THE CHALLENGES OF WATER RESOURCES AVAILABILITY AND DEVELOPMENT IN HUAI RIVER BASIN, CHINA

ABSTRACT

The impact of climate change was examined on the processes for water uses in domestic, production and eco-water consumption, which is central to the allocation and conservation of water resources in the ecological system and socio-economy in arid Northeast of China. The population growth requires adequate supply of water especially during glacier ice- melt, anomalous rainfall, water pollution and reservoire dwindles. Our focus on the relationships between natural factors and social factors, as well as effect of different scales of water use for socio-economic expansion and ecosystem water demand. It incorporates the factors of water ecology-economy and water social economy into a large intricate system with respect to the interactive relationship between socio-economic and eco-environmental systems. Again, it empirically measures changing water resource susceptibility under several climate and human activities which develop coherent water resource allocation thresholds to deliver sustainable growth of ecosystems and the socio-economic system in the China's northeast region. The paper recommends measurable adjustments to present regime of water utilization in regards to impeding and inevitable changes in climatic and human actions around the Huai River Basin (HRB) tributaries. In effect, outcomes of the research will assist in mitigating imminent water scarcities and shortages for both economic and social development of the study area.

Keywords: Water Resource, Availability, Challenges, River Basin, Scarcity, Allocation

INTRODUCTION

Huai River Basin is a preponderantly evolving area in China. The number of industries serviced by the Huai River Basin (HRB) is continuously on the increase including paper making factories, production of coal chemical, textiles and food processing. One major industry having unprecedented growth on the basis of the basin is agriculture, which has been used to produce rice, wheat, soya beans, and cotton. The basin spreads its tributaries to four main cities including Luohe, Zhenghou, Zhoukou and Bengbu which share several infrastructural lands such as sluices, dams and other water project constructions; (Ma, 2006; Yang et al., 2012).

At the heart of the Huai River Basin is droughts controls system which is made up of over 5000 sluices and 57000 reservoirs (Zhang, Liang, & Shao, 2010). Obviously, Huai River Basin facing several issues common to infrastructure similar to it around the world. Apart from using certain tributaries as source of water supply for populace; it is the site for disposal of wastes from agricultural, domestic and industrial activities. The basin is

highly susceptible to pollution from chemical, metal and organic substances. Agricultural practices cause pollution due to chemical wastes washed-off from fertilized land. Similarly, organic and metal wastes are generated by industries around the basin. In addition, most of the cities surrounding the basin whose huge piles of untreated sewage are dumbed or eventually washed-off into it (Goudie, 2006).

In 2009, sewage of over 8.6 billion m^3 was discharged into the Huai River whose 78 % capacity was short of chemical oxygen demand (COD) and ammonia nitrogen (NH_3-N) required combinations in drinking water (Huai River Commission, 2009). As expected, the uncontrolled pollution in the river is a serious concerned. According to studies conducted by (Huang, et al., 2004); (Wang B. Y., Zhang, Hu, & Wang, 2006); (Hu, Wang, Deng, & Li, 2008); (Zhang, Liang, & Shao, 2010), an estimated 200 or more severe water pollution happened throughout the Huai river basin channels (Huang, et al., 2004); (Wang B. Y., Zhang, Hu, & Wang, 2006); (Hu, Wang, Deng, & Li, 2008). There is presence of organic pollution prevailed in Huai River especially in tributaries such as Jialu River (Zhang, Tang, Song, & Li, 2009) and the Jiangsu (Ma, Wang, & Wang, 2005); (Wang, Yu, Huang, Hu, & Wang, 2009); (Wang B. Y., Zhang, Hu, & Wang, 2006). Nevertheless, much is not done in terms of the effects of hydrochemistry caused by human actions on the Huai River. In another study, (Zhang, et al., 2011) investigated the Huai River's ion chemistry control mechanisms; but, no mention was made to specific statistics for dry season situation. Consequently, a sampling campaign was embarked upon in the middle of 2009 which is dry season in order to identify the hydrochemistry in the upper spreads of Bengbu Sluice in Huai River Basin.

There is ever increasing rate of human advancements giving rise to intense changes universally both in climatic conditions and forms of land-use in catchments. In general, the effects of these changes on environment and ecological advancement are receiving extensive attention (Vorosmarty, Green, Salisbury, & Lammers, 2000); (Li, Liu, Zhang, & Zheng, 2009); (Ma, Xu, Luo, Aggarwal, & Li, 2009); (Yang, et al., 2010). On a catchment scale, the effects of these processes of hydrology including infiltration, groundwater recharge, and runoff continue to adversely take tolls in the sense of balance of water resources' demand, supply and quality of water; thereby causing imbalances in

environment, ecosystems, and economy. The direct consequences of land use change are rate of flood incidences (Brath, Montanari, & Moretti, 2006), base-flow (Wang B. Y., Zhang, Hu, & Wang, 2006) and annual mean discharge (Costa, Botta, & Cardille, 2003), whereas the variability of climate can alter the peak-flows, flow routing time, and volume (Prowse, 2006). In future, an effective planning, management and water resources development requires an adequate knowledge of the influences of climate variability and land use forms on hydrological processes.

One approach of estimating the effect of management on water, chemical yields of agriculture, and sediment is Soil and Water Assessment Tool (SWAT) which is a physically based, basin-scale, spatially distributed, and continuous-time method operating on basis of a daily time step whose goal is to estimate the influence of management on agricultural chemical yields, sediment, and water in watersheds.

The problem of water cycle and distribution in areas bounded by Huai River Basin are common features in local and regional scales. In this arid Northeast region, water resources are a key factor restricting socio-economic development and affecting ecological security, and plays a significant function in attaining sustainable socio-economic development in the imminently (Chen Y. , Li, Li, & Li, 2016). Major factors attributing to these are the land use, land cover and climate change; unprecedented increases in the annual temperature trend while annual rainfall is relative stable over the period of time. These climatic conditions however are among the major issues affecting the present-day human communities in the Northeast China environs. Thus considering the above facts, the present review aims to provide a detailed information on the climatic conditions and human factor on water resource cycle of Huai River Basin. The information will be useful for the ascertaining the degree of variation in water resource availability and development caused by human and climatic condition.

HUAI RIVER BASIN DESCRIPTION

The Huai River Basin stretches from 30_550N to 34_560N and 111_550E to 117_300E, which encompasses the upper reaches of Bengbu Sluice, including the Ying River, Guo River, Shi River, Feng River, Pi River, and the mainstream of the Huai River. The Huai River originates from the Tongbai Mountain in Henan Province, flows easterly through

southern Henan, northern Hubei, northern Anhui, and northern Jiangsu, finally into the Yangtze River at Jiangdu, Yangzhou.

Elevation of the study area ranges from about 23 m to 2,153 m. Variations in elevation are indicative of different land-use patterns and climatological changes. Over 50 % of the study area is cultivated land. The chief enterprises include textiles, chemical pesticides, food processing, alcoholic beverages and wine in Bozhou, Fuyang, and Bengbu. The major urban areas are the metropolitan areas of Zhoukou, Fuyang on the Ying River, Bozhou on the Guo River, and Bengbu on the Huai River (NBS Survey Office in Anhui 2010). The climate throughout the study area varies from northern semi-tropics to sub-humid with warm, moist summers, cool and dry winters. Average temperature ranges from 11.8—16 ^{0}C while the temperature could reaches up to 28 ^{o}C in summer. The mean annual precipitation was 600–1,400 mm per year and most of the precipitation falls in the form of rain during the four-month period from June through September (Wang et al. 2001). Monthly variations in the water discharge of the Huai River main channel show an appreciable seasonal variability with low discharges in the dry season (October–May) and high values in the wet season (June–September).

WATER RESOURCE CHALLENGES IN HUAI RIVER BASIN

Three parameters for measuring water quality including NH_3-N, industrial wastewater discharge, and COD used in the west region of the river basin showed greater discharges when compared to the eastern region, and pollutant discharges in nearby Nansi Lake were at a high level than other regions. Obviously, there were regional discrepancies in values of industrial output, COD discharges, NH_3-N, industrial wastewater. The regions having huge industrial wastewater discharges were centrally situated. Regions in east revealed lesser and stable quantities of industrial wastewater discharges as against those in the west.

Conversely, entire industrial output was considerably greater, while industrial pollutants discharges were lower in the Luozhuang District and Zoucheng. In 2010, the association between industrial output values and discharges of industrial wastewater was examined

using a correlation analysis at the county level and a significant correlation (0.614 and 0.312) was observed between the quantities of industrial wastewater, industrial output value and industrial COD discharges (s, 0.614 and 0.312 correlation indices respectively) as depicted in Table 1 (Guoyong et al., 2015).

Table 1 Correlation between pollution load and industrial output in Huai River Basin and Shandong Region.

	Industrial output value	Wastewater	Industrial COD	Industrial NH_3-N
Industrial output value	1	0.614**	0.312*	0.233
Wastewater discharge	0.614**	1	0.813**	0.592*
Industrial COD	0.312*	0.813**	1	0.755**
Industrial NH_3-N	0.233	0.592**	0.755**	1

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

The construction materials are considered as high-energy-consumption/low-output/high pollution industries; textiles, electric power, and petrochemical are considered as high-energy-consumption/high-output value/high-pollution industries; and the medical manufacturing and mechanical sectors are low-energy-consumption/high-output value/low-pollution industries. The food processing industry contributed 11.4 % of economic production, and 23.55% and 26.05 % of COD and NH_3-N discharges respectively. Again, it was found that no significant correlation existed between the quantity of industrial NH_3-N discharge and value of industrial output. The Gross Domestic Product (GDP) per capita of the Huai River Basin with in Shandong Province (HRBSP) and the four cities situated nearby (Heze, Zaozhuang, Jining and Linyi) is expressed as the economic factor, and the industrial wastewater discharge is expressed as the industrial load factor.

The Gross Domestic Production (GDP) of the four prefecture-level cities improved suddenly at 18.2 % per annum, which indicates the speediness of economic growth, particularly in the Heze city that has the fragile economic grounds in Province of

Shandong. At the beginning stages of economic growth, industrial water pollution treatment investment could be negligible.

During early stages of industrialization, the primary industries were trailed by secondary industries. Results of industrialization led to a greater percentage of secondary industries as against primary and tertiary industries. The decline of primary industries by less than 20 % was matched with the corresponding secondary industries though surpasses tertiary industries, which was known as mid-stage of industrialization process. Whereas primary industries drop to nearly 10 % which led to a number of secondary industries reaching its highest while the supremacy of tertiary over secondary industries gave rise to the emergence of the post-industrial phase (Kuznets, 1986); (Li, Wei, Wang, & Zeng, 2015).

In 2010, it was estimated that the GDP of the HRBSP was put at 810.14 billion Yuan. The primary, secondary, and tertiary sectors contributed 11.32%, 50.23%, and 38.46 % of the industrial arrangement in the study area, with respect to industrial outputs valued at 100.71, 430.77, and 278.66 billion Yuan.

HUAI RIVER BASIN SOCIO-ECONOMIC DEVELOPMENT

There are several perspectives for the seemingly speedy and sluggish pace of growth in Huai River Basin. These include:

POPULATION DENSITY

In the socioeconomic development standpoint, the large-scale agricultural growth in the Huaibei plain started in the Jin and Wei empires over one thousand years past. During the period, grain production was predominant alongside mass migratory type of settlement. A great amount of people died in the natural disasters and turmoil of wars by end of Dougjin Dynasty in 316–420 AD. Land reclamation became popular due large-scale migration and large mortality numbers happened then again because of the regimes instability during the Tang and Sui dynasties. Similarly, the growth of Huaibei plain during the Song, Yuan, Ming and Qing dynasties stretched out from the upstream to the

middle region steadily occasion by massive people migration. Certain scholars attributed that population grew abruptly in the Qing Dynasty between 1616–1911 in the four provinces of Shandong, Henan, Jiangsu, and Anhui. In particular, the Anhui and Jiangsu population enlarged by 16.7 times more (that is, 3.45 million to 82 million); the Shandong population increased by 18.9 times more (that is, 1.76 million to 33.2 million); and the Henan figure even enlarged by 26 times more through the years 1851 and 1661.

In 2007, a total population of Huai River was estimated as 170 million, which is nearly 13% countrywide. In addition, the urban population estimate was 56.57 million, contributing 9% of total urban population China, and rate of urbanization of 33.3%. The average population density in the Basin was 631 people/km², 4.5 times higher than the national average figures, which makes it topmost in seven other river basins in China. In Huai River Basin, the GDP reached 2.2 trillion Yuan, with GDP per capita of 13.2 thousand Yuan. The total cultivated land in the basin area was 190 million mu, which is about 11.7% nationwide. Though, rate of land per capita was 1.12 mu (about 0.075 ha), lesser than the national average estimates. Also, the total grain output was 94.9 million tons, which is 17.4% of the national output figures.

Scio-economic development

The current population in the Huai River beach area and flood plain is higher than in the 1950s and 1960s. The fixed assets have improved significantly in terms of regional economic development. Once a flood occurs, its property damage will be serious. The recurrent natural flooding damages have constrained the regional economic growth. Consequently, the strength of local economy weakens, and the capability to manage disasters and production restoration after a disaster is short. Thus, socio-economic progress needs includes:

(a) Economic development: The speedy socioeconomic expansion in the Basin, the economy is expected to further grow, which will impact on its water demand especially in agricultural production, the industrial, urban and rural population. Socioeconomic progress in the Basin will accelerate the expansion pace of water conservancy projects,

water infrastructure improvement, increases in the water conservancy projects capacity, reinforcement of support capability of water resources in order to attain coordinated growth. More so, there is increasing need to strengthen the integrated management of water, which include water project optimal operation, allocation of water resources, enhancing water use efficiency, water consumption reduction, and the environment protection.

(b) People's livelihood improvement: Water conservancy expansion and people's livelihood enhancement are interwoven. The protection of life and property is related directly to flood control measures; whereas mental and physical health is linked to drinking water safety, and improvement of water environment impacts on social harmony in which people live and work in peace and prosperity. There is opportunity for upgrading in the existing flood control and disaster mitigation system of the Huai River. In fact, wide portions are prone to the menace of flooding as well as several issues including water shortage, water pollution, inadequacy of water supply facilities, and safety of drinking water. In many areas, soil and water resources are overexploited, resulting in damages to the water ecological environment of varying proportions.

(c) Equally accessible basic public amenities: Natural situations and the socioeconomic growth level differ widely throughout the Huai River Basin giving rise to lopsided water conservancy growth, low capability and level of public service in this direction. To achieve a stable growth and bridge the development shortfall a coordinated and comprehensive expansion of the river basin water resources, enhance public amenity capability in water conservancy, encourage building of backbone and vital river harnessing ventures, reinforce the expansion of the river basin water resources, and speed up schemes to connect the low-lying portions, small and medium rivers. There is need to focus consideration on the development of rural water management, the capability upgrading to combat flood disasters, and advance water situations for rural economic and agriculture growth.

(d) Food security: In China, the Huai River Basin is provides most of breadbasket, which is a vital part in ensuring the nation's food security. Consequently, there is a necessity to increase construction and management of rural water conservancy structure for protection of cultivated land areas and control of flood, increase capacity for available irrigation zones, improve water-saving irrigation system, steadily develop the effective irrigation zones, expansion the irrigation coverage and management reinforcement.

Physical pattern

The arid Northeast region has exceptionally different features of water resource formation and conversion, spatio-temporal distribution and water cycle process, which are illustrative of those found in arid regions throughout the world. Oases and deserts in flat plains are short of water even with several sources of water and land. Oases and desert ecosystems are severely impacted by hydrological practices. The magnitude of oases is influenced by the quantity of runoffs such as glaciers, melting snow and precipitation. These sources are relatively sensitive to variations in hydrological practices and water conditions. Recently, studies have revealed that prospecting climate variations may lead to bigger disparity between spatial distribution of productivity and water resources, which may increase struggle over water for economic and ecological purposes (Chen, Li, & Fan, Progress and Prospects of Climate Change Impacts on Hydrology in the Arid Region of Northwest China, 2015).

According to the Fourth Assessment Report of the IPCC, one main obvious consequences of climate change is water cycles variations and matching changes to the coefficient of runoff (IPCC, 2007). Specifically, the arid northwest zone's land surface patterns and climate have been impacted by diverse characteristics of the water cycle. Water resources are multifaceted, and there is substantial elasticity in water resources and runoff. Whenever, there is slight variation in temperature and precipitation triggered by changes in climatic conditions; there is a substantial fluctuations in runoff leading to a major effect on eco-hydrological practices in arid zones. Fluctuations to water cycles of mountainous regions triggered by the effect of climate change further exacerbate the water system instability. Consequently, the reaction of water resources and future trends,

watershed surface water and groundwater water cycle processes and mechanisms in arid regions due to climate change have attracted global efforts.

GLACIER MELT WATER CHANGING TRENDS

The glacial melt inflection point, time of occurrence, the procedure and strength of its impacts on water resources in the arid northwest zone are a key hot spot in the debate on future water resource developments in the endorheic drainage basins of the region. Mountain precipitation and glacial melt-water are the core sources of majority of the northwest region rivers. Nonetheless, glaciers are tremendously subtle to change in climate, which further impact on water resources due to direct the influence on quantity of river runoff from snow reserves, and headwater glacial ice (Ma, Fan, Zhang, & Su, 2014). Global warning continues to affect precipitation and temperatures in the 20th Century; the mainstream of the glaciers throughout the world have moved back considerably, notably the fast retreat happening in the past two decades (Wang, Zhang, & Li, 2011).

Interestingly, this magnitude of change was totally unanticipated and tough to expound and forecast with available models. In Northwest China, Water resources are sourced from snowmelt and mountain precipitation, which are predominantly subtle to global climate variation as well as a substantial insecurity. Water formation in mountainous areas is realized from glacial meltwater and high mountain snow, low mountain bedrock fissure water, and mid-mountain forest precipitation (Chen Y. , Li, Li, & Li, 2016). But, climate variation results uncertainty in terms of the growth prospect and reduction of mountain glaciers and snow cover, and spatio-temporal variations in precipitation, which implies the ambiguity of future water resource trends under climate situation The rise in temperature and the global climate variations implies that glacial melt-water increases, runoff from rivers linked to melt-water will obviously increase. However, the huge quantity of small glaciers situated at lower elevation will increase abruptly.

FLOODING AND DISASTERS

By 1949, a number of management actions for a disaster alleviation and flood control system were set up in the Huai River, which was considered as a milestone in this regard.

The water storage capability in the upper part of the river was reinforced to cover an area of 27, 000 km^2 in control of a large-scale reservoir. The flood discharge ability upgraded considerably to 7000 m^3/s from 2000 m^3/s in the upper reaches; and to 7000–13000 m^3/s from 5000–7000 m^3/s in the middle reaches flanked by Wangjiaba and Hongze lake; and to 18270 m^3/s from 8000 m^3/s in the lower reaches.

The strength of the flood discharge system of Yishusi River system into the sea was upgraded to 14200m^3/s from 1000 m^3/s previously. The flood control standard is 10 years' frequency for the upstream of the Huai River, and 100 years' frequency for important flood control and protection areas and important cities. The standard for flood control has been elevated to 50 years' frequency for important flood control and protection areas in the middle and lower reaches of the Yishusi River. The flood control standard is elevated to frequency of 20 years for key trans-provincial tributaries in Huaibei with an exception of the Hongru River, which is frequency of 10 years. In addition, the conditions of flood-release for low-lying land hitherto susceptible to waterlogging were enhanced, and the river drainage standard of key drainage river ways has stretched to a 3-year return period.

The appreciation and the requirements for controlling flood are directly linked to socioeconomic growth, which continues to vary proportionately. Presently, the development of the Huai River has reached appreciable height when put side-by-side with local socioeconomic growth, but, there is need to enhance its flood control system. In fact, there is a stretch to achieving the requirements of socioeconomic progress. Obviously, the impact of this can felt in inadequate ability to store floodwater, lower flood-control standard in upper reaches, congested flood discharge in the middle reaches, poor flood discharge outlet, and small discharge ability in the Hongze Lake for low and medium water level.

INSECURITY OF MAIN STORAGE ZONE OF THE BASIN

The flood-storage zone in the Huai River and the beach areas are contribute vitally in the discharge, storage of floodwater and flood control safety guarantee. In 2010, a staggering

1.45 million people reside in floodwater storing and beach areas in the mainstream, while approximately 930,000 people are under this direct threat. The consequence is in the inability protect lives of people and property. Also, it disrupts the regular flood and the flood control of whole basin. In fresh development plan for the Huai River, there are measures in place for flood-storage modification and the resettlements of people living in the regions of floodwater storage and mainstream beach areas.

The immigration in the beach areas and the floodwater storage districts in the mainstream can be achieved peacefully through government's guidance, all-inclusive planning and steady execution to assist the residents in dangerous zones to transfer to safer zones, which charts the path to the disaster mitigations. Although flood plains are typically dangerous places for flood but also a fertile land which is good for agriculture. Therefore resettlement could not be a good solution.

INDUSTRIAL ACTIVITIES

In practice, water is the topmost critical resource for the sustainable growth of societies as well as for the basic support of all human and natural arrangements (Ni, Wu, Wu, Lu, & Chris, 2012). Naturally, water bodies possess distinctive geographical features in which river basins are a hydrogeological component. A basin is a whole drainage structure, whereby diverse water forms are cycled within the basin by means of continuous movement and mutual transformation (Sun, Zhong, Zhang, Liu, & Hua, 2007). But, the rate of human activity such as urbanization, industrialization, and the expansion of megacities, quantities of waste products and pollutants increases are discharged directly into waterways which have contaminated several groundwater aquifers (Abu-Zeid, 1998); (Biswas, 1991). Integrated water resource management of watersheds makes a single unit arrangement significant for synchronizing the growth of environmental safeguards and economic resources.

(Mays, 2007); (Mays, Groundwater Resources Sustainability: Past, Present, and Future, 2013) describe sustainability of water resource as the capability to utilize water in appropriate quantities and quality from the domestic to the universal measure to meet the

ecosystems and humans demands for the contemporary and the future to support life. It means the protection of humans from the harms caused by natural and human disasters which impact life sustenance. In this kind of management setup, there is a need to thoroughly comprehend the composite interactions between water use, land use and ecological quality, particularly from the perspective effects interconnected to human activities capable of triggering the ecosystems degradation (Cai, 2008).

In China, speedy growth of economic activities has open up fresh issues for managers of water resource, due to the increasing water demands and inadequacy of resources obtainable, combined with stark water pollution and different water-associated ecological trepidations (Liu & Speed, 2009). Consequently, China undertook a great deal of effort to stimulate continuous economic process, modify structure of industrial development, and advance organized reform at the same time (Zhang, Liu, Zhang, & Tan, 2014). Socioeconomic progress is a topmost and fundamental influencer on water quality of river basin, and the regional model of expansion, particularly in trends of economic progress and estimation of water pollution lasting cycle.

The Huai River Basin is situated between the Yellow River and the Yangtze River, which forms a geographical boundary between china's northern and southern regions (Zhao, Liu, Xia, Zhang, Yu, & Eamus, 2012). From the inception of 1980s, industrialization and urbanization of the Huai River Basin in Shandong Province (HRBSP) section have improved speedily, exacting great pressure on the region's water resources. After the 1990s, the structure of industrial setup of the HRBSP was developed with emphasis on industry fields such as chemical fertilizers, papermaking, tanning, and winemaking (Shi Y. , 1999) (Shi, 1999). Recently, the study area's secondary industries are very efficient as well as China's gross domestic product (GDP) biggest contributors. The river basin's main area lies round the Eastern Route of the South-to-North Water Diversion Project, which requires the rigorous water quality Grade III standard. The HRBSP's water pollution control scheme is evolving, which makes main dual goals of spring-cleaning diverse water bodies in the basin and the river ecosystem restoration far from being attained.

To attain improvements in water quality and industrial progress, the need to understand the connection between water quality and industrial progress cannot be overstated. Studies have shown that the consequence of economic advancements is emission levels increases, but there are prospect of reducing emissions through structural and technological modifications (de Bruyn, van den Bergh, & Opschoor, 1998). The twelve industrial sectors enlisted by the National Economical Industry Classification (GB/T4754-2002) were mostly secondary industries category. The water pollution loads (COD, NH_3^+) and industrial output values of these industrial sectors were acquired from the General Survey Database of Pollution Sources for Province of Shandong, which served as the basis for describing industrial pollutant loads by end of 2010. The pollution survey considered other industrial sectors such as agriculture, and domestic pollution sources. In addition, it took into account centralized pollution treatment facilities and pollution generation or discharge facilities. In particular, the industrial pollution sources survey take in the basic registration data of companies; production parameters; raw material consumption; conditions of facilities susceptible to pollution; statistics on the emission, control, discharge, and widespread exploitation of several kinds of pollutants; and the setup and operation of different pollution avoidance and control facilities.

LANDFORMS AND MOUNTAINS

According to (Chen Y. , Li, Li, & Li, 2016), the China's arid northwest zone is regarded as location of high mountains and large basins. The effect of these prominent physical features is great due to activities of plateau uplift, the East Asian monsoon, and westerly circulation. The outcome is creation of a special climate system consisting three key geographical entities such as oasis, mountains and deserts. This produces material migration and processes of energy conversion largely water-driven. The arid northwest zone is entirely massive, with composite regional topography and various ecosystems such as the Altay, Lofty Tianshan, the Gobi Desert Kunlun and Qilian mountain ranges.

Unlike, the special arid northwest region is different from low-latitude subtropical arid zones because its location is in the moderately humid latitudes, giving rise to its unique and composite climate structure. Studies have revealed that nearly 50 years on, the oases,

mountains, and deserts of Northwest China continues to witness diverse climatic changes. Obviously, this is evident in the variations and in the speed of temperature changes, precipitation and instability in the timings of climatic (Li, Chen, & Shen, Analysis of Changing Pan Evapouration in the Arid Region of Northwest China, 2013). In the same vain, there are substantial regional variances in climate change within the same ecosystem. In particular references to the high barriers formed by the terrain, the northern and southern slopes of the Tianshan Mountains continue to experience changes in climate conditions (Wang *et al*., 2015).

Again, the northwest zone is susceptible to the negative effects of human activities and global warming, which lead to instability in climate system and exceptionally profound to changes in worldwide climatic conditions. In the past 5 decades, the climate of Earth has warmed up with matching increases in temperatures around the arid northwest zone by twice or thrice rate, more than the global average figures. China's average levels of precipitation fell sharply, the precipitation variability enlarged with a matching rise in precipitation in northwest zones. These special changes in climate conditions are closely related to rise and fall in the Western Pacific Subtropical High, Siberian High, Qinghai-Tibet Plateau Circulation, North American Subtropical High, Circulation and other atmospheric pressure structures (Li *et al*., 2012; Chen *et al*., 2014a; Li *et al*., 2016a).

HUAI RIVER BASIN WATER RESOURCES CONSERVATION

In recent years, a number of drought disasters and flooding on a large scale are common occurrence annually due to the distinctive natural landscapes of the HRB. Certain water resource conservation schemes have been introduced including structural and non-structural approaches.

STRUCTURAL APPROACH

Approximately 5700 reservoirs have been built with an overall loading capacity of 30 billion m^3, in which 38 are big reservoirs offering a overall loading capacity of 20 billion m^3 as well as a 62 billion m^3 flood control capacity. In addition, over 17 flood detention zones and big lakes for mitigating flood incidences have been erected with installation capacity of 35.9 billion m^3 full loading, and a 26.3 billion m^3 capacity for flood storage. Several other artificial channels have been erected to cover a vast landmass of 2,100 km. Various kinds of dikes were created having a length of 50,000 km, and a key dike length of 11,000 km. Discharge capacity for River channel has been considerably supported, in effect, the upper mainstream channel discharge capacity increased to 7000m^3/s from 2000m^3/s. Similarly, the middle mainstream channel discharge capacity improved from 5000m^3/s-7000m^3/s initially and later to 13000m^3/s. More so, the middle mainstream channel discharge capacity was boosted to 18270m^3/s from 8000m^3/s. Recently, the mainstream in the upstream flood control standard is review after a 10-year period, while flood control standards of major flood protection zone, main cities in the lower and middle reaches were upgraded to a 100-year period of review. In the case of major tributaries, flood control standards reviews were modified from a 20-year to a 50-year period.

NON-STRUCTURAL APPROACH

non-structural measures of flood prevention regulation command system jointly form system mechanism for flood prevention and disaster reduction:

a) The flood monitoring scheme

Flood forecasting and hydrological data are the foundation for effective mitigating flood throughout rainy time of year. In 2014 alone, over 329 hydrological stations, 220 gauge stations and 2,488 rain gauges, 1,489 water quality monitoring stations, 324 moisture stations and 3,024 ground water monitoring stations make up a vast the hydrological network and flooding monitoring scheme were installed across the Huai River Basin. In addition to these stations, 1,250 of them were dedicated for the purpose of reporting and delivering hydrological data at different flood season. There are regular time interval

hydrological elements created as specified requirement for river flood prediction system (Huaihe River Commission (HRC), 2014); (Wang, Chiu, & Yang, 2016).

(b) Transmission of information

In practice, the country's telecommunication systems are used for transmitting hydrological information. There are provisions of special transmission lines for remotely situated reporting stations without telecommunication system coverage.

(c) Flood forecasting and warning

The Flood Fighting and Drought Defying Headquarters (FFDDHS) is responsible for flood forecasting and warning tasks carried out at diverse levels such as the river basin commissions, the central government, the provinces/municipalities/autonomous regions and prefectures. (Jiang, Xia, Wang, & Zhao, 2009); (Li, Bao, Xue, Hu, & Fang, 2008); (Ma, Fan, Zhang, & Su, 2014). Nowadays, an integrated system of flood monitoring, flood dispatching and flood control discussion, forecasting and warning which comprises weather prediction, flood monitoring and forecasting has been developed in the Huai River Basin which thereby support flood controls around river basin areas. Nevertheless, there is need for work to be carried out on flood risk management such as probability flood forecasting system, reservoirs and hydro-junction flood risk dispatching models (Wang, Chiu, & Yang, 2016).

d) Setting up of the drought-causing climate threshold

The Standardized Precipitation Index (SPI) is a technique for designating the drought degree in a quantitative manner. This is useful for indicating the intensity of drought and duration of drought in several regions (Yan, Wang, & Wu, 2010). Habitually, the Huai River Basin experiences the negative effects of unexpected heavy drought-flood change of events (Cheng, Xu, & Luo, 2012).

e) Water resource allocation

The evaluation of the climate change impact on the processes and intensity of future water use for manufacturing, domestic and eco-water consumption is a main challenge in deciding the most effective water allocation approach in compound water-ecology-social economy scheme of the arid northwest zone (Chen Y. N., 2014). The impact of global warming and population size explosion continue to trigger increasing demand for water in manufacturing, living and eco-environment purposes.

CAUSAL FACTORS EFFECTS ON WATER RESOURCES

The various variables and their representations in the study are presented in Table 3.

Table 3. Description of causal factors and assigned variables for the study

Variables	Definitions
Water Resource (WR)	Quality of water supplied per population
Climatic conditions:	
Rainfall (RAIN)	Rainfall
Precipitation (PREC)	Precipitation
Flood level (FLO)	Flood level
Temperature (TEMP)	Temperature
Humidity (HUM)	Humidity
River level (River)	River level
Human activities:	
Road (RD)	Construction of access roads
Drainage (DR)	Drainage channels blockade
Water supply(WS)	Water supply requirements
Population (POP)	Size of population
Electricity (ELEC)	Electricity dams on the rivers
Housing (HOU)	Private Housing
Waste disposal (WD)	Waste disposal in rivers an basins
Pollution source (POLL)	Pollution material generation
Industrial (INDUS)	Industrial activities
Land-use:	
Rice farming (RICE)	Rice plantation
Agriculture (AGRIC)	Agriculture purpose
Irrigation (IRRIG)	Irrigation farming

Forestry (FROST)	Forest conservation
Residential (RESID)	Residential area

RECOMMENDATION

In order to adapt to the varying flood control requirements, additional upgrading is needed for the Huai River disaster mitigation and flood control project system: :

a) To build 10 large-scale reservoirs such as the Chushandian Reservoir.
b) To reinforce reservoirs and sluices in dangerous state, and upgrade flood-discharge capacity in the upper reaches.
c) To enforce complete control of the Huai River by adjusting the mainstream flood-discharge areas, raise flood channels for medium-scale floods, and combine flood discharge capacity in the middle reaches;
d) To harness the river way to supply water into the Yangtze River, and strengthening the levees of the Hongze Lake, building the 2nd phase water project to access water into the sea by building the Sanheyue big sluice.
e) To improve and consolidate the flood control in the basin's lakes and its backbone river flood control engineering system.
f) To expand the flood discharge capacity through diversion water to the south from the east in the Yishusi river system using existing scheme.
g) To build flood storage and retention zone, and standardized levees.
h) To connect main tributaries such as the Shaying River, the Hongru River, and small and medium rivers step-by-step.
i) To undertake activities such as dewatering, storing, interception.
j) To harness waterlogged low-lying zone using sensible low-lying land subareas.
k) To reinforce the building of seawalls and city-wide flood control in order to increase the flood control and disaster mitigation scheme.

CONCLUSION

Global response to climate change and the actions required to mitigate its effects upon most components of the natural ecosystems and human activity. Huai river being a home to morethan 200 million people with vast agricultural undertaken driven by sustained

rapid growth of agricultural and industrial activities is facing.The present-day human society of the Northeast China arid region, an area susceptible to evolving global climate change, relies on mountain precipitation and glacial melt water as the basic water source system. At present, there is higher insecurity concerning water resources, the customary rules guiding the water cycle changes, and demand in eco-water. Socio-economic development increases water demand largely due to increase in human population which continues to sway the water resource availability and deepening scarcity. Furthermore, Northeast China's Huai River Basin is the cause of a number of chief international rivers, and uncertainty of water resources occasioned by climate change continues to raise tensions among Central Asian nations. Reginal discrepancies in industrial out put showed greater discharge of industrial waste in the northwest compared to the eastern region. Direct consequences of land use changes in Huai river affect flood incidences, base flow, annual mean discharge, variability of climate, flow routing time and flow value while population density, climatic conditions, geographical distribution, glacier melt ice, flooding, insecurity of main storage zone of the basin, land forms, maintenance and industrial activities pose a challenge on water distribution towards sustainable water management. Naturally, alternation of wet and dry climate zones couple with cumulative increase in population density and socio-economic activity can pose new requirements on water management strategy. Therefore an effective planning management and water resources development requires an adequate knowledge of climate variability and land use forms on hydrological processes. Intense investigation on hydrochemistry as affected by pollution due to human activity is worthy. Future planning should incorporate absorbing new technology and Deeping understanding of water governance and management system however constant state-control monitoring could improve the water quality in the Huai basin and beyond.

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