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Integrated water resource management for mega city: a case study of Dhaka city, Bangladesh

Nasir HOSSAIN[1) ABCDEF], Khalid Md. BAHAUDDIN[2) ABCDEF]

[1)] Khulna University, Khulna 9208, Bangladesh; e-mail: nhossain586@gmail.com
[2)] Bangladesh Society of Environmental Scientists, Bangladesh

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Abstract

Dhaka the capital of Bangladesh is facing a serious water scarcity problem due to the big gap between demand and supply of water system. When accelerating water scarcities and pollution in and around urban centers are superimposed on issues like continuing urbanization, lack of investment funds for constructing and maintaining water infrastructures, high public debts, inefficient resources allocation processes, inadequate management capacities, poor governance, inappropriate institutional frameworks and inadequate legal and regulatory regimes, water management in the megacities poses a daunting task in the future. To overcome these water related problems, water can be a designing element for structuring future development with the combination of sustainable approaches for social and physical transformation, open up opportunities for water management system. Therefore an integrated approach like integrated water resource management (IWRM) system is required that responds to problems that are all interrelated. Alternate supply and demand management tools such as ground water recharge, rainwater harvesting, effective water pricing, reclaimed water use are suggested to meet the deficit of current supply system through the efficient use of the scarce resources available. Institutional reform and improved water planning are required to facilitate economic growth and social development. Finally, human resource development is identified as key factor for the sustainable effective management of this valuable resource.

Key words: *Dhaka, human resource development, institutional reform, IWRM, water supply and demand*

INTRODUCTION

Water is a key element in the development of society and a vital necessity for any living being. A growing population, urbanization, increasing pressure on land and water resources by different competing usage and degradation of scarce resources challenge the extraction, management and protection of the water resources all over the country like Bangladesh.

Bangladesh is one of the most densely populated countries in the world. More than 130 million people live in an area of 147 540 km^2 and the population is increasing at a rate of around 1.6% annually. Approximately 44% of the population lives below the poverty line. Dhaka, the capital city of Bangladesh is a megacity with a population of about 16 million that is growing at an annual rate of around 5%, one of the highest amongst Asian cities.

Dhaka will be the second largest city of the world by the year of 2015. The huge population put forth massive pressure on water supply system and causes huge amount of deficit every year. Various sectors such as urban households, industries, agriculture and ecosystem are experiencing competition for share of water. Unplanned urbanization, economic development as well as huge population have caused in-

creased interaction among different water uses, changed the water environment of Dhaka, polluted the river bodies and ecosystem, lowered ground water table and altered water and sediment regime.

In this context, it has been realized that integrated water resources management (IWRM) should be the guiding principles to address these culminating problems. IWRM is a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

DHAKA CITY AND WATER ISSUES

It is not easy to imagine a more water-affluent megacity than Dhaka. Dhaka receives 2000 mm of rainfall annually. It is located close to the convolution of the mighty Ganges, Brahmaputra and Meghna rivers and it is frequently flooded, often catastrophically. These three rivers constitute the world's second biggest river system with an annual discharge 25 times than that of the Nile. However, Dhaka is one of the most challenging megacities in its water management.

Dhaka is the political and economic centre of Bangladesh. The country has more than 130 million people in an area of 147 540 km^2 making it extremely crowded. Dhaka's population is approaching 16 million with a growth rate of around 5% per year.

Bangladesh is one of the poorest countries of the world with 44% of people living below the poverty line. It has been estimated that around one-quarter of Dhaka's population live in slums.

The water supply and sewerage services have been allocated to one single public authority. It now supplies 0.51 km^3 of water per year against the demand of 0.73 km^3, serving around 72% of the city dwellers. The quality of the supplied water is very much in question. Almost 1000 private wells abstract another 0.35 km^3 per year of groundwater, mainly for industrial purposes. Groundwater is used far beyond the sustainable rate and this groundwater mining puts a serious strain on the environment. The groundwater table has gone down 20 to 30 m the past three decades and continues to sink 1 to 2 m per year.

Seventy per cent of the population has adequate sanitation and 30% are served by sewer networks. Only one sewage treatment plant exists, with a treatment capacity of 49 000 domestic connections. This is not a great pact for a megacity of the size of Dhaka. Over one-quarter of population lacks adequate sanitation altogether. The share of unaccounted for water is around 53%. It has gradually decreased from the level of 75% in 1980. There are currently important discussions on various water management issues such as the cost recovery of water services through tariff regulation, increased involvement of the private sector to water management etc. in order to bring more efficiency and transparency to the water sector of Dhaka.

Serious surface and groundwater pollution with detrimental effects on public health follow from the massive infrastructure shortcomings in water supply and sanitation. They are reinforced by occasional and often dramatic flooding, which raises the water level to streets and dwellings. Storm water management systems have been developed but not at pace with the growing population, particularly for the Eastern part of Dhaka with a population of 3 million. Several decades ago, the city was covered by a canal network of 24 canals and included a large area of natural wetland. This system was able to keep flood damage fairly low. The unplanned and largely illegal sprawl of the city ever since has led to the situation in which no proper storm water infrastructure exists. The most important flood protection system today is the Dhaka Western Embankment which is able to keep about half of the city area virtually flood-free.

SITUATION OF WATER AVAILABILITY AND ACCESSIBILITY IN DHAKA CITY

Dhaka Water Supply and Sewerage Authority (DWASA) is primarily responsible for providing water to about 90% of the Dhaka metropolitan area (DMPA). Remaining 10% depends on private wells. It is required to mention that the coverage of 90% DMPA does not mean that all people in this area get continuous DWASA supplied water. About 91% of the total water served by DWASA is utilized to meet the domestic water demand and about 9% is supplied to industrial and commercial sectors. Everyday around 1794.44 million liter (ML) water is produced by DWASA as per May 2008. More details are given in Figure 1. About 1540 MLD of this supply is abstracted from 471 deep tube wells (DTW) situated in Dhaka City and 14 DTWs in Narayanganj. The rest 254.44 MLD is produced through two surface water treatment plants (SWTP) in Dhaka (Saidabad & Chandighat) and one SWTP in Narayanganj (Godnail). About 223.1 MLD is solely produced by the Saidabad SWTP. In addition to this around 1179 DTWs are currently operated by the private agencies

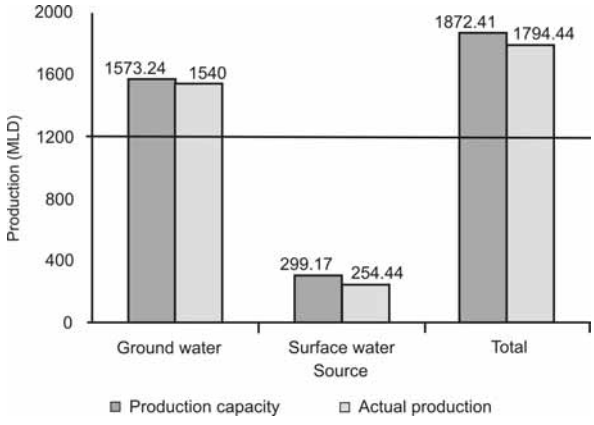

Fig. 1. Water production per day in Dhaka city; source: own study

DTWs are currently operated by the private agencies to meet the present water demand of the city. About 585 private DTWs supply water for domestic use and 562 DTWs for industrial and commercial use.

Figure 2 showing the demand supply and deficit trend for Dhaka city since 1963. The total water demand for Dhaka city was increased from 150 million liter (ML) in 1963 to 1760 ML in 2003. In 1963 the total deficit for water supply in Dhaka city was 30 ML which substantially increased to 260 ML in 2003 while Figure 3 shows the present and future water demand scenario in Dhaka city.

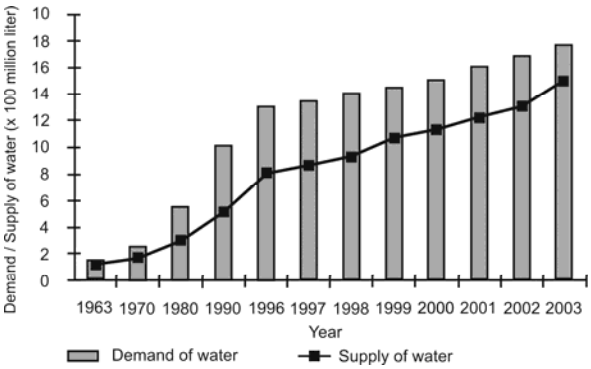

Fig. 2. Demand, supply and deficit of water in Dhaka city: source: own study

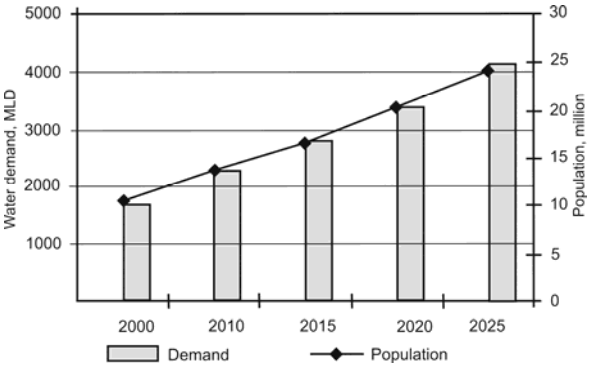

Fig. 3. Present and future water demand scenario in Dhaka city; source: own study

Though the city is surrounded by four rivers Buriganga, Balu, Turag and Tongi Khal, only about 14.18% of supplied water, as showed in Figure 4 is obtained from these rivers. Water of the surrounding rivers and lakes has already exceeded the standard limits of many water quality parameters because of the discharge of huge amount of untreated and municipal wastes. Treatment of this water has become so expensive that water supply agencies are almost entirely dependent on ground water aquifer for their potential alternate source of supply. It is observed that the annual abstraction in public sector has increased from 177 million cubic meters (MCM) in 1990 to 562 MCM in 2008. The number of private wells has increased from 130 in 1990 to 289 in 1999. This number significantly increased to 1179 in 2008. As an outcome upper parts of the aquifer became dewatered throughout the area except the northeast and southeast corner of the city.

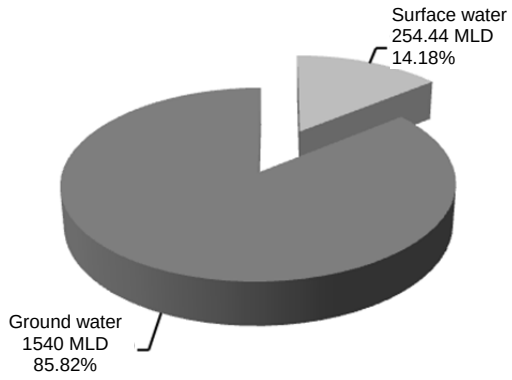

Fig. 4. Source wise water production per day in Dhaka city; source: own study

Dhaka experiences a hot, wet and humid tropical climate. The city is within the monsoon climate zone, with an annual average temperature of 25°C. Nearly 80% of the annual average rainfall of 1,854 mm (73 in) occurs between May and September. The aquifer of this city is primarily recharged by direct rainfall, river water, and floods through direct infiltration and percolation. But due to unplanned urbanization, the recharge area of the city is decreasing significantly with time. It is observed that the water level is declining at the rate of about 2 to 3 m per year depending on the locations. The vulnerable conditions of the aquifer may result in drying of existing wells, land subsidence, and intrusion of contaminated water from adjacent polluted rivers. Covering the vertical recharge inlets with pavement materials or other construction materials causes water logging for even small duration heavy rainfall in most areas of Dhaka city. Inadequate storm water sewer infrastructure and improper maintenance of storm sewer system further aggravate the scale of this problem.

CONCEPT OF INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

The Global Water Partnership (GWP) has defined IWRM as: a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (GWP-TAC, 2000). Thus, IWRM is a process that addresses the following three overriding elements:

- Economic efficiency in water use: because of the increasing scarcity of water and financial resources, the finite and vulnerable nature of water as a resource, and the increasing demands upon it, water must be used with maximum possible economic efficiency.

- Social justice and equity concerns: the basic right of all people to have access to water of adequate quantity and quality for the sustenance of human well-being must be universally recognized.
- Environmental and ecological sustainability: the present use of the resource should be managed in a way that sustains the vital life-support systems, thereby not compromising the use of the resource by future generations.

The GWP Technical Advisory Committee (GWP-TAC) has proposed a framework for moving towards IWRM (Fig. 5). Concurrent development and strengthening of the following three elements are needed [ALBERT *et al.* 2001]:

- 'Enabling environment' comprises national, provincial, and local policies and legislation. These constitute the 'rules of the game', which enable all stakeholders to play their respective roles and promote their participation.
- 'Institutional roles' define clear demarcation of responsibilities between actors, the separation of regulation from service provision functions, adequate coordination mechanisms, filling jurisdictional gaps, and eliminating overlaps and matching responsibilities both to authority and to capacities for action.
- 'Management instruments' comprise water resources assessment, demand management, social change instruments, conflict management, regulatory instruments, economic instruments, and information and communication instruments.

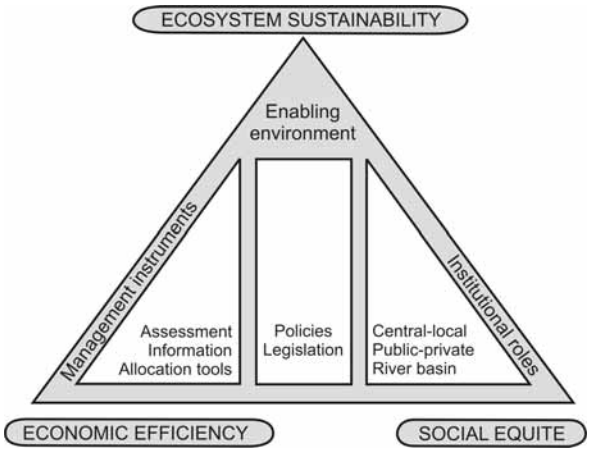

Fig. 5. Complementary elements for IWRM; source: GWP-TAC (2000)

CONCEPTUAL FRAMEWORK OF INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) FOR DHAKA CITY

A conceptual framework of Integrated Water Resources Management (IWRM) has been developed for management of water resource system (WRS) of Dhaka city. The steps of decision-making process in IWRM are shown in Figure 6. In this process, development objectives and goals should be defined considering all problems, issues and constraints. Then strategies to achieve the objectives should be set followed by generation of water management options. After that, impacts of each management options on water resource system (WRS) and national development goals should be assessed under different scenarios. During impact analysis, strategies, scenarios and management options should be reviewed in terms of national development objectives. Finally, best water management options will be selected through multi criteria analysis (MCA). Following this framework, problems and issues of water resource system of Dhaka city were identified and best management options were selected. Considering the major water issues and problems discussed in above, following model is being proposed.

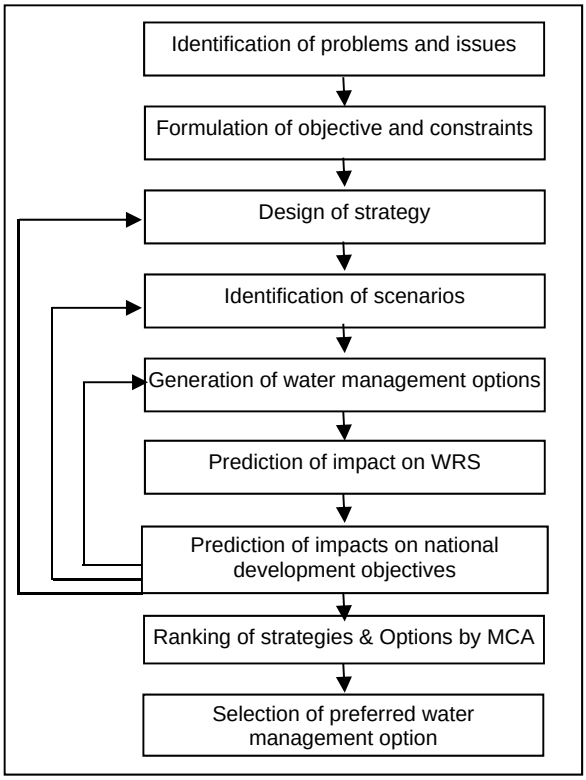

Fig. 6. Conceptual framework of IWRM; source: own study

This paper has identified possible options to reduce problems/issues in Dhaka city. In summary, Dhaka city suffers from flooding, water deficits, pollution in both surface water and ground water and overexploitation of ground water. The developed possible options are:

Option 1: Balance surface and groundwater development

- Reserve the surface water for environmental demand and domestic supply
- Sustainable use of ground water
- Strong enforcement of laws for surface water and ground water pollution from different sectors

- Increase surface water availability by augmenting water from Jamuna to Buriganga through Dhaleswari to save Buriganga river and protect environment for population in Dhaka city
- Ban water use from wetland and reduce LLP use in the region

Option 2: Live with flood and demand management

- Flood proofing
- Flood preparedness and early warning system
- Decrease water loss by using lined channels
- Regulatory laws on discharging industrial waste

Option 3: Full development

- Pump the water from Jamuna to Dhaleswari and Old Brahmaputra to meet the sectoral demands
- Waste water treatment and reuse
- Effective water pricing
- Rain water harvesting
- Rehabilitate the existing FCD project

CONSIDERING ISSUES AND MEASURES TOWARDS INTEGRATED WATER RESOURCES MANAGEMENT (IWRM) IN DHAKA CITY

In order to manage this complicated situation it has become necessary to integrate four major issues; these are socio-economical issues, biophysical issues, institutional issues and water quality issues. Making wise decisions about water resources management requires knowledge and wisdom from different disciplines to identify alternatives for action and to assess their effects. Engineering knowledge might focus on physical infrastructure systems, whereas sociology or psychology might focus on human impacts. Large capital investments, willingness to pay, people's participation and religious view have been identified as key aspects of socio-economic issues.

Water management is already very challenging because of its temporal and spatial distribution. Moreover the present supply system of Dhaka city is having difficulties to manage the enormous increased demand of the growing population and fulfill the huge deficit caused by the economic development. All of these problems are related with each other.

Thus the aim is to provide a water and resource management system to meet the rising demand economically and to facilitate growth and development by using scarce resources as efficiently as possible. Water supply and demand management through groundwater replenishment, rainwater harvesting, reclamation, recycling and reuse, waste reduction and new source development plans can give increased security to domestic water supplies and resolve the current water deficit problem. Revised domestic and industrial water pricing and reallocation can reduce the misuse and unnecessary loss of water. Institutional reform and effective water resource planning are necessary to increase revenue collection. Selection of target population and people's participation are vital for the potential application of IWRM**.** Resource development is further essential for the sustainable management of this valuable resource.

WAY FORWARD TO INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)

Potential application of IWRM includes planning phases of the proposed program, institutional reform, water resource planning and human resource development. Relevant study needed to be carried out to address information and data acquisition, preliminary market assessment for potential users, economic considerations, environmental and social analysis, possible complementation plan, willingness to pay, scale of decentralization, level of people's participation, religious view required to be carried. Users should be categorized based on produced water quality and quantity, water capacity to meet future demand, current water supply, demand and deficit, current and future rates and fees, aspects of water use legislation, attitude of agencies, organization and users toward produced water use.

Lack of proper institutional legislation and policy is the central problem. Existing institutions should be reformed with comprehensive water code addressing legal issues. Legislation for groundwater right should be introduced. Some of the agencies, responsibilities and jurisdiction can be consolidated. National water resource planning agency might be powered with more authority and political control. Decentralization of water service provision can be effectively used in this regard. A central repository of water and other resources data with advanced GIS facilities can be built.

Water plan should contain the integrated planning and management principles, pricing and decentralization policy, consideration of social and environmental impacts in the evaluation of water projects, public participation, accomplishments and goals and projection of water supply, demand and subsequent measures to balance them.

Education program to increase public awareness should be introduced. Existence of government staff with necessary skill and training are required. Local consultants with appropriate understanding of local conditions are likely to be more successful in this context. Building the capacity of higher educational system in environmental science, engineering and management will play a vital role in future management of water resources.

CONCLUSION

Water problem is one of the crucial challenges in Dhaka city. The priorities for water resources development and management in an integrated manner should be assessed according to the economic and social values of water. Three main key elements are

therefore urgently needed for the IWRM process in Dhaka city as well as whole Bangladesh: stakeholder participation with elected representatives; the pricing of water to put an economic value on it; and a knowledge base to support decision-making at different levels. Socio-economical, biophysical, institutional and water quality issues must be considered in area-wise service provision, process optimization and policymaking. Alternate water supply and ground water recharge system should be implemented on the basis of priority and feasibility analysis. Simultaneously change in water consumption behavior, modification of pricing, taxing, reduction of system loss, development of human resource, institutional reform and sustainable planning considering impacts of climate change should be brought under common goal to get the best outcomes. It is expected that the scarcity and stress on water resources, which at present handicap Dhaka city, would act as a catalyst for the IWRM process in the country.

REFERENCES

AHMAD E., KAMAL M.M. 2004. Water management in Dhaka city. In: Water Resources Management and Development in Dhaka City. Ed. M.Q. Hassan. Dhaka. Goethe-Institut p. 33–38.

AHMAD Q.K. (ed.) 2000. Bangladesh water vision 2025: Towards a sustainable water world (Global Water Partnership) [online]. [Access 10.03.2013]. Available at: http://www.gwpforum.org/publications.htm

ALBERT X., MARK O., BABEL M.S., GUPTA A.D., FUGL J. 2001. Integrating resource management in South East Asia. Water 21, October. Iss. 3.5 p. 25–30.

ANDREWS C.T., YNIGUEZ C.E. 2003. Water in Asian cities: Utilities performance and civil society views (Manila, Philippines. Asian Development Bank. ISBN 971-561-524-4 pp. 97.

Asiatic Society of Bangladesh 2004. Banglapedia: National encyclopedia of Bangladesh (Dhaka: ASB) [online]. [Access 10.03.2013]. Available at: http://www.banglapedia.org.bd/HT/P_0326.HTM

ARSEL M., SPOOR M. (eds.) 2010. Water, environmental security and sustainable rural development: Conflict and cooperation in Central Eurasia. 5. Routledge. London, New Yeark. ISBN: 978-0415461610 pp. 304.

Bangladesh Bureau of Statistics 2008. Area, population and literacy rate by Paurashava, Bangladesh.

BISWAS A., LUNDQVIST J., TORTAJADA C., VARIS O. 2004. Water management for megacities. Stockholm Water Front. 2 p. 12–13.

BISWAS A.K. 2005. Integrated water resources management: a reassessment. In: Integrated Water Resources Management in South and Southeast Asia. Eds. A.K. Biswas, O. Varis, C. Tortajada. New Delhi. Oxford University Press p. 325–341.

FEYEN J., SHANNON K., NEVILLE M. 2009. Water & urban development paradigms – Towards an integration of engineering, design and management approaches. London. Taylor and Francis Group. ISBN 9780203884102 pp. 712.

KHAN H.R., SIDDIQUE Q.I. 2000. Urban water management problems in developing countries with particular reference to Bangladesh. International Journal of Water Resources Development. Vol. 16. Iss. 1 p. 21–33.

KHAN H.R. 2010. Overview of IWRM issues, National Expert Consultation (NEC) on Integrated Water Resources Management (1999) [online]. Dhaka. Bangladesh Water Partnership. [Access 10.03.2013]. Available at: http://www.bdnetwork.com/bwp/necon.htm

Global Water Partnership (GWP) 2000. Integrated water resources management. TAC. Background Papers. No. 4 ISBN 91-630-9229-8 pp. 68.

HAQ K.A. 2006. Water management in Dhaka. International Journal of Water Resources Development.Vol. 22. Iss. 2 p. 291–311.

HAQUE A., HASSAN A., CHOWDHURY J.U. 2003. Water resources system of Bangladesh. [Launch Workshop of Research Project on CLASIC, BUET]. [Dhaka, Bangladesh].

HUQ S., ALAM M. 2003. Flood management and vulnerability of Dhaka city. In: Building safer cities: the future of disaster risk. Eds. M.A. Kreimer, A. Carlin. Washington D.C., The World Bank p. 121–136.

MELLO S., HOLENDA F. 2009. There is a city on the riverside. In: Proceedings of the 7th International Space Syntax Symposium. Eds. D. Koch, L. Marcus, J. Steen. Stockholm: KTH. Ref. 075 p. 1–12.

Ministry of Water Resources, Government of the People's Republic of Bangladesh 1999 [online]. National water policy. Dhaka. [Access 10.03.2013]. Available at: http://www.partnersvoorwater.nl/wp-content/uploads/2011/07/WARPO2004_Natonal-Water-Policy

PEETERS S., SHANNON K. 2011. Readdressing Dhaka's public water bodies: A Design Research. Journal of Environmental Design and Planning. Vol. 7 p. 24–46.

HOSSAIN S. 2004. Urban poverty and household adaptations in Dhaka city, Bangladesh [online]. [Access 10.03. 2013]. Available at: http://www.tasa.org.au/conferences/conferencepapers04/docs/GLOBALIZATION/HOSSAIN.pdf

SHANNON K. 2009. Water urbanism: Hydrological Infrastructure as an urban frame in Vietnam, In: Water & urban development paradigms-towards an integration of engineering, design and management approaches. Eds. J. Feyen, K. Shannon, M. Neville. Heverlee, Belgium. CRC Press p. 55–65.

WARPO 2000a. Land and water resources. National water management plan project. Topic Paper No. 7. Dhaka.

WARPO 2000b. National water management plan. Draft Development Strategy (DDS). Annex F: Social Analysis. Dhaka.

WARPO 2001. National water resources management plan. Main report 2001. Vol. 2. Dhaka, Bangladesh pp. 212.

Nasir HOSSAIN, Khalid Md. BAHAUDDIN

Zintegrowane zarządzanie zasobami wodnymi dużych miast: przykład miasta Dakka w Bangladeszu

STRESZCZENIE

Słowa kluczowe: *Dakka, zasilanie i zapotrzebowanie na wodę, zintegrowane zarządzanie zasobami wodnymi, reforma instytucjonalna, rozwój kadr*

Stolica Bangladeszu Dakka doświadcza poważnych problemów związanych z niedostatkiem wody z powodu różnicy między zapotrzebowaniem a możliwością jego zaspokojenia. Kiedy na rosnący deficyt wody i zanieczyszczenia w i wokół centrów miejskich nakładają się takie problemy jak: postępująca urbanizacja, brak funduszy inwestycyjnych na budowę i utrzymanie infrastruktury wodnej, wysoki dług publiczny, niewydolny proces alokacji zasobów, nieodpowiednie zarządzanie, słaby nadzór, niewłaściwe ramy instytucjonalne i nieodpowiednie reguły prawne i kontrolne, zarządzanie wodą w dużych miastach stanowić będzie w przyszłości trudny problem. Aby pokonać problemy związane z wodą, powinna ona stać się elementem planowania przyszłego rozwoju w powiązaniu ze zrównoważonym podejściem do fizycznej i społecznej transformacji i do możliwości zarządzania zasobami wodnymi. Dlatego, potrzebny jest zintegrowany system, taki jak zintegrowane zarządzanie zasobami wodnymi, który mógłby reagować na problemy, które są wzajemnie ze sobą powiązane. Proponuje się alternatywne narzędzia zarządzania dostawą i zaopatrzeniem w wodę takie jak zasilanie wód gruntowych, gromadzenie wód opadowych, efektywna wycena wody, wtórne użycie wód uzdatnionych, aby sprostać obecnemu deficytowi zaopatrzenia w wodę przez wydajne wykorzystanie skąpych zasobów. Niezbędna jest reforma instytucjonalna i usprawnione planowanie, aby ułatwić wzrost gospodarczy i rozwój społeczny. Rozwój kadr uznaje się za kluczowy czynnik w zrównoważonym i wydajnym zarządzaniu tym cennym zasobem.