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REVIEW PAPER

World Water Scenario and Extent of Groundwater Extraction in India

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ABSTRACT

Water is the elixir of life. Earth and Mars have been recognized to have water. About 70 per cent of earth's surface is covered by water which is estimated to be 1400 million cubic kilo meter enough to submerge the earth 3000 meters deep. However only 2.7 per cent of earth's water is fresh water and the rest is salt water. Ground water is the most preferred and vital source of fresh water for irrigation. Currently more than 80 per cent of needs of irrigation as well as for drinking purpose in India are met by groundwater. This shows the prime position occupied by groundwater resource in India's agriculture as well as health of the population. The groundwater-irrigated area has increased 500 per cent since 1960 (Shah, 2009). Global statistics for groundwater irrigation are now available from a UN-FAO survey. Now a day's irrigated agriculture is the largest abstractor and consumer of groundwater, with almost 40 per cent of all cultivated land under irrigation being 'water well equipped' with large groundwater-dependent agriculture economies in South & East Asia. The nations with the largest groundwater-use areas are India (39 M ha) and China (19 M ha). Unnoticed extracting of ground water over its limits like recharge capacities it is a disquieting issue in Indian agriculture and in future food security of our country.

Key words *world water scenario, Groundwater extraction, overexploitation, Geological status of India*

The World water resource which constitutes salt water in ocean around 97.3 per cent and fresh water only about 2.7 per cent. The availability of fresh water this earth is itself scarce, all the needs of human being is met with this scarce water resource. Among 2.7 per cent of fresh water polar ice and glaciers covers 75 per cent which is again unavailable for human consumption. Mankind left with only 25 per cent of fresh water (9.28 Million BCM), ground water less than 800 m deep accounts 10 per cent and ground water 800-4000 m deep accounts to 12.6 per cent which has to be explored. Lakes and Rivers on the earth contribute only 0.34 per cent. Thus crisis about water resources extraction and management arises because 97 per cent of water is not available for use and it is characterized by its high uneven distribution. Therefore, the importance of water has been recognized and larger importance is given on its economic use and efficient management (Table 1)

The global area equipped with irrigation facilities in percentage of land area, majority of the countries fall under less than one percent irrigated area. In precise Africa is the one of the largest continent having 23 percent of geographical area but it has only 12 per cent of world's arable land similarly Asia (excluding USSR) with only 21 percent of world geographical area it has about 32 per cent of world's arable land followed by North Central America having 20 percent of worlds arable land. It has been seen that irrigated area in the World as about 18.5 per cent of the arable land in 1994 (Table 2). In 1989, 63 per cent of world's irrigated area was in Asia, whereas in 1994 this percentage has gone up to 64 per cent. Also 37 per cent of arable land of Asia was irrigated in 1994. Among Asian countries, India has the largest arable land, which is close to 39 per cent of Asia's arable land. Only United States of America has more arable land than India. Majority of nations ground water irrigated area falls between 0-30 percent but if we come across USA , Western Europe and South East Asian continents there is increase in area equipped with irrigation facilities that is up to 70-80 per cent (Fig 1 and 2).

The two new studies conducted between 2003 and 2013 by the University of California-Irvine (UCI), using data from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites data revealed that out of 37 largest aquifers of the earth 13 aquifers were depleted with little or no recharge. 8 were classified as "overstressed" with nearly no natural recharge to balanced usage. Another 5 were found to be "extremely" stressed, depending upon the level of restock in each. The Indus Basin aquifer of India and Pakistan, which is one of the largest ground water basin serves as a source of fresh water for millions of people, is the second–most overstressed aquifer with no natural replenishment to counterbalanced usage. NASA report highlighted groundwater depletion in Punjab, Haryana and Rajasthan in the map, more than 100per cent ground water has been depleted in these states. The ground water exploitation in India. Few states namely Punjab, Haryana and Rajasthan have already reached "over exploitation" state more than 100 percent, and Karnataka also explored the GW resource up to an extent of 70-8 percent it is an alarming issue (Fig 3).

India is the top extractor of ground water about 220-

Table 1. World water resource at a glance

A. Sources of Water		
Item	**Volume (Million BCM)**	**Per cent**
Salt Water in Oceans	1348.00	97.29
Fresh Water	37.50	2.71
Total	**1385.50**	**100.00**
B. Sources of Fresh Water		
Item	**Volume (Million BCM)**	**Per cent**
Polar Ice and Glaciers	28.20	75.24
Ground Water < 800 m deep	3.74	9.98
800 - 4000 m deep	4.71	12.57
Lakes and Rivers	0.13	0.34
Others (soil moisture and atmospheric vapours)	0.70	1.88
Total	**37.48**	**100.00**

Source: Water resource economics, M G Chandrakanth

230 BCM, twice that of USA and six time higher than the Western Europe. India's ground water consumption is at exponential growth rate, in 1998 it was only 37 per cent, and it rose to 58 percent in 2010. Now India's pumping average is 75 acre-inch of ground water per well per year. Parallel way number of bore wells also increased from 0.1 million in 1960 to 25 million in 2010. This kind of unplanned and unscientific extraction of ground water resources may lead to pressure on availing ground water resources. Adverse effect of this situation we already facing as increase in depth of bore well, increase in frequency of well failure, worsening of quality of ground water such as salinity, water logging in and soil salinity in canal command area etc.

Groundwater resources availability in India:

India is a country with an extremely diversified hydro-geologic set up. The Hydro-geological map showing the broad group of consolidated and unconsolidated water bearing formations along with their yield prospects are shown in Fig.4. If we closely observe figure 4 and table 3 we can correlate that Himalayan region has the highest potential of groundwater yield of >40 liters/sec and act as major source of recharge for the Indo-Gangetic & Brahmaputra alluvial plains. Followed by Indo-Gangetic, Brahmaputra alluvial plains which has GW yield potential

Table 2. Global survey of ground water irrigation

Region	**Ground water irrigation**		**Ground water volume used**	
	M ha	**Proportion total (per cent)**	**Km per annum**	**proportion total (per cent)**
East Asia	19.30	29	57	34
South-East Asia	1.00	5	3	6
Middle East &North Africa	12.90	43	87	44
Latin America	2.50	18	8	19
Sub-Saharan Africa	0.40	6	2	7
Global Total	112.90	38	545	43

Source: Stephen Foster and Tushar Shah, GWP 2012 World water for irrigation purpose

World water for irrigation purpose

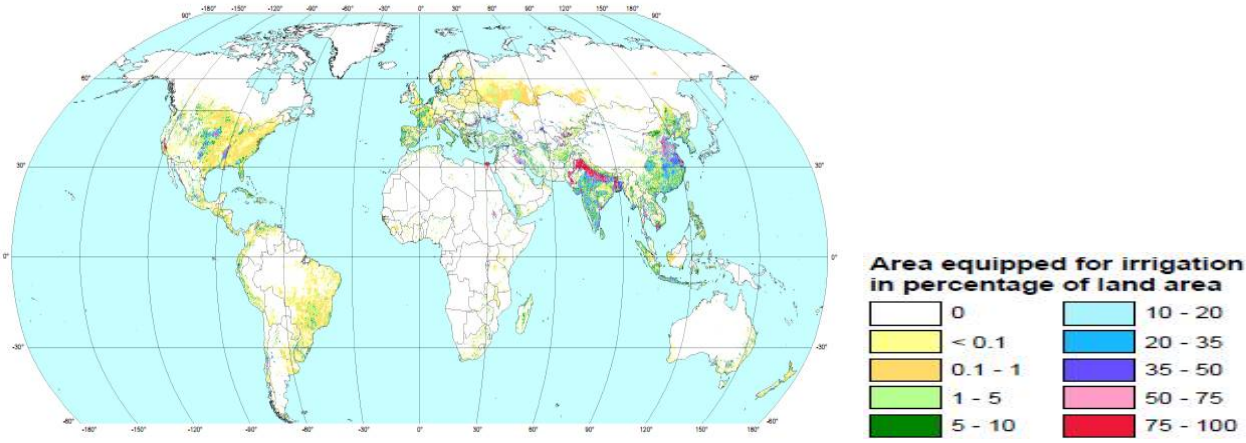

Fig. 1 The map shows area equipped for irrigation in percentage of cell area (2000-2008 base periods)

between 25-50 liters/sec which is the potential GW reservoir in the country and highly productive multi-aquifer systems, serves the Punjab, Haryana Uttar Pradesh and West Bengal which are major food producing states of India. Other three regions are poor in GW yield potential which comes under Hard rock and plateau regions of the country where GW extraction becomes serious problematic issue, because in the search of GW famers drilling bore wells up to more than 2000 feet depth at Kolar, Karnataka(Table 3).

Totally 19 river basins in India which is a rich source

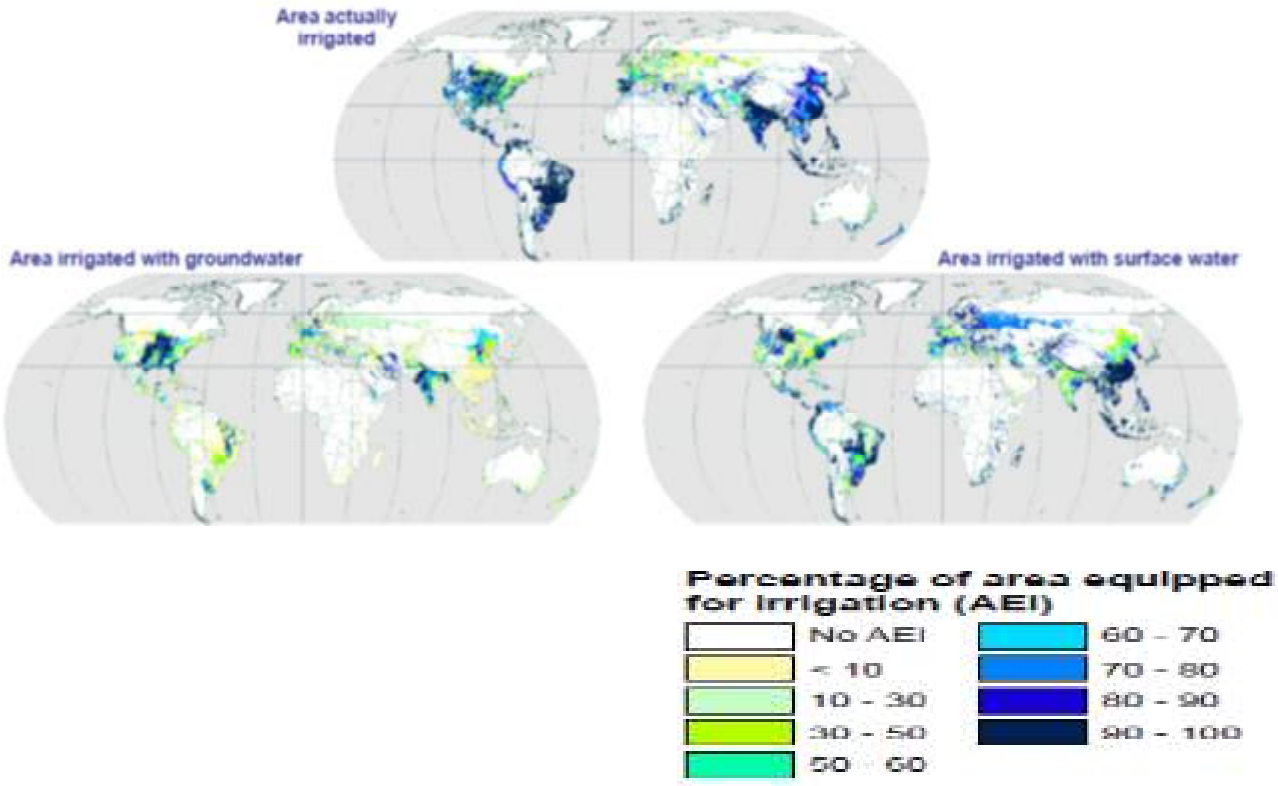

Fig 2: The maps show the percentage of area equipped for irrigation that is actually irrigated, irrigated with groundwater or irrigated with surface water.

Source: https://www.researchgate.net/publication/264556183_Update_of_the_digital_global_map_of_irrigation_areas_to_version_5

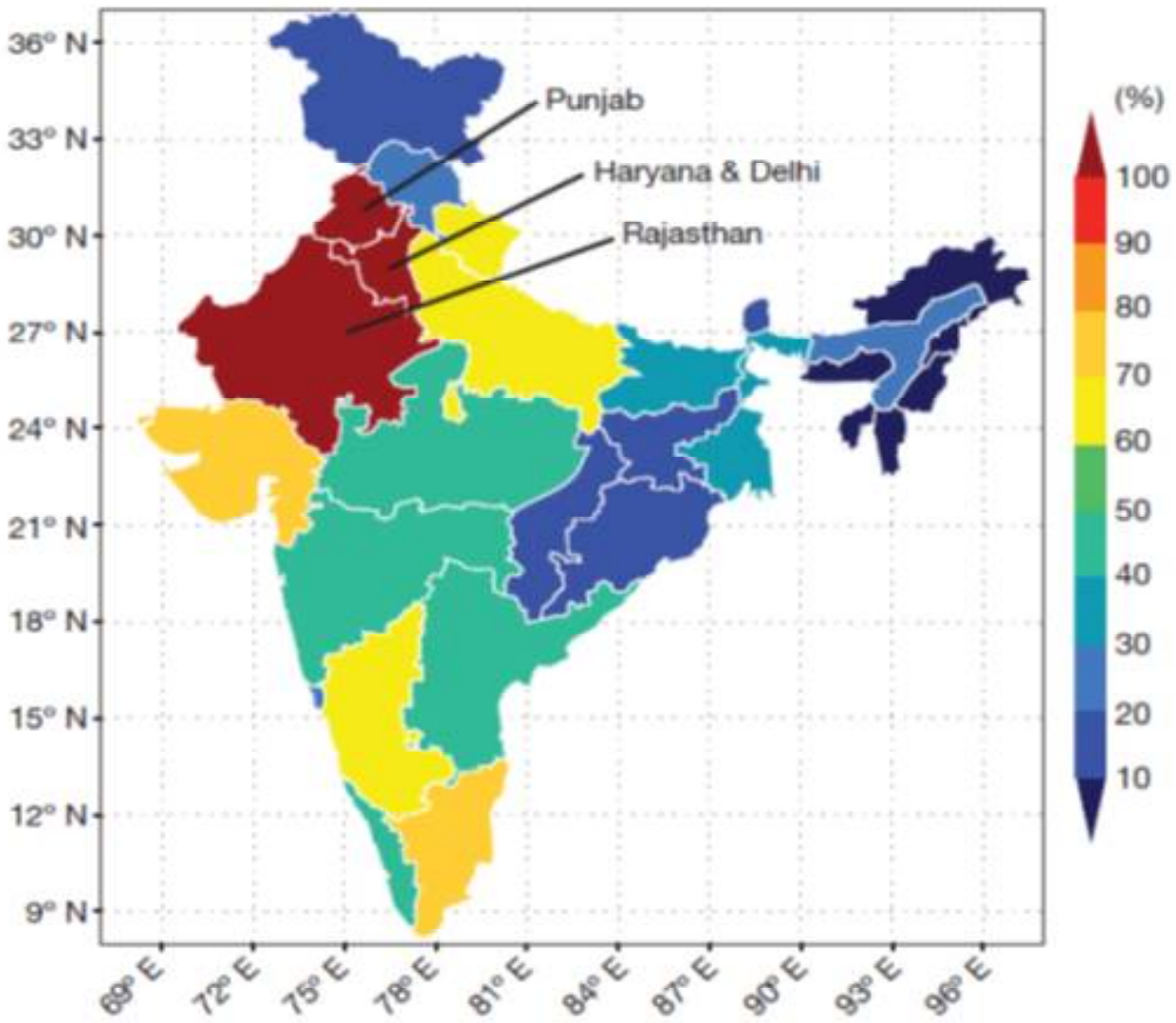

Fig. 3. Ground water exploitation in India.

Table 3. Hydro-geological status of India

Sl. no	Area /region	States	GW Yield potential (Liter/sec)	Remarks
1	Northern mountainous terrain and hilly areas	Himalayan region , Kashmir to Arunachal Pradesh	1-40	Little scope for GW storage. major source of recharge for the Indo-Gangetic & Brahmaputra alluvial plains
2	Indo-Gangetic , Brahmaputra alluvial plains	Punjab , Haryana, Uttar Pradesh, Bihar , Assam , West Bengal	25-50	Potential GW reservoir in the country. highly productive multi-aquifer systems
3	Peninsular shield area	Karnataka , Maharashtra , Tamil Nadu , Andhra Pradesh , Orissa and Kerala	2-10	GW exploitation is largely through dug wells
4	Coastal area	Gujarat, Kerala, Tamil Nadu, Andhra Pradesh , Orissa	5-25	inherent quality problems and the risk of seawater ingress impose severe constrains
5	Cenozoic Fault Basin and Low Rainfall Areas	The Narmada, the Purna and Tapti valleys, parts of Rajasthan and Gujarat	1-10	GW is extensively saline

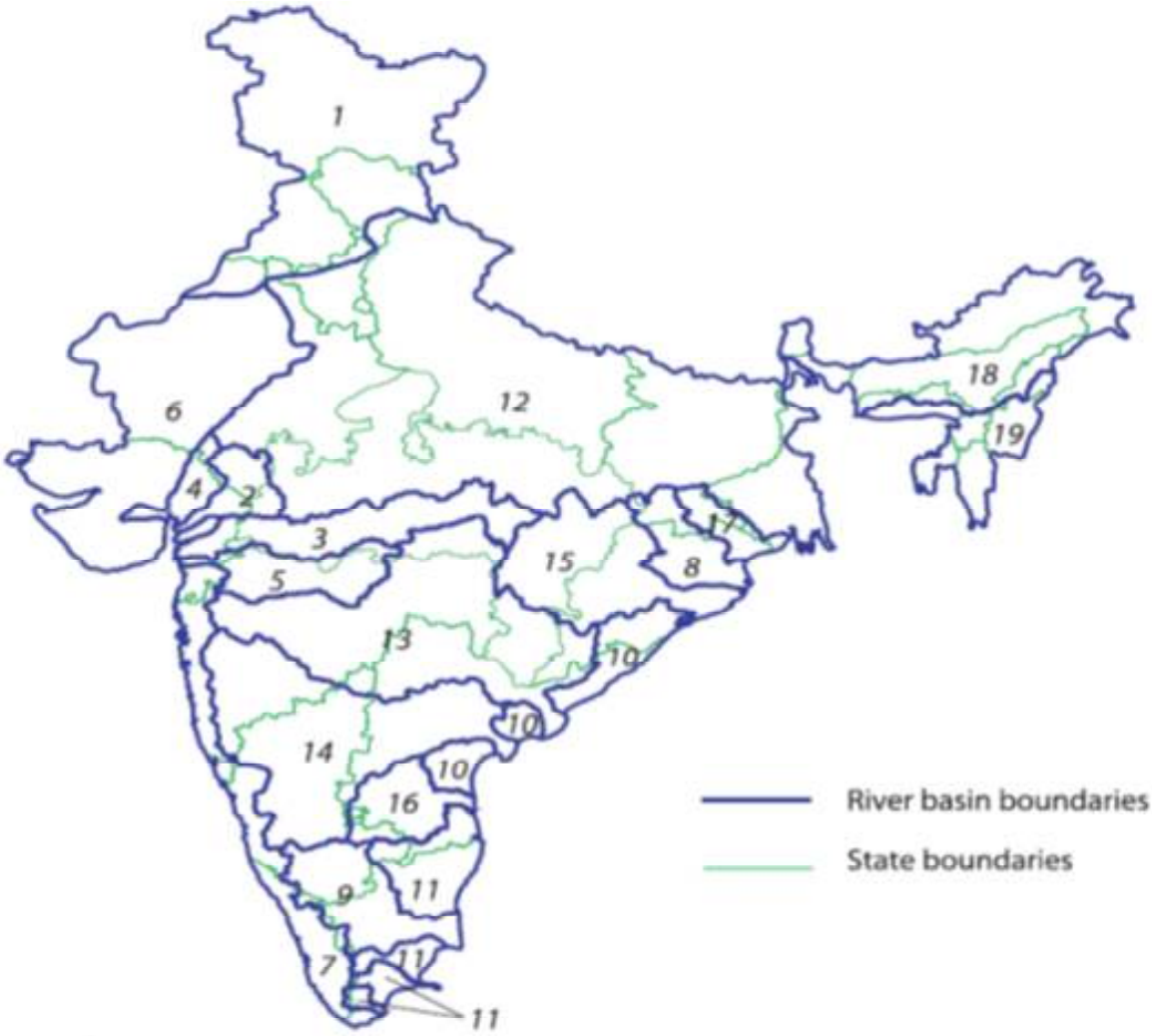

Fig. 4. River basins of India

1 Indus
2 Mahi
3 Narmada
4 Sabarmati
5 Tapi
6 Westerly flowing rivers –group 1
7 Westerly flowing rivers –group 2
8 Brahmani and Baitarani
9 Cauvery
10 Easterly flowing rivers –group 1
11 Easterly flowing rivers –group 2
12 Ganga
13 Godavari
14 Krishna
15 Mahanadi
16 Pennar
17 Subarnarekha
18 Brahmaputra
19 Meghna

Table 4. Water resources of India

Estimated average annual precipitation(Including snowfall)	4000 BCM
Average annual potential (in rivers)	1869 BCM
Estimated utilizable water	1123 BCM
i) Surface water	690 BCM
ii) Ground water	433 BCM
Per capita water availability (Based on census 2011)	1545 Cubic meter
Storage capacity of major and medium completed projects	253 BCM
Per capita water storage	208Cubic meter
Estimated surface water utilization	450 BCM
Annual ground water withdrawal	245 BCM

Source: Ministry of Water Resources, River Development and Ganga Rejuvenation

Note: BCM=Billion cubic meter River basins

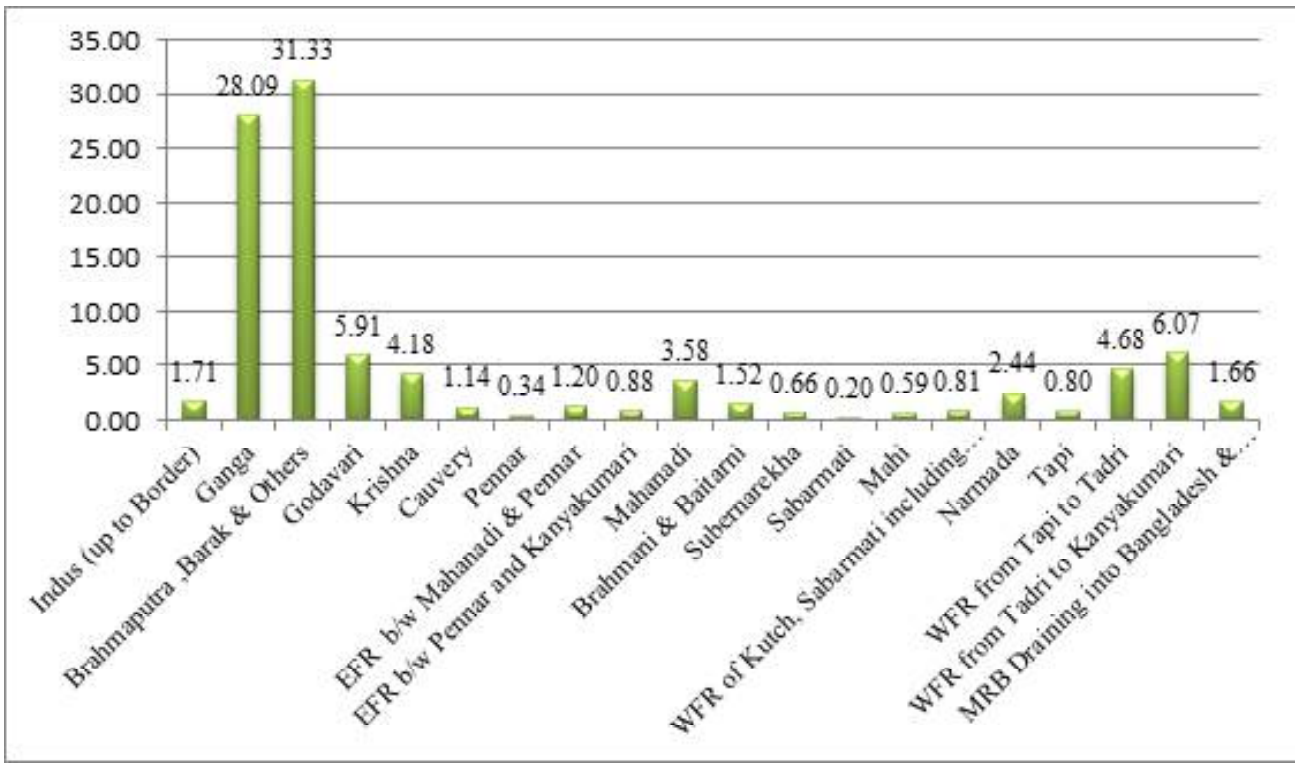

Fig. 5. River basin wise percentage of annual average water availability in India

Table 5. River basin wise average annual water availability

Sl. No.	Name of the River Basin	Average annual availability (cubic Km/year)
1	Indus (up to Border)	73.31
	a) Ganga	525.02
	b) Brahmaputra ,Barak & Others	585.60
2	Godavari	110.54
3	Krishna	78.12
4	Cauvery	21.36
5	Pennar	6.32
6	East Flowing Rivers Between Mahanadi & Pennar	22.52
7	East Flowing Rivers Between Pennar and Kanyakumari	16.46
8	Mahanadi	66.88
9	Brahmani & Baitarni	28.48
10	Subernarekha	12.37
11	Sabarmati	3.81
12	Mahi	11.02
13	West Flowing Rivers of Kutch, Sabarmati including Luni	15.10
14	Narmada	45.64
15	Tapi	14.88
16	West Flowing Rivers from Tapi to Tadri	87.41
17	West Flowing Rivers from Tadri to Kanyakumari	113.53
18	Area of Inland drainage in Rajasthan desert	0.01
19	Minor River Basins Draining into Bangladesh & Burma	31.00

Source: Central Ground Water Board (2012)

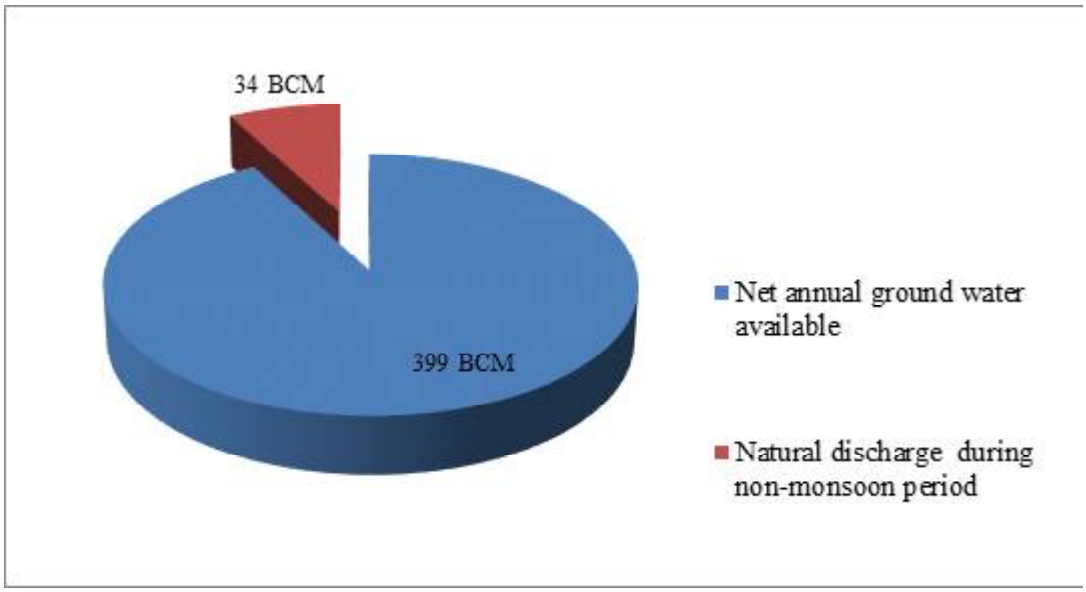

Fig. 6. Annual replenishable ground water in India (in BCM)

of water resource. If you consider river basin wise average water availability can be seen in table 3 where Ganga and Brahmaputra river basin which occupy for 525 and 585 cubic km per year respectively provides highest (60per cent) water needs for millions of people. And all other river basins serve the local needs of people, for example Cauvery river basin runs for about 21 cubic km per year provides water for drinking and irrigation purpose for both people of Karnataka and Tamil Nadu. The river basin wise percentage of average annual water availability in the country, 28 percent of water received from Ganga basin and 31 percent from the Brahmaputra river basin who serves the food bowl states of the country namely Punjab, Haryana, Uttar Pradesh and West Bengal. These states are blessed with major ground water replenishable recharged aquifers zone from Himalayan region (Figure 4)

There by Ministry of water resources, river development and Ganga rejuvenation assessed in India's water potential. India is blessed with 4000 BCM of average annual precipitation and average annual River potential is 1869 BCM(47 per cent) but utilizable water is 1123 BCM (28 per cent) among which is further distributed into surface water(61 per cent) and ground water(39 per cent). Even though we have 433 BCM of ground water we can use only up to the extent of natural rechargeable water (National

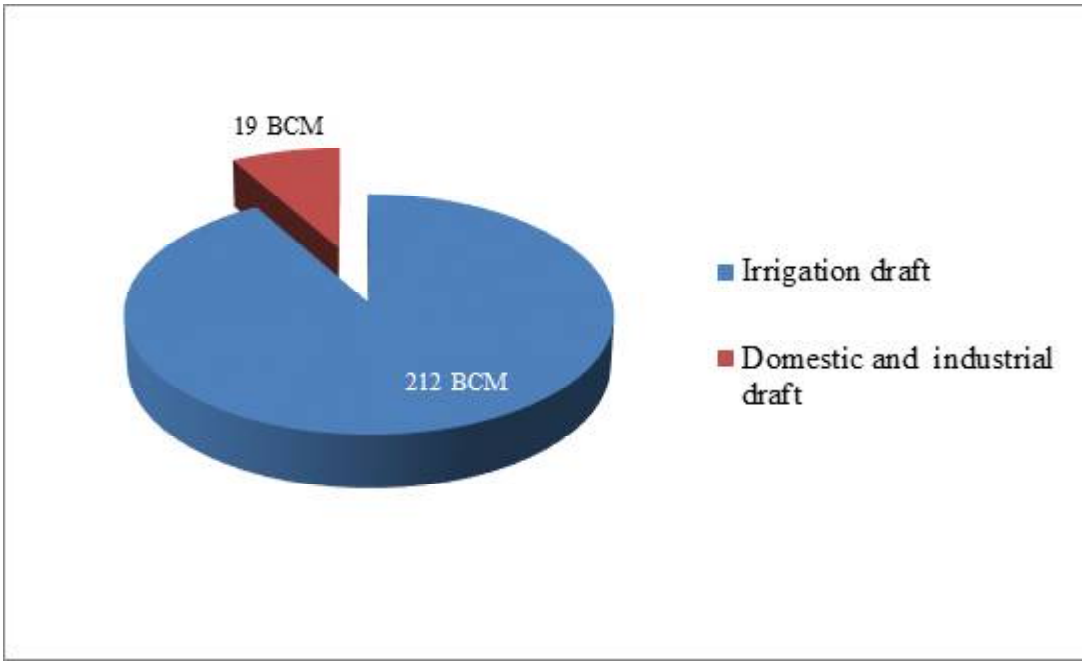

Fig. 7. Annual ground water draft (in BCM)

Table 6. State wise categorization of assessment units of India

Sl. no	States/ Union Territories	Total No. Number of assessed units	Safe		Semi-critical		Critical		Over exploited	
			No	%	No	%	No	%	No	%
	States									
1	Andhra Pradesh	1108	867	78	93	8	26	2	84	8
2	Arunachal Pradesh	16	16	100	0	0	0	0	0	0
3	Assam	23	23	100	0	0	0	0	0	0
4	Bihar	533	529	99	4	1	0	0	0	0
5	Chhattisgarh	146	132	90	14	10	0	0	0	0
6	Delhi	27	2	7	5	19	0	0	20	74
7	Goa	11	11	100	0	0	0	0	0	0
8	Gujarat	223	156	70	20	9	6	3	27	12
9	Haryana	116	18	16	9	8	21	18	68	59
10	Himachal Pradesh	8	6	75	0	0	1	13	1	13
11	Jammu & Kashmir	14	14	100	0	0	0	0	0	0
12	Jharkhand	208	200	96	2	1	2	1	4	2
13	Karnataka	270	154	57	34	13	11	4	71	26
14	Kerala	152	126	83	22	14	3	2	1	1
15	Madhya Pradesh	313	224	72	61	19	4	1	24	8
16	Maharashtra	353	324	92	19	5	1	0	9	3
17	Manipur	8	8	100	0	0	0	0	0	0
18	Meghalaya	7	7	100	0	0	0	0	0	0
19	Mizoram	22	22	100	0	0	0	0	0	0
20	Nagaland	8	8	100	0	0	0	0	0	0
21	Orissa	314	308	98	0	0	0	0	0	0
22	Punjab	138	23	17	2	1	3	2	110	80
23	Rajasthan	239	31	13	16	7	25	10	166	69
24	Sikkim	4	4	100	0	0	0	0	0	0
25	Tamil Nadu	386	136	35	67	17	33	9	139	36
26	Tripura	39	39	100	0	0	0	0	0	0
27	Uttar Pradesh	820	605	74	107	13	32	4	76	9
28	Uttarakhand	17	11	65	5	29	1	6	0	0
29	West Bengal	269	231	86	38	14	0	0	0	0
	Total of States	**5792**	**4235**	**73**	**518**	**9**	**169**	**3**	**800**	**14**
	Total of UTs	50	42	84	5	10	0	0	2	4
	Grand Total	**5842**	**4277**	**73**	**523**	**9**	**169**	**3**	**802**	**14**

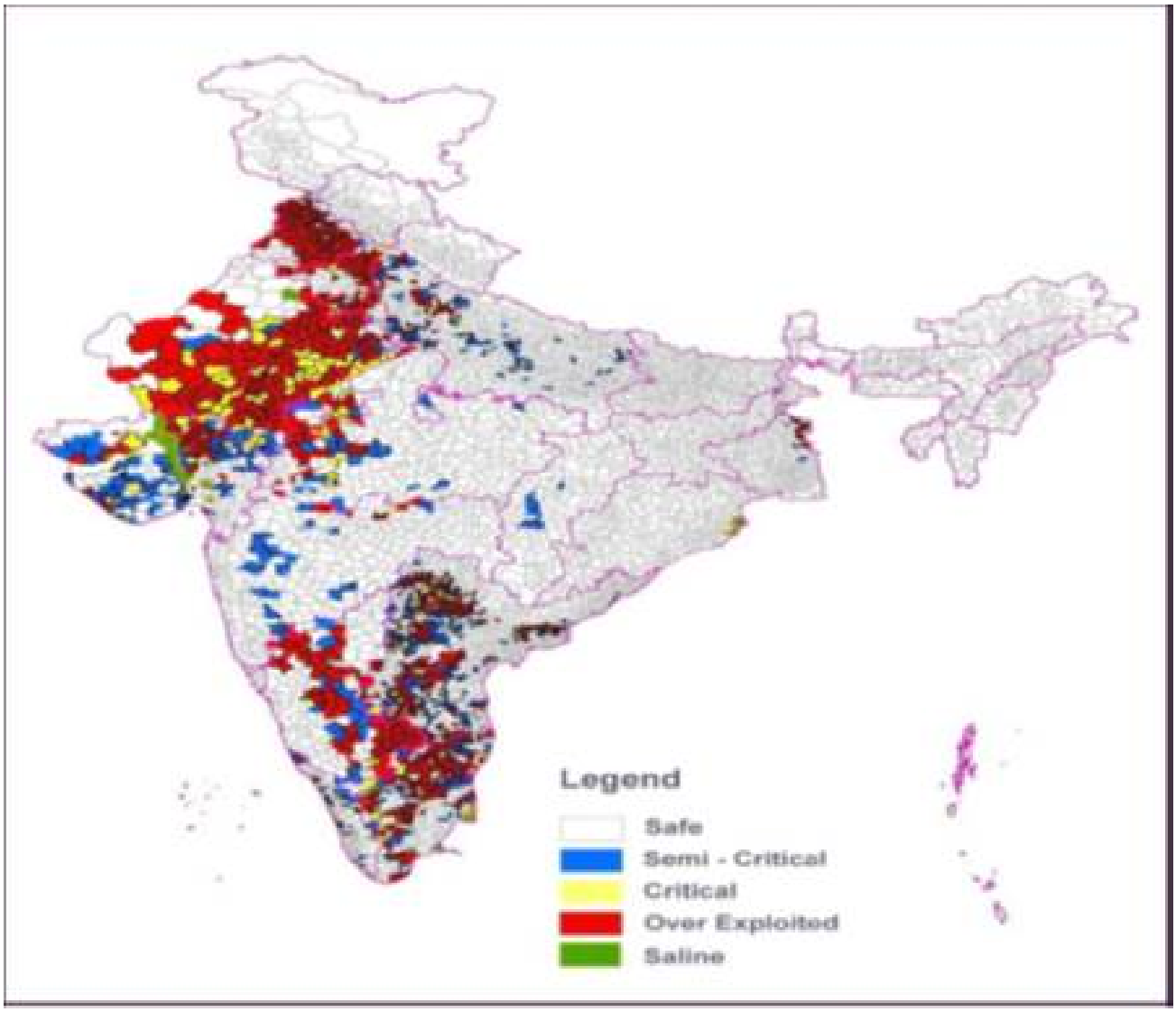

Fig. 8. Categorization of assessment units in India

water policy 2002) but in some states Punjab, Haryana, Delhi we are extracting more than the replenishable water so ground water is depleting in these states. Based on 2011 census if we work out the per capita availability of ground water in India its 1500 cubic meter per annum determines how we are pressurizing our ground water resource and it is an issue of sustainable use of any natural resource. (Table 4).

Rainfall is the important source of ground water recharge in India, which is supplemented by other sources such as recharge from canals, irrigated fields and surface water bodies like tanks. A major portion of the ground water withdrawal takes place from Indo-Gangetic, Brahmaputra alluvial plains aquifers, which are also the active recharge zones and holds the replenish able ground water resource. The replenishable ground water resource in the active recharge zone in the country has been assessed by Central Ground Water Board jointly with the concerned State Government authorities. The assessment was carried out with Block/Mandal/ Taluka/Watershed as the unit and as per norms recommended by the Ground Water Estimation Committee (GEC)-1997. As per the latest assessment, the annual replenish able ground water resource in this zone has been estimated as 432 billion cubic meter (bcm), out of which 399 bcm is considered to be available for extraction for various uses after keeping 34 bcm for natural discharge during non-monsoon period for maintaining flows in springs, rivers and streams (Central Ground Water Board, 2006) (Figure 5 and Table 5).

Ground water extraction for various uses and evapotranspiration from shallow water table areas constitute the major components of ground water draft. In general, the irrigation sector remains the main consumer of ground water. The ground water draft for the country as a whole has been estimated as 231 bcm (CGWB, 2006), about 92 per cent of which is utilized for irrigation and the remaining 8 per cent for domestic and industrial uses. Hence, the stage of ground water extraction, computed as the ratio

of ground water draft to total replenish able resource, works out as about 58 per cent for the country as a whole. However, the development of ground water in the country is highly uneven and shows considerable variations from place to place (Figure 6).

The state wise assessment units categorization as a part of the resource estimation as per the GEC norms has been prepared, the assessment units have been categorized based on the stage of ground water extraction and long term declining trend of ground water levels. As per the assessment, out of the total of 5842 assessment units in the country, 4277(73 per cent) assessment units with stage of ground water extraction below 70 per cent have been categorized as 'Safe'. 523 (9 per cent) assessment units with stage of ground water extraction in the range of 70 to 90 per cent have been categorized as 'Semi-Critical'. Ground water extraction was found to be to the extent of 90 to 100 per cent of the utilizable resources in 169 assessment units (3 per cent), which have been categorized as 'Critical' and ground water extraction was found to exceed more than 100 per cent of the natural replenishment in 802 units (14per cent) which have been categorized as 'Over-exploited' (Table 6 and fig 8).

CONCLUSION

The groundwater extraction has due ambiguous property right or easy accessible or due to water extraction techniques etc. growing rapidly. NASA's report on groundwater extraction clearly indicates India already explored its natural water resources, in future water becomes highly scarce for irrigation. In hard rock region of India, Deccan plateau farmers are incurring higher cost of production due to severe failing percentage of borewells dugged for irrigation which is leading to farming becoming nonviable with groundwater, farmers are using the groundwater very cautiously and setting minds towards rainfed farming and integrated farming.

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