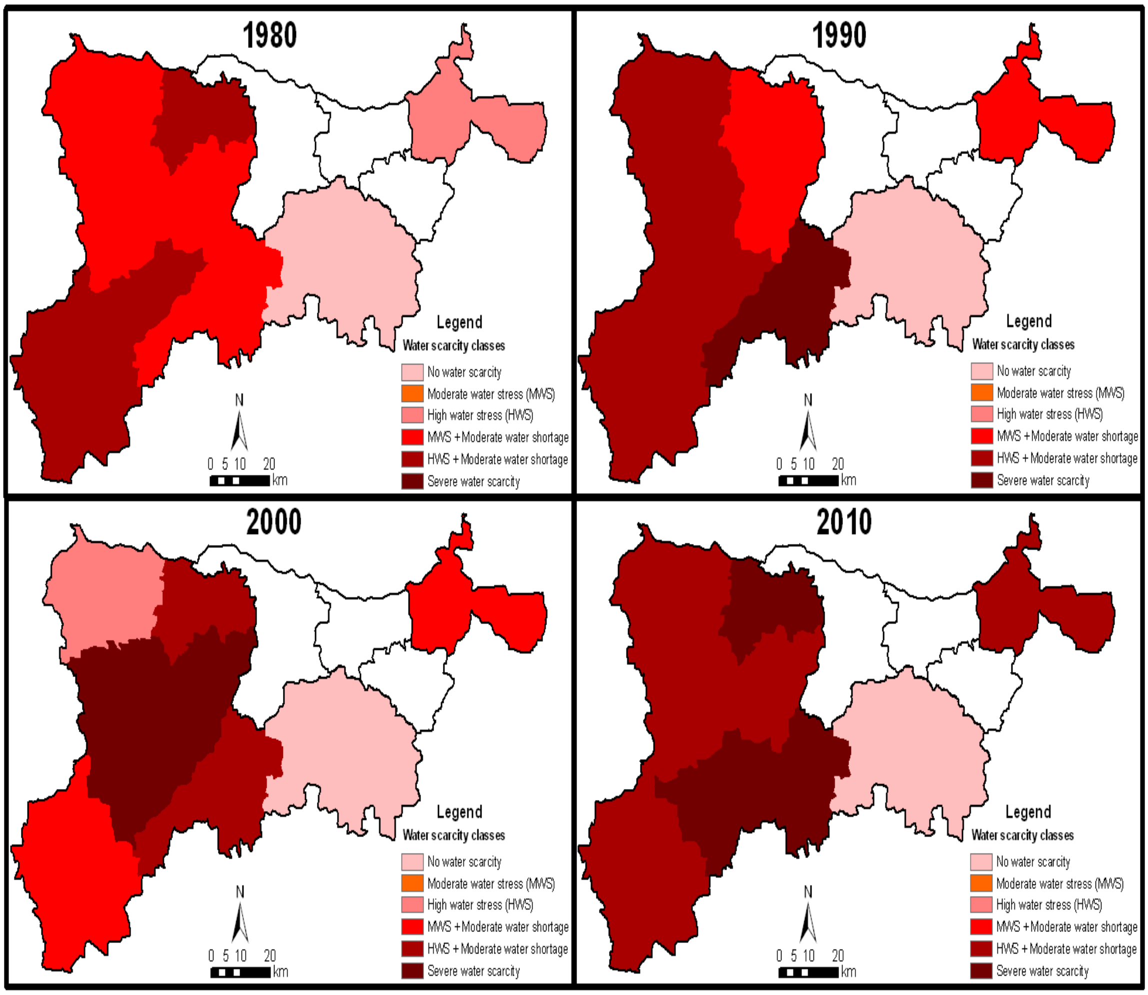

Fig. 4 Study Area: Water Scracity

ER CONSUMPTION

Sectored water consumption data have been collected from tahsil and collector office of Jalgaon district for nine tahsils during 1980-2010. Dataset with six sectors, namely domestic, Livestock, electricity, manufacturing, and irrigation. Average annual water consumption data for 1980-2010 were used to calculate sect oral water consumption for the year 1980, 1990, 2000 and 2010. Values were then aggregated to tahsil scale. Water consumption for each sector is presented in Table 5a & 5b. According to the calculations, agriculture is the dominant water user, accounting for 79% of total water consumption in the study area. Next largest is domestic, other and manufacturing sectors, which make up 15 %, and 6 % of total water consumption respectively. The results showed that over 80% of the total study regions population lived under some level of water scarcity. All people suffered from demand-driven water stress, and about a half of them also from population-driven water shortage, and fluctuation of availability of water resources due to high surface temperature, aridity and erratic south-west monsoon. This indicates that the main causes of water scarcity in the study area are over-exploitation of available water resources, which is mostly due to irrigated agriculture, as presented in Table 5a & 5b. The table indicates that the production of Jawar, cotton, sugarcane and fruits accounts for 80 % of the total agricultural blue water consumption in the study region. The proportion of Jawar, cotton, sugarcane and fruits is 61%, making it the dominant cause of high agricultural water withdrawals. There is also a notable overlap between cotton producing areas and areas that suffer from water stress, which suggests that they are indeed connected.

Table 3: Tahsil wise per capita water availability (M^3 / Year)
(Source: Computed by researchers, 2015)

Tahsils	Population & Water availability	1981	1991	2001	2011	2021	2041
						Projected	
Chalisgaon	p	0.251044	0.329268	0.356808	0.394600	0.441952	0.500000
	W	382	382	382	382	382	382
	A	1522	1160	1071	968	864	764
Bhadgaon	p	0.11234	0.127723	0.142168	0.157226	0.172241	0.187312
	W	126	126	126	126	126	126
	A	1122	987	886	801	732	728
Pachora	p	0.182855	0.227437	0.251907	0.278588	0.307617	0.339148
	W	208	208	208	208	208	208
	A	1138	915	826	747	676	613
Jamner	p	0.200976	0.244795	0.288804	0.319393	0.348138	0.375989
	W	696	696	696	696	696	696
	A	3463	2843	2410	2179	1999	1851
Erandol	p	0.116900	0.133488	0.148114	0.163802	0.180543	0.198597
	W	153	153	153	153	153	153
	A	1309	1146	1033	934	847	770
Parola	p	0.125102	0.154399	0.169919	0.187916	0.208587	0.231532
	W	175	175	175	175	175	175
	A	1399	1133	1030	1931	839	756
Dharangaon	p	0.123113	0.146654	0.160692	0.177712	0.196567	0.217462
	W	159	159	159	159	159	159
	A	1291	1084	989	895	809	731
Amalner	p	0.214300	0.241332	0.262522	0.290328	0.326329	0.366794
	W	277	277	277	277	277	277
	A	1293	1148	1055	954	849	755
Muktainagar	p	0.093257	0.115323	0.137753	0.152267	0.166732	0.180904
	W	150	150	150	150	150	150
	A	1608	1301	1089	985	900	829
Region	p	1.419887	1.720419	1.918687	2.121832	2.348706	2.601563
	W	2326	2326	2326	2326	2326	2326
	A	1638	1352	1212	1096	990	894

Where: P= Population in million, A= Per capita water availability in M^3 /year, W= Run-off water resources

Fig. 4

Table 4(a): Population under different water scarcity categories, presented in tahsil scale Population under water scarcity (Million) 1980-81

Tahsil	Available water resources (MCM)	Population (Million)	WSI %	WCI (M3/C/yr)	Population not under water scarcity	High water stress	Moderate watershortage	Moderate water shortage	Total under water scarcity
Chalisgaon	382	0.2510440	69	1522				0.251044	0.251044
Bhadgaon	126	0.1123400	107	1122				0.112340	0.112340
Pachora	208	0.1828550	80	1138			0.182855		0.182855
Parola	175	0.1251020	82	1399			0.125102		0.125102

Erandol	153	0.1169000	66	1309			0.116900		0.116900
Amalner	277	0.2143000	49	1293			0.214300		0.214300
Dharangaon	159	0.1231130	178	1291				0.123113	0.123113
Jamner	696	0.2009760	16	3463	0.200976				
Muktainagar	150	0.0932570	76	1608		0.093257			0.093257
Region	2326	1.4198870	62	1638	0.200976	0.093257	0.639157	0.486497	1.218911
					14.00%	7%	45.00%	34.00%	86.00%

Table 4(b): Population under different water scarcity categories, presented in tahsil scale population under water scarcity (Million) 2010-11

Tahsil	Available water resources (MCM)	Population (Million)	WSI %	WCI (M3/C/yr)	Population not under water scarcity	High water stress	Moderate water shortage	Severe Water scarcity	Total under water scarcity
Chalisgaon	382	0.394600	103	968			0.3946		0.3946
Bhadgaon	696	0.319393	29	2179	0.319393				
Pachora	208	0.278588	140	747				0.278588	0.2786
Parola	126	0.157226	191	801				0.157226	0.1572
Erandol	153	0.163802	122	934			0.163802		0.1638
Amalner	175	0.187916	97	931			0.187916		0.1879
Dharangaon	277	0.290328	85	954			0.290328		0.2903
Jamner	159	0.177712	259	895				0.177712	0.1777
Muktainagar	150	0.152267	100	985			0.152267		0.1523
Region	2326	2.121832	125	1096	0.319393		1.188913	0.613526	1.8024
					15%		56%	29%	85%

Source: Computed by researcher's 2015

Table 5 (a): Tahsil wise Population, available water resources and water consumption (1980-81)

Tahsil	Population	Available water	Water consumption (M^3/yr)				
	(Million)	resources (MCM)	Irrigation	Domestic	Livestock	Industry	Total
Chalisgaon	0.2510440	249	204	7	18	20	249
Bhadgaon	0.1123400	92	83	2	8	10	103
Pachora	0.1828550	149	95	5	16	18	134
Parola	0.1251020	133	83	2	10	12	107
Erandol	0.1169000	79	68	3	5	7	83
Amalner	0.2143000	125	123	4	16	18	161
Dharangaon	0.1231130	118	110	3	10	12	135
Jamner	0.2009760	509	178	6	45	50	279
Muktainagar	0.0932570	103	82	2	15	17	116
Region	1.4198870	1558	1026	34	143	164	1367

Table 5 (b): Tahsil wise Population, available water resources and water consumption (1990-91)

Tahsil	Population	Available water	Water consumption (M^3/yr)				
	(Million)	resources (MCM)	Irrigation	Domestic	Livestock	Industry	Total
Chalisgaon	0.329268	386	265	8	20	18	311
Bhadgaon	0.127723	158	124	3	10	7	144
Pachora	0.227437	195	160	6	18	14	198
Parola	0.154399	171	119	4	12	6	141
Erandol	0.133488	204	90	4	7	5	106
Amalner	0.241332	116	113	6	18	8	145
Dharangaon	0.146654	130	129	6	12	14	161
Jamner	0.244795	502	213	8	50	18	289
Muktainagar	0.115323	120	126	3	17	5	151
Region	1.720419	1983	1339	48	164	95	1646

Source: Computed by researcher's 2015

CONCLUSION

Like climate change, water scarcity is emerging as one of the most significant global challenges of our age. It is found that demand-driven water stress was the dominant type of water scarcity in the study region. Majority (84%) of the total population (1.802439 million) lived in areas that suffered from demand-driven water stress and around a half in areas that also suffered from population-driven water shortage. Alarmingly, 29 % of the population lived under severe water scarcity (over 70% of available water resources are consumed and per capita water availability is less than 895 m^3 per year). Scarcity has the most widespread in Pachora tahsil, Bhadgaon and Dharangaon tahsils. The study region is generally perceived as a water scarce region, even though its water resources are relatively abundant. The results reinforce the view that the actual problem in the region is the availability of water resources and its uneven distribution and excessive use. Currently, most areas use their available water resources excessively. These are also the areas where majority of the region's population is concentrated, and the pressure on scarce water resources is only expected to grow in the future due to increasing population. Consequently, there is a real need for measures to alleviate water scarcity in the study region. Such measures have traditionally included, for example, reducing water use intensity and increasing water use efficiency. In the current globalised world, however, a great deal of water intensive products are not consumed at the place of production but traded elsewhere, thus the wider context of water management cannot be ignored.

Water scarcity is a serious and growing problem across many tahsils of the study region. Over abstraction, in particular, has been driven by changing agricultural patterns, changing household use (appliances, household size and behavior), tourism and industrial activity. Water scarcity has therefore, raised sharply up the semi-arid drought- prone area's policy agenda. Water scarcity problems will be exacerbated due to climate change, increasing the vulnerability of socio-ecological systems. It is observed that the availability of the water resources fluctuated year by year due to high surface temperature, aridity and erratic monsoon. Most of the water of it is utilized for the cash crop production such as banana and sugarcane. In general, the scarcity and stress of fresh water resources in the study region is expected to increase in the future if the current trends of population growth and agricultural policies persist and the issue of shared water resources is not resolved. While still expected to increase, the water scarcity magnitude will be lessened in some tahsils due to their extra use.

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