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The Dried River deltas: a Comparison of Amu Darya, Yellow River & Murray-Darling Rivers.

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Abstract :

Since the industrial revolution, the human desire to control water and to reclaim wetlands has led to widespread ecological degradation. The first signs of over-irrigation and the consequent land degradation and silting in waterways were among the causes that led to the fall of Mesopotamia. The over-use of water has stopped eight rivers in the world from their rendezvous with the seas. These are Colorado, Amu Darya, Syr Darya, Indus, Teesta, Rio Grande, Yellow and Murray-Darling rivers. This paper summarizes the similarity and causes of drying of Amu Darya in Uzbekistan, Yellow river in China and Murray-Darling Australia. Due to rising populations, which required more food and more resources, the post-Second World War era saw a shift away from traditional water management. Additional land was brought under cultivation, facilitated by long distance irrigation canals. The scope of water use also saw a dramatic shift. It was now harnessed for electricity and industrial applications. Further, new infrastructure was required to meet the enhanced scope of water use. Large dams for electricity and irrigation. There was shift to water-intensive crops. These developments led to the huge extraction of water from rivers thus disturbing water cycles leading to drying of rivers before reaching their deltas.

Keywords: *Rivers, Basin, Murray-Darling, Yellow river, Amu Darya, Deltas, Non-Traditional Crops (NTC).*

1 INTRODUCTION

Freshwater is finite. Post second world war paradigm with regard to water in river and its renewability has been falsified. As the rivers of most continents dry up and ripped of water before reaching their deltas, due to practice of adopting water intensive non-traditional crops (NTC). To satisfy their water demand, the governments have gone for extensive water infrastructure development. These infrastructures included dams along with reservoirs, canals which transported water to distance places and weirs and lock that hold water in smaller rivers and streams. These hydrological infrastructures were thought to provide or mitigate society from floods and drought. But have failed in years of low rainfall and also have proved detrimental to the health of river and land fertility, as they hamper the movement of river sediment. Uzbekistan, Australia and China provide a window to understand why their respective rivers have dried up. The classic case of Aral Sea drying as both its rivers failed to reach their delta in Aral Sea. Similarly Murray-Darling River in Australia and Yellow river in Chine are suffering from this phenomenon. This paper is an attempt to summarize the mis-management of river basins that have led to drying of rivers. All these rivers share some common features with regard to climatic condition, being food basket and cash crop hub in their respective countries.

The Amu Darya and Murray-Darling basins share some of the climatic features like high temperature and evaporation. The solar radiation over Amu Darya Basin in Uzbekistan is around 3000-3100 hours annually transferring about 140-160 kkal/cm^2. This warms the air and soil, leading to high evapotranspiration from water bodies and plants. The evaporation from soil is further aggravated due to dryness of air and low relative humidity which is around 20-30%. (UNEP and GLAVGIDROMET, 1999) This is one of the reasons why agriculture is possible only through irrigation. Whereas in Murray-Darling basin 94% of the rainfall that falls in the basin is being used by plants (transpired) or evaporating from the land and surface water. The Murray-Darling Basin receives 530,618 GL or 530 km^3 of annual rainfall. Of this, 94% evaporates or transpires, 2% drains into the ground, and the other 4% becomes run-off (Pink, 2010).

The climate in Yellow river Basin is influence by the continental monsoon circulation system, with mean annual precipitation of 500 mm throughout the basin. But it is unevenly distributed across space and time. The basin is divided into three reaches.

The upper reach of the basin is influenced by highland climate which is at the source of the river and semi-arid continental climate. The source of the river Qinghai-Tibet Plateau is the world's highest and largest grassland Plateau altitudes is around 4500m and above with highland climate precipitation around 300mm. exiting the source region, the river travels to the north and enters the Gobi Desert and Ordos Plateau. The climatic condition here is Semi-arid Continental Climate with precipitation around 150mm (Wohlfart, C. et al. 2016).

Crossing this region the river turns south to Loess this is the second reach of the river. The climate is Semi-arid monsoon climate with average rainfall reaching up to 750 mm, and temperature ranging from 12 to 14^{0}C. The large part of the rainfall occurs in the summer months from July to August (Wohlfart, C. et al. 2016). More than 60% of the rainfall is received during June & September; this is partly due to intensive rainstorm. (Yang and Ishidaira, 2010).

At the end of the Loess Plateau region the river makes a sharp turn to east towards its delta in Bohai Sea. This region of the basin is alluvial plain area with elevation around 200m. Like the middle reaches the basin in the lower region also receives high rainfall averaging around 700mm (Yang and Ishidaira, 2010)

Compared to other major rivers of the world the water run-off in these three rivers is also quite low. Table 1 illustrates that.

Table 2: Water Run-Off Comparison. *(Source: PG-2; Savoskul. O.S. & Smakhtin. V. 2013)*

Water Run-Off Comparison	
River	**Water Run-Off**
Brahmaputra	687 km^3
Ganges	445 km^3
Mekong	466 km^3
Indus	235 km^3
Amu Darya	**79 km^3**
Yellow river	**49 km^3**
Murray-Darling River	**23.7 km^3**

2 MIS-MANAGMENT

2.1 Amu Darya Basin

The Soviet planning for converting Central Asia as cotton hub, for which the whole nature of rivers was transformed for the irrigation of land. It was based on "Transformation of Nature", a Marxist-Leninist philosophy. Its basic elements were "*the purposeful change of the geographical environment consciously undertaken for the improvement of natural conditions in the interest of mankind*" (Kelly, P.M. et al., (1983), p.208)

Both inter-republican Amu Darya and Syr Darya basin were among the first river basins which experienced massive world-wide infrastructure development in 1930s Kelly, P.M. et al., (1983). The others were Murray-Darling in 1914 and in 1930s Tennessee valley in United States of America. All of these projects had technical outlook to the rivers undertaken by engineers for optimizing the benefit derived from infrastructure development & operations.

The phase started with completion and initiation of various irrigation infrastructures like KaraKum Canal, Reservoirs on Syr Darya and Amu Darya were completed. The irrigated area in Central Asia of both the river basins increased by 153% from 4.51 million in 1960 to 6.92 million hec in 1985 and by year 2000 it reached 7.85 million hec. Desert in Qarshi, Sherabad and Mirzachal zones were integrated with irrigation projects for cultivation of cotton (Kazbekov and Qureshi, (2011). The orientation was irrigation and not electricity generation to promote cotton production (UNDP: Weinthal, (2006). The growing season in Central Asia starts from April to September and from October to March. The Upper riparian states were required to hold water in winters to supply for April to September and in return they got fossil fuels in winter for electricity. This arrangement came to known as Soviet gas-coal-water-electricity barter arrangements.

Uzbekistan became the epicentre of cotton monocracy. Around 170,000 kms of canals were built to irrigate the land for cotton. From few hectors around the oases the arable land increased to 7 million hecs by 1980s. That is around 89% of arable land is irrigated (Environmental Justice Foundation (EJF), (2012).

The outcome of this Grandeur Project by 1970s started to reflect with the shrinking of Aral Sea. By 1974 Syr Darya which was the most regulated river of Central Asia dried up before reaching its delta in Aral Sea. As all the water resource was state property and therefore was provided as "free good". This led to water use inefficiencies. The water withdrawal in Central Asia increased from 64.7 km^3/hr in 1960 to 120 km^3/hr in 1980 i.e. increase in water use by 53.9% (UNEP, 2005: Severskiy, et.al. (2005).

Due this large water withdrawal from the rivers the result started showing up as early as in 1962, when Muynak which was costal on the delta of Amu Darya became a peninsula after Aral Sea started receding due to four years of water withdrawal from Amu Darya (Hinrichsen, (1995).

The Soviets declared cotton as industrial crop for which monocracy of cotton crop in Central Asia was forced. Mono-cropping is an agricultural practice in which the same crop is planted year after year, without practicing crop-rotation or resting the soil. The hallmarks of industrial crop production are: Mono-cropping, intensive application of commercial fertilizers, heavy use of pesticides, reliance on genetically engineered (GE) seeds and intensive irrigation (http://www.sustainabletable.org/804/industrial-crop-production).

This replaced the traditional crop rotation practice with regard to agriculture. Hence this led to dependency on mechanization, pesticides, herbicides and fertilizers. Damming and reservoirs on the rivers restricted the rivers silt to reach the downstream areas, thus negatively effecting soil recharging capacity.

Due to over irrigation salinization of soil in Amu basin of Uzbekistan is around 66 percent. This requires the process of Leaching i.e. to drain salt from the top soil. This has led to 93.4% of water withdrawal from Amu Darya (UNCTAD: Golub, (2015).

Cotton was grown in Central Asia and in Uzbekistan since 5^{th} & 6^{th} century but within the crop rotation model. The climate of Uzbekistan being continental arid and semi-arid is appropriate for heat loving cotton crop. The problem is soil condition and high levels of evapotranspiration in Uzbekistan. That led to excess water application per hec. In Uzbekistan 14000 m^3/s of water is applied to cotton crop compared to other similar climatic areas like Pakistan and Egypt about 9000 to 10000 m^3/s respectively. The yield in Uzbekistan of cotton has also decreased by 1990 due to monocracy to 700 kg/hec compared to other areas like Turkey 1330kg/hec and Australia 1560kg/hec (UNDP: Weinthal, (2006).

Even the irrigation infrastructures are highly inefficient. Massive water loss occurred due to seepage in in-lined canals and through evaporation in Uzbekistan which is around 1000 mm, the aridity contributes to around 14km^3/yr of water loss from the reservoirs and canals. It was always supply orientation which never took such issues into consideration.

2.2 Murray-Darling Basin

Murray-Darling river basin has very different Anthropocen footprints. Prior to the arrival of Europeans with their doctrine of terra nullius ('nobody's land', because no one lived there!), Murray-Darling basin was occupied by people known as aborigines for >40000 years. The basin is a part of Australian island. Australia was an isolated from rest of the world and was discovered in post-industrial year. It was only in 1800s, that the European arrived on the island and declared it terra nullius (Shiel, (1996). River basin has no documented human footprints. Murray-Darling basin is the largest river basin of Australia. Prior to European settlements, the basin and larger Australian landmass was inhabited by Aborigines, who survived by food gathering and hunting. The river basin didn't have any history of settled agriculture.

The Australian climate, frequent droughts in Murray-Darling basin especially the federation drought from 1895 to 1902 and low wool prices in the 1890s, changed the face of Murray-Darling Rivers from free flowing to being regulated. During the drought river systems

This drought and expedition of the Canadian brothers George and William Chaffey in the 1880s, who got successful at Mildura (Vic) and Renmark (SA), necessitated the irrigation in Australia (http://www.nma.gov.au/ data/assets/pdf_file/0005/19337/Murray_ Darling_full_colour.pdf). The success of Chaffey Brothers with irrigated agriculture, success of irrigation in Northern India during British Rule and the Soldier's settlement, a form of compensation for returning servicemen, was a major plank of agriculture policy between the two world wars and after 1945. The expansions of agriculture relied heavily on irrigation with the construction of inter-annual dams, wires and lock which reached its peak in 1970s. The first dam constructed was the Hume dame which got completed in 1929. The other major infrastructure development was the Snowy Mountain project which included hydroelectricity schemes. From 1949 to 1974 water was transferred to Murray-Darling Basin through a network of 16 dams and seven power stations, linked by 275 kms of underground tunnels (Molle and Wester, (2009).

These water infrastructures made the Murray-Darling basin the Australia's food bowl, the Murray-Darling River Basin produces some 40 percent (%) of the nation's agricultural products, including grapes, cotton, rice, and dairy. The Basin also contributes to the world's food supply through exports of food and fibre. It has been satisfying both the domestic and export market. The Basin feeds around 20 million people. Overall, the Murray-Darling Basin dominates irrigation farming in Australia. The total area of crops and pastures irrigated in the Basin is 1,472,241 hectares. This is 71.1% of the total area of irrigated crops and pastures in Australia (2,069,344 hectares), 18.7% of the total area of crops, pastures and grasses, and 1.7% of the total area in farms (Shiel, 1996; MacDonal and Young, 2001).

This magnitude of agriculture production also reflects in the consumption patterns of water in the basin. Agriculture had the largest share of water in 2004–05 in the Murray-Darling Basin, accounting for 83% of water consumption in the Basin; households (2%) and other industries (2%) consumed minor amounts in comparison. The remaining 13% of total water consumed in the Murray-Darling Basin was by the water supply industry, which includes losses in delivery systems. This pattern still continues. (Moore and Naughten, (2016). Figure 1 illustrates this pattern.

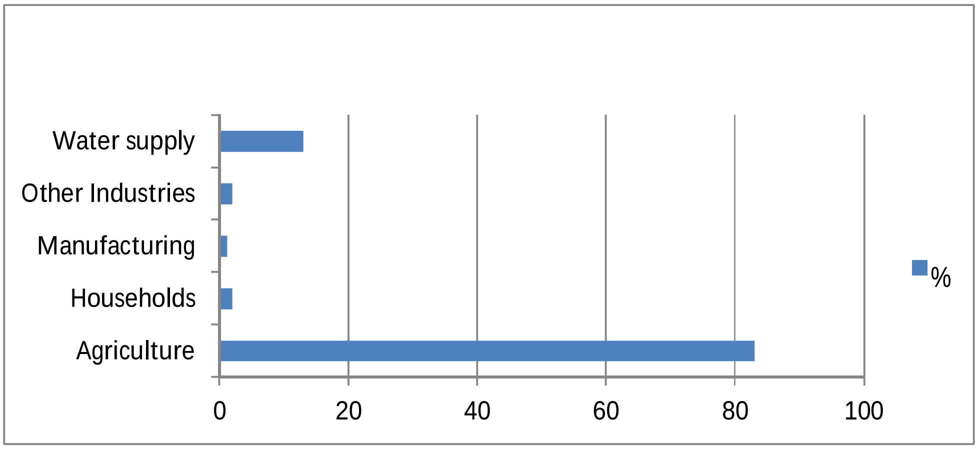

Figure 1: Water Consumption in the Murray-Darling Basin 2004-2005. (*PG-124; Pink, B., 2010*)

This kind of extensive water consumption has led to intensive water resource development. It has affected the both water quality and quantity with regard to surface run off in the Murray-Darling River system. The average flow of the river at the mouth has reduced by 61%. 75% of all water is taken out of Murray River. The incidents of cease-to-flow period have increased from 1% of the time under the historical climatic condition to 41% of the times (Glazer and Likens, (2012). Only 27 per cent of the Murray River's pre-European flow now reaches the sea. The mouth was first closed with sand in 1981 and now needs permanent dredging to stay open. Table 2 highlights the incident of Murray-Darling rivers flow to its delta/mouth. The outflow has reduced from 54% to 21%. The water loss has occurred due to water diversion required for agriculture and due to evaporation from the reservoirs.

Table 3: Average Annual Water Balance for Murray-Darling Rivers.

	Natural Conditions (GL/Year)	Current Conditions (GL/Year)
Runoff	23,850	23,850
Inter-Basin Transfers	0	1,200
Diverted	0	11,520
Evaporated from Reservoirs	0	1,100
Consumed by Wetlands, Floodplains etc.,	10,960	6,970
Outflow to Sea	12,890	5,070
Outflow to Sea as a % of Runoff	54%	21%

2.3. Yellow River Basin

From being a 'river of sorrow' because of its floods now the Yellow river is water stressed. The water stress is caused by drying up phenomenon in the lower reaches of river, as the river failed to reach its delta. Particularly since 1970s this drying up of Yellow river flow is a combination of climate change and particularly by Anthropogenic (Yan-fang SANG et al. (2011).

Yellow river dried up in post-World War Second era for the first time. It has dried up more than 30 times in the recorded history and failed to reach its delta as its water was all used up. It ran dry throughout 1990s. In 1994 it ran dry for 122 days, as water in the river got finished 180 miles from its mouth/delta in Yellow Sea. In 1997 the river failed to reach its delta for 226 days, producing dry river bed stretching 372 miles from its delta. It failed to reach Shandong Province, the last Province on Yellow river en-route to the sea. (http://www.worldwaterconservation.com/chinawater1.html) the outflow on the river was reduced by 10% of the outflow of 1940s. By the beginning of 2000s more water which was held back by dams & reservoirs was released to maintain the necessary flow in the river and to arrest the drying up phenomenon in the river. Table 3 illustrates it.

Table 4: Interruption of water flow in Lower Yellow river.

Period	Number of Years with Incidence of River Drought	Number of days with River Drought in Decade	Longest duration of River Drought in Specific Year. Days (year)	Season with Occurrences of River Drought	Frequency of River Drought (%)	Average Length of dry river bed (km)
1960-69	1	41	41(1960)	April/June	10	
1970-79	6	71	19 (1979)	April/June	60	242
1980-89	7	103	37 (1981)	April/June	70	256
1990-99	9	909	226 (1997)	Feb./Oct.	90	700

(source Wang, Y. Et al. 2001, pg-507)

The climate change effects are felt more in Upper & Middle reaches affecting the stream flow, whereas anthropogenic factors dominate annual river runoff in lower reaches (Tang, Q. Et al. (2007).

According to Greenpeace China Yellow river basin has experienced a rise of 0.88^{0}C in average temperature in post-world war second era. This can be experienced in glacial retreat, late formation of permafrost and its early melting and degradation of numerous lakes and wetlands that feed the regions rivers. As a result of this it is becoming drier each year, its fresh water reserves have declined by 13% between 2000 & 2009. Severe droughts occurred in 2000, 2007 & 2009 (Cho (2001). The rise in temperature has affected the precipitation patterns negatively and at the same time boosted evaporation rate in the basin, affecting the river flow negatively and also leading to disappearance of section of head water.

In 2006, the official New China News Agency reported faster glacial melt across Qinghai-Tibet Plateau, the source of the river. The glaciers are melting at a faster rate of 7% due to global warming and have shrunk by 17% since 1980s, due to an average rise of 2^{0}C temperature over Tibet at the source of river. This has affected the rainfall negatively; a fall in rainfall events, warming of temperatures has thawed the surface layer of Permafrost and disrupted underground water channels. Underground water levels are sinking due to excess moisture being absorbed deeper into the warmer grounds as a result of this less water is funnelling into the Yellow river (Yardley (2006). In the lower reaches of the river the precipitation fall was around 2% to 10% in post 1970s era (Zhang, et al., (2012).

The precipitation change phenomenon accounts for 40.8% of times for fall in stream flow, from 1970s to 1990s China experienced an average fall of 10% in precipitation affecting the runoff by 30% of the normal years (Changming and Shifeng, (2002). Table 4 illustrates that.

Table 5: Rainfall and Runoff in the three Reaches of Yellow river. (*Giordano, M. et al 2004, pg-18*).

	Area (000 km$^{2)}$		TIME PERIOD					1990s Change from Average
			1956-70	1971-80	1981-90	1991-00	Average	
Upper	368	Rain (mm)	380	374	373	360	372	-3%
		Runoff (BCM)	35	34	37	28	34	-16%
		Runoff Yield (%)	25%	25%	27%	21%	24%	-13%
Middle	362	Rain (mm)	570	515	529	456	523	-13%
		Runoff (BCM)	29	21	23	15	23	-34%
		Runoff Yield (%)	14%	11%	12%	9%	12%	-25%
Lower	22	Rain (mm)	733	689	616	614	671	-8%
		Runoff (BCM)	1.5	1.1	0.6	0	0.8	-100%
		Runoff Yield (%)						
Basin	752	Rain (mm)	482	451	455	413	454	-9%
		Runoff (BCM)	65	56	61	43	57	-24%

The fall in rainfall at the source is lowest; lower in the Lower reach but maximum at the Middle reach. The fall in water runoff is highest in the lower reaches followed by middle course and is least in the upper course.

Climate change leading to temperature rise, dryness and fall in precipitation has led to fall in water runoff in Yellow river. Droughts along with floods have been a regular feature in the river basin. Records show that between 206 BC and 1949, China experienced a total of 1056 severe droughts, with an average of one severe drought in every 2 years. But between 1950 and 2008 18 extreme droughts hits were experience with an average of 3.2 droughts per year. (Cho (2001).

Apart from the climatic factors, human have also negatively influenced the water runoff in Yellow river leading to dry up of the river. Water withdrawal from limited Yellow river runoff of 58 km^3 has quadrupled which has dried up river in lower reaches. The consumptive use of water has been the feature of water use since 1950s in China. Agriculture in Post Second World War has become the main source of consumptive use to water, accounting to 80% of water withdrawal in China.

Agricultural irrigation began more than a thousand years ago in the river basin as result agricultural society appeared on the Yellow river bank more than 7000 years ago (Hays (2009). In ancient times irrigation was carried by canals using natural flow of water. The Zhenggno canal was completed in 246 BC during Qin Dynasty it irrigated about 80000 hectares (hec) of land in the North of the present Xi'an. During the Han Dynasty which unified China developed the first dedicated river bureaucracy for Yellow river. A new office known as the Director of Water Conservancy (Tu-Shui) was created under the ministry of Public Works (Yang and Ishidaira, (2010).

In Post Second World War particularly since 1950s to initial years of 1970s vast irrigation projects came up in the middle reaches to the upstream of Huayuankon Gauge and about 7.13 million hec of land was brought under irrigation. This increase is nearly a factor of 10 since 1950s. In lower reach due to the suspended river that is lower to Huayuankon Gauge water was diverted to outside areas from Yellow river Basin for irrigation (Yang and Ishidaira, (2010).

In the upper reach in Hetao Province and where the river turns to East, there existed the old oasis agriculture. Due to reservoirs water availability was made easy. For the people of the region the party propaganda the limitless use of water. This led to misuse due to over irrigation from 1959 to 1961. About 80% to 90% of water use in the region was withdrawn for agriculture. Due to the absence of drainage system in the region the problem of salinization appeared, leading to fall in farm productivity. The region used six times more water to produce a pound to grain compared to lower reaches. Due to problem of salinization irrigation was stopped and was restarted in 1970s with drainage system (Giordano et al., 2004).

By 2009 the total effective irrigated area in the basin was 7.51x106 hec of which about 60% that is 4.5x106 hec, comprised of 70 large scale irrigation districts with larger than 201x03 hec of the command area. Middle scale irrigation existed in 670 districts from 670 to 20000 hec, it accounted for 15% of the total irrigated area. Small scale irrigation existed in remaining 25% that is about 1.90X106 hec was irrigated. For this amount of irrigated area the water diversion from Yellow river increased from 7.9X109 m^3/yrs in 1949 to 30.8X109 m^3/yrs. The amount of water withdrawal increased from 1949 level by 390% (Yang and Ishidaira, (2010).

To satisfy huge population of China agriculture has become single largest consumer of water amounting to 81% that is more than world average of 70%. The rise in irrigate agriculture in Yellow river basin is around 347.2% that is from 140.3X10^4 hecirrigation area in 1950-59 to 487.1 X10^4hecin 1990-95. This rise in agriculture led to water consumption increased by 245% that is from 12.23 bcm in 1950-59 to 487.1 billion cubic meters bcm in 1990-95 of which agriculture constitutes 80% of water consumption (Giordano et al., 2004).

In Yellow river basin water use is also highly inefficient. Farmers are using 15 times more water for same quantity of crop ground anywhere else. Factories in China consume about 20 times more water to produce a ton of steel compared to Western factory. And 30 times more water than used by Japanese industry for the same product. (http://on.aol.com/video/yellow-river-drying-up-in-china-481387885g Up in China).

China in order to become self-sufficient in food production and to satisfy hunger of growing population which is highest in the world departed from traditional irrigation system to Western philosophy of taming rivers. The communist approach to Yellow river has been a departure from earlier attitude to Yellow river. The new government view Yellow river floods as a threat to development of China and wanted to get rid of yellow colour of the river as it wanted to make it clear. Hence projects were undertaken to control the flooding in the river and to utilize it for irrigation, energy and transport. This new approach led to Chinese seeking Soviet help to tame Yellow river floods. The new approach led to capital intensive project which were to be financed by Soviet Union. The project started with construction of Sanmenxia Dam, but it failed in first two year as result of sediment deposit, as there was no provision for sediment outlet in foreign Soviet Design. The Soviet exist from China due to their political difference, did not hamper Chinese enthusiasm for hydro projects. The government continued to invest in these projects. Irrigation and dam construction continued through 1950s under the slogan "Big diversion, Big irrigation" (Smil, 1979).

By 1955 program to tame Yellow river and to provide power and irrigation the govt approved 46 dams on the river with capacity of 23000 megawatts of power, along with tens of 1000s small dams on its tributaries with total head of 1537 metres (mts), further to generate 110 million kilowatt hours, the irrigated area was to be expanded from 1.09 to 7.73 million hec and to stretch the navigable section of the river from 160 to 3610 kms. This was to achieve ambition of General Mao to control river permanently and to make its water clear (Mei-e, 1995)

By 2012 there were 29 large reservoirs across the river basin. The flow events to control floods are contained by 10 large dams on the main stream plus 3100 small reservoirs along with the channels with total storage capacity of 58 bcm that is almost whole of the river. Of the 29 large reservoirs 12 of them have capacity of 60.9 Km^3 with effective capacity of 38.5 Km^3. If we take the average runoff of the river as 58 Km^3 then the effective capacity of 38.5 Km^3 is 65% of total runoff. This storage capacity has ripped off water from river during the drought years when the runoff was 49 Km^3. The construction of reservoirs and rising withdrawal of water from the river has resulted in drying up of river in lower reaches. Due to huge water consumption from Yellow river leading to water depletion has to the development of river characteristic of intermittent river. The water flow at the last gauging station Lijin has decreased from about $150X10^8m^3$ to about $45X10^8m^3$. The water diverted to reservoirs and dams has reached to alarming rate of 30 km^3 that is even more than 60% of river runoff. In Shandong Province amount of water diverted was $88.2X10^8m^3$ between 1986-90 reaching to 123 $X10^8m^3$ (Yang, D. Et al., 2010).

These hydraulic infrastructures have also negatively affected quality of the sediment that was carried by the river. The river carries sediment coarser than .05mm. The heavy sediment settles at the bottom of the reservoirs thus the lighter sandy sediment gets carried by the river. Reducing the quantity and quality of coarse sediment reduces the rate of channel accretion thus inviting heavy expenditure on dyke construction, thus risking flood prevention. The land fertility also gets affected as sandy sediment is detrimental to crops and aggravates the desert expansion (Shiyang, 1987).

The dams and reservoirs have aggravated the loss of water by evaporation. In China the water loss due to evaporation in Yellow river basin is about 1.00 to 9.95% of the annual runoff volume of outflow from the reservoirs that is about 12 km^3/y of water lost to evaporation, this is about 20.7% of water from the river given the river runoff of 58 km^3/y (Shiyang, 1987).

3. CONCLUSION

Agriculture is the largest consumer of water; the world average is around 70%. But in the above mentioned basins the share of agriculture water consumption is more than 80%. This high water consumption in these basins is fuelled by the adoption of NTC and farming methods. The non-traditional crop like cotton and its monocracy in Uzbekistan; wheat, rice, cotton and corn in China and again combination of wheat, rice and cotton and other water intensive crops in Australia. In respect of China the shift to NTC was necessitated by growing large population. In case of Uzbekistan cotton monocracy as erstwhile Soviet Union needed to become self-sufficient in cotton. Australia graduated from meat and fur exporter to United Kingdom to cereal and fibre supplier for the world.

To support these NTC's the respective governments went for non-traditional hydrological infrastructure like Dams, Reservoirs, Weirs, Locks and open canals to bring water to trans-basin areas. These infrastructures were also built to mitigate societies from the problems of floods and drought.

The canals have brought water to trans-basin area and ushered green revolution. But at same time have proved detrimental over the period time, as they are the biggest source of water loss due to evaporation and seepage. Water availability was made easy and subsidised by the respective governments of the basin. This has led to cropping of NTC which were crops of temperate and high rainfall zone. Problems of over-irrigation leading to salinization of soil appeared and the same was one of the reasons for the fall of Mesopotamian Civilization.

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