# I. ECONOMIC ANALYSIS

## A. Subject

1. The subject for analysis is a project planned to be implemented throughout the 2008-2013-period at an estimate total cost in fixed 2006-prices of USD 900 million equal to BDT 62135 million, and to include primarily the following components,

- Rehabilitation of the entire DWASA distribution network with the objective to extend levels of supply to 24-hours/day under standard pressure, and lower the now extensive system loss to standard level
- Construction of additional capacities for surface water treatment to ensure water at drinkable standard, and initiate a reduced utilisation of the now ground water production capacity in order to protect natural ground sources
- Rehabilitation of the main network with the objective to facilitate supply over longer distances from the sources as required due to the extension of surface water supply

2. The subject area is the DWASA service area, including the not yet connected slum, pocket and fringe areas.

3. The period subject to analysis is the year-2008-2045 period including the project implementation period and the following period of operations until end of the project investment. The baseline data included is in general from mid 2005, except to minor extent from early-mid 2006 when data are provided by the project itself.

## B. Objective

4. The primary objective of the analysis is to estimate to what extent the project economic performance meets the ADB standard performance criteria equal to an economic internal rate of return (EIRR) of 12%. Since, this standard is a nominal rate, and the analysis carried out in fixed prices, the EIRR criteria is by accounting for USD inflation assumed only to be 10%.

5. A second objective is to assess, to what extent required tariff extensions are affordable for household consumers, including for households at lowest income level.

## C. Method and Data

6. The analysis is carried out at project level and in line with the ADB standard guidelines, why the situation ‘without project’ and ‘with project’ are compared in economic value terms, including both finance cost and values of time spend. All projects anticipated to change the actual situation are included in the ‘with project’ situation, however when the economic cost/benefits are estimated, these are finally adjusted only to include the impact of the ADB project subject. All finance cost included are estimated in fixed 2006-prices.

7. Baseline data are in particular provided by key DWASA publications (e.g. MIS-reports and audit report on accounts) and by socio-economic surveys and other analysis carried out by the project. Data from the various sources are neither in all cases found consistent nor covering in specific all aspects of the analysis. Besides, the said socio-economic surveys are based on relative

restricted samples. However, the reliability of the available data is in general found satisfactory as a basis for the economic analysis.

## D. Water demand

8. Water demand is in general depending on the number of consumers and the unit consumption of the various consumer categories. However, in the DWASA service area the impacts of variation in unit consumption will be insignificant on mid to long-terms as the consumption is expected to be stabilized and restricted to a constant level by tariff incitements and individual customer metering. Hence, on mid to long-terms the overall demand will be driven only by the significant growth in number of consumers. On short/mid-terms the demand will also be driven upwards due to the improved conditions of supply that is an impact of the ADB-project and other on-going projects.

9. Unit water demand is in general depending on real demand and the condition of supply and level of tariff. However, the actual water demand in the DWASA serviced area is most probable to an all dominant extent dependent on the condition of supply, whereas the level of tariff will only have any impact on level of consumption on mid to long-term. Real demand will probably have impact on the level of consumption on short to mid-term as the overall supply of water for consumption is improved by the project.

### 1. Households and other consumer categories

10. The actual number of inhabitants in the service area is 8,6 million, and this number is expected to increase over 11,5 million in 2013 by the end of the project intervention, to 29,4 million in 2045 by the end of the project investment lifetime. With an actual average household size of 4,8 inhabitants in the same area, the number of households is actual 1,78 million, and expected to increase over 2,39 million in 2013 to 6,15 million in 2045. The expected growth in inhabitants in the DWASA service area is presented in more detail per administrative district (Thana) and per DWASA service zones in Annex-2, Section A. The breakdown on DWASA zones has been undertaken to support a more detailed review of the baseline situation of demand and supply.

11. Since, new industrial units are expected mostly to be established outside the DWASA service area, the now number are assumed to be constant in the analysed period, whereas the number of the other customer categories, including larger commercial businesses, communities (e.g. public and religious institutions) and offices are expected to vary over time with the population, since the citizens are their main clients.

### 2. Household demand of in-house supply

12. Actual household consumption in the respective DWASA service zones is increasing with the extent of metering, which is indicating no tariff dependency. Moreover, accounting also for the situation of still only joint metering in multi-store houses, the individual households have only much restricted information on their actual consumption/tariff-relation, and hence no motivation to adjust consumption in order to lower their spending on water. Finally, accounting also for the margin for even extensive tariff increase, the actual demand is most probable not depending on level of tariff at all.

13. Most probable, the actual household demand is all dependent on the supply conditions. Hence, by a pilot rehabilitation of the supply condition to optimal level, household consumption in

the pilot area was found to stabilize at around 200 l/c/d, whereas the actual average level of metered household consumption in the overall serviced area is only around 113 l/c/d. Moreover, level of metered household consumption is varying significant across the DWASA service zones, e.g. from 63 l/c/d in zone 2 to 167 l/c/d in zone 3, a variation that with equal tariff conditions can only to minor extent be explained by variation in household real demand, and hence to major extent only by the varying supply situation across zones. This also brings an explanation to the consumption/metering paradox, since the service zones with more extensive household metering, are most probable also the zones with a more rehabilitated network and hence more optimal condition of supply.

14. By deduction from the household consumption/metering variation across zones, the implied level of household consumption in a zone with 100% metering would be around 183 l/c/d, or approximate the same level as actual found in the said pilot test at optimal supply conditions. Consequently, actual real household demand is most probable around 180 l/c/d. The analysis of variation between unit household consumption and metering is presented in more detail in Annex-3.

15. The ADB-project is planned succeeding to rehabilitate the DWASA supply network and establish additional surface water supply throughout 2009-2013 to approach optimal supply conditions in the overall serviced area end of 2013. Though tariff and the extent of joint metering are to be increased, the impacts of such interactions on level of consumption are only possible to be minor on short-terms. Hence, as the supply conditions are improved on short-terms, the expectation is a significant increase in metered household demand from actual 113 l/c/d to the experienced level of joint metered household consumption equal to around 150 l/c/d. As tariffs are more significant increased on mid-terms and household metering also introduced at individual household level, then metered household demand is expected succeeding to decrease to stabilise after ten years around 120 l/c/d equal to the experienced level of individual metered household consumption. The referred to quantities of consumption at increasing tariff level and more intensified metering, are based on the experiences in Denmark throughout the 1990'ties.

16. The actual average level of non-metered household consumption is around 93 l/c/d and most probable all dependent on the supply conditions, why it is expected unchanged over time until on mid-terms as the number of non-metered households has been declined to zero.

17. Consequently, with the expected development in unit household consumption and accounting also for the expected household growth, the total household consumption is expected to increase from actual 292 million $m^3$, over 607 million $m^3$ in 2013 at the end of the project interaction, to 1265 million $m^3$ in 2045 at the end of the project investment lifetime.

### 3. Other customer categories demand of in-house supply

18. Also 10.380 non-household customers are supplied in-house by DWASA, including larger commercial units, industrial units, community units and office units. Minor commercial businesses are probably in most cases supplied in combination with and hence not separate from household supply. The unit consumption is varying from around 1400 $m^3$/year for community supply to 1921 $m^3$/year for larger commercial supply.

19. Consequently, by the expected development in non-household unit consumption and accounting also for the expected growth in the respective customer categories, the total non-household consumption is expected to increase from actual 19 million $m^3$, over 27 million $m^3$ in 2013 at the end of the project interaction, to 65 million $m^3$ in 2045 at the end of the project investment lifetime.

### 4. Non DWASA Household demand

20. Around 11% of households in the service area are supplied from other sources than DWASA piped supply, including private hand tube wells, DWASA standpipes, DWASA tankers and private vendors. Only roughly estimates on actual unit consumption can possible be deducted from available statistics, varying from around 36 l/c/d for standpipe and hand tube well supply, over 27 l/c/d for tanker supply to 15 l/c/d for vendor supply. The unit consumption from standpipe, hand tube well and tanker are most probable to dominant extent dependent on the conditions of supply, since the water collection/distribution issue is a major constraint on the quantity possible consumed. Consumption supplied by private vendors is constrained by the same issue, however probably also depending on the more extreme price of water in this case of supply. Since the constraints by the collection/distribution issue is constant, and since the price of private vendor supply is probably increasing slightly with household income, the unit consumption of the respective sources of out-house supply is expected to be constant over time.

21. By the end of the project interaction around 80% of those households now supplied by hand tube wells and vendors are expected to be supplied instead by DWASA in-house connections, whereas the number of households supplied by standpipes and tankers are expected to increase with the population growth. By accounting for such growth in number of consumers, the total consumption of out-house supply will increase from actual around 11 million $m^3$, over 4 million $m^3$ in 2013 by the end of the project intervention, to 7 million $m^3$ in 2045 by the end of the project investment lifetime.

## E. Water supply

22. Customers in the DWASA service area are supplied from sources in the area, since only around 0.5% of total supply to the area is provided by private operators from sources outside the area. Around 82% of the total supply to the area is supply from DWASA owned sources, including around 56% supplied by direct by DWASA and around 26% supplied indirect by various private operators. Around 17.5% is supplied by private operators from their own sources. Accounting for the system loss during distribution, the direct supply by DWASA actual consumed is only around 42% of the total quantity of water consumed in the area, however in year 2045 by the end of the project investment lifetime this percentage is expected to be around 76%

### 1. Production and supply by DWASA

23. The actual DWASA production capacity of water is 605 million $m^3$/year. However, with an actual utilisation of the ground water and surface water capacities respectively of 89% and 84%, the actual production is 535 million $m^3$/year. However, due to an actual system loss in the distribution network of 41% the actual supply for consumption is only 316 million $m^3$/year.

24. The ADB-project rehabilitation of the entire distribution network is expected succeeding throughout 2009-2012 to reduce the system loss to 20% at the end of the rehabilitation period. Besides, additional water supply is expected to be provided by extended surface water capacity, including by the ADB-project in 2013. However, part of the extended capacity is supposed to facilitate a reduction in the now utilisation of the ground water capacity in order to protect the natural ground water sources from drying out on long-terms. Hence, accounting also for the expected increase in water demand and an utilisation of 90% of the surface water capacity, the total supply for consumption is expected to increase to 631 million $m^3$/year in 2013, and the utilisation of ground water capacity reduced to 50%.

25. However, due to succeeding increase in demand due to growth in the population, additional surface water capacity is required around 2020 and moreover around every 5th year from year 2035, each assumed at similar capacity as the one established in 2013 by the ADB project. Even with such extensive increase in capacity on long-terms, the utilisation of the ground water has to return from around year 2030 and ahead to the now experienced in order to meet the demand of 1.331 million m3/year in year 2045. Hence, unless the surface water sources permits the establishment of even more extensive surface water production capacities, the utilisation of the ground water sources will not be sustainable on long-terms. If the surface water sources do not permit such more extreme extension of production on long-terms, either a reduction of the population growth on long-terms has to be supported by the establishment no later than year 2030 of satellite urban centres outside the now DWASA service area, or additional water has to be supplied from more distant ground water sources. Since, this problem of meeting demand on long-terms is probably a general physical infrastructure service problem in Dhaka city, final solution on this long-term problem should more appropriate be considered as a general urban planning problem to avoid eventual economic sub-optimizing implied by solution at sector level.

### 2. Production and supply by other operators

26. Customers in the DWASA service area are also supplied by various private operators in and outside the DWASA service area.

27. Hence, private operators are operating 691 deep tube wells (DTWs) owned by DWASA, and around 450 DTWs owned by themself. Total supply from these DTWs are roughly estimated to around 418 million $m^3$/year. These DTWs are operated by large commercial or community units primarily for the supply of these units themselves and a few households nearby (e.g. a university with a few associated domestic buildings on the estate area). This segment of the service area is not expected to change due to project interventions in the DWASA supply, and hence not included in the economic analysis.

28. A roughly estimated number of 575 hand tube wells are proving a supply of around 9 million $m^3$/year. The dominant part is supplied for household consumption among around 8.2% of the total households in the service area. Around 23% of the hand tube wells are connected to the DWASA distribution network, and hence indirect supplied by DWASA water production. Around 80% of these households are willing to change to a DWASA piped connection and hence expected succeeding to be connected throughout the ADB-project period.

29. Private vendors are supplying around 0.3 million $m^3$/year to around 0.2% of the total area households. Around 80% of these households are willing to change to a DWASA piped connection and hence expected succeeding to be connected throughout the ADB-project period.

30. Finally around 1850 non-household consumers is supplied with a total volume around 3.4 million $m^3$/year by private operators from sources outside the service area. This segment of the service area is not expected to change due to project interventions in the DWASA supply, and hence not included in the economic analysis.

## F. Tariff and Affordability

### 1. Actual level of tariff

31. Assuming the distribution of DWASA cost on water and sewerage services equal to the respective distribution of revenues, then 75% of the overall DWASA annual cost is required for the provision of water service. By such assumption the actual unit cost of water supplied for consumption is 6.81 BDT/$m^3$ in year 2006-prices. Accounting for the expected development in demand and supply, the unit cost in 2006-prices is expected to increase over 10,40 BDT/$m^3$ in 2013 at the end of the ADB-project period to 10.61 BDT/$m^3$ in 2045 at the end of the project investment lifetime.

32. However, due to tariff differentiation between the various customer categories, this unit cost is not direct reflected in any tariff in specific. Hence, actual tariffs in 2006-prices are 5.38 BDT/$m^3$ for the metered non-commercial customer categories (households and communities) and 17.78 BDT/$m^3$ for the metered commercial categories (commerce, industry and office).

33. Non-metered customers are billed on the basis of their property value. The commercial and community customers are due to their large unit consumption assumed all metered, whereas around 41% of the piped household customers are not metered. The actual unit cost of water for non-metered households is around 7.44 BDT/m3 in 2006-prices, which indicates a relative overpricing since the supply cost are not varying from metered household supply.

34. The use of standpipes are free of charge for the direct customers, however DWASA has booked revenues separate for this service, probably reflecting government subsidizing. No tariff is specified, however the revenue equal by a roughly estimate around 35 BDT/$m^3$.

35. A minor quantity of water is also provided by DWASA direct to customers by tanker service at a tariff roughly estimated to around 20 BDT/$m^3$.

36. Besides, water is supplied to larger extent by private operators of hand tube wells and to minor extent by private vendors. According to surveys, tariffs for this supply are respectively around 20 BDT/$m^3$ and 250 BDT/$m^3$.

37. Estimates of the DWASA unit finance cost of supply are presented in more detail in Annex-2, for the ‘without project’ and ‘with project’ situations respectively in Section D and Section H.

38. The actual and expected tariffs for the various customer categories are presented in more detail in Annex-2, for the ‘without project’ and ‘with project’ situations respectively in the first line of Section E and Section I.

### 2. Required future levels of tariff

39. Due to the various project investments over time, tariffs are succeeding required to increase in order to ensure full cost recovery. The required tariffs are calculated in year 2006-prices, however of course in practice assumed current to be regulated for inflation.

40. The respective tariffs for non-household customer categories are assumed to follow the percentage growth in the unit cost of water supplied by DWASA, where as the tariff for supply by standpipes and the various private operators are assumed to be constant. Hence, the commercial customer tariff will increase over 27.16 BDT/$m^3$ in 2013 to 27.71 BDT/$m^3$ in 2045, whereas the community tariff will increase over 8.21 BDT/$m^3$ in 2013 to 8.38 BDT/$m^3$ in 2045.

41. Since, the supply of non-metered household is overpriced and besides to be all replaced by metered connections on short/mid-terms, this tariff is assumed constant.

42. Accounting for these assumptions and the respective total consumption per customer category, the non-metered tariff is regulated to balance the full cost recovery level of cost. Hence, this tariff is required succeeding to increase to a level of 9.64 BDT/$m^3$ in 2013, followed by a 10 year period with a tariff varying at its maximum around 13-14 BDT/$m^3$, and thereafter succeeding to decrease over the following 20 year period to 9.78 in 2045, the final level where is will remain.

### 3. Tariff affordability

43. Households at average income level are worldwide experienced to have a preference and also to afford combined spending of around 4-5 % on water & sewerage services. Hence, the assumption in the analysis a preference and affordability level of 4.5 %.

44. The actual water service proportion of the DWASA combined tariff is 75%, however on long-term as the DWASA sewerage service has been improved to optimal level the water service proportion should by experience from e.g. Europe be expected to decrease to around 33%. Hence, the income proportion preferred / afforded for water service will decline from actual 3.4% to 1.5% in 2045.

45. According to a recent sociologic survey in the service area, the average annual household income is around 360.000 BDT. In the non-serviced area now expected to be connected on short/mid-terms, the average annual household income is around 80.000 BDT, including around 65.000 BDT in the slum part of this area.

46. At the expected DWASA tariff and average unit consumption level of metered households this implies, that households in the serviced area will face no affordability problem. Hence, even in the mid-term period as tariff is at the maximum level around 13-14 BDT/$m^3$, households will only spend around 30% of the income part preferred / affordable for water service.

47. In the non-serviced area in general, and in particular in the slum area, the average households will only face affordability problems in the period on mid-terms as the tariff is at maximum level. However, the implications are restricted and only require a reduction respectively with around 25% and 33% in the average unit meter consumption. Since the expected unit household consumption in the said period is 150 l/c/d, reductions of even 33% will still imply a supply of 100 l/c/d, and this quantity is still at a significant higher level than actual consumption around 35 l/c/d in the un-serviced area.

48. Moreover, the DWASA tariffs includes a 5% provision for bad debts. Hence, DWASA household customers with an income at a level equal to households in the non-serviced area is probably not in practice ever paying their bills, and their water consumption this way regular cross-subsidized by the DWASA customers at higher income levels.

49. The assessment of affordability for the average household customer in the overall service area and in its non-serviced low income part is presented in more detail in Annex-4.

### 4. Intended tariff constraints on water demand

50. Though tariff is required to increase to ensure full cost recovery, they are increasing from a much modest level, and only to approach maximal level on mid-terms. Hence, for the tariff to be a

more efficient constraint on unit customer consumption, the tariff should be differentiated by the introduction of 'blocked tariffs' per customer category, where the blocks are intervals of unit consumption quantities and tariffs to increase with such quantity.

51. Moreover, appropriation for future DWASA investment should be included in the DWASA budget to facilitate an increase in the outset level for such differentiation and to legalise accumulation this way of annual profits. The latter increase is not included in the analysis, however with the considerable affordability margin for further tariff increase, such increase is practicable. This way e.g. the now included tariff could be billed only for quantities up to the now average level of consumption, whereas quantities above this level should be billed at one or more levels of increased tariffs. To support the estimate of such annual budget appropriations, DWASA is recommended to prepare a self-financed 10-year investment plan.

52. Besides such increase and differentiation of tariffs, the facilitating of more customer awareness of scarce water resources and of more information at individual household level on the billed quantity and cost of water consumption is required, the latter to be supported by the introduction of metering also at individual household level.

## G. Economic cost of supply

### 1. Indirect customer cost of supply

53. Whereas the actual unit cost of supply by DWASA is 6.81 BDT/$m^3$, the actual customer cost of supply is far more extensive, since more household supplied out-house have currently to spend considerable time on collection of the water (e.g. transport to/from the source and often waiting in long queue at the source). However, more costly is the individual treatment by all customers of part of the water supply to drinkable standard (e.g. the spending of time and cost of gas to boil and bottle the water for drinking purposes). Finally, due to the low pressure in the DWASA distribution network around 30% of household consumers and 60% of non-household consumers have installed sucking pumps with the implication of additional cost, in particular on the use of electric power. By the accounting also for such additional cost on the water supply, the unit cost of DWASA supply is actual 77 BDT, or 90 BDT accounting also for the out-house supply from other suppliers.

54. Due to the planned improvement of pressure in the distribution network, the extended number of in-house connections, and in particular the improvement of the quality of water to drinkable standard, these additional supply cost for each customer are expected to decline significant. Hence, the overall actual unit cost of 90 BDT is expected to decline over 64 BDT in 2013 to only 15 BDT in year 2045. Consequently, on long-term the customer unit cost of supply is expected to approach the unit cost of water as supplied by DWASA, e.g. in 2045 equal to 10.61 BDT.

### 2. Conversion to economic cost

55. Due to the Bangladesh regulation and subsidizing of more cost components, in particular non-skilled salary and energy, the economic cost of DWASA piped supply are assumed to be slightly more expensive than the finance cost of supply. Since, DWASA is accounting by accrual principles and generating no profits for company income taxation, the included baseline production cost of DWASA water supply is approximate net of local tax. By experience from comparable water supply cases under similar net tax conditions, consequently an overall conversion factor of 1.05 has been applied. Besides, all estimated taxes and duties are excluded from the project investment cost

before the EIRR-calculation. The conversion factor of 1,05 is to be considered ‘conservative’, since a more detailed study of shadow prices in Bangladesh would probably uncover extraordinary government subsidies on energy, and hence probably a slightly higher conversion factor.

56. The billed customer cost on water supply and the various additional cost implied by individual customer collection, treatment and sucking of water, is presented in more detail per customer category in Annex-2, for the ‘without project’ and ‘with project’ situations respectively in Section E and Section I.

## H. Project economic performance

57. The ADB standard economic selection criteria is an economic internal rate of return (EIRR) of 12% in nominal terms equal to around 10% in real terms.

58. Accounting for the assumptions and expectations presented, the EIRR is found to be 11.5%, why the ADB-project meets the standard criteria. This EIRR estimate is most probable to be considered a conservative estimate, since not quantified key parameters if possible quantified definite would increase the EIRR estimate. Even if more detailed study of shadow prices in Bangladesh would imply a slightly higher economic conversion factor.

59. Hence, actual tariffs for the DWASA supply is reflecting the tariffs at the stage when water is distributed by DWASA to the connected subscriber building.. However, surveys on actual spending of water at individual households level indicates, that the subscribers in multi store buildings are most probable increasing the DWASA billed amount as the bill is passed on to each household in the building as a not specified part of the monthly house rents. In some cases the subscriber probably also have to pay ‘bonus’ to DWASA staff to ensure efficient supply. More household connections are probably also supplying more households than actual living in the connected building, and in such cases at even more increased levels of tariff. Due to such staged billing/distribution of the same amount of water, the end users are probably in cases of more such stages facing a tariff approaching more the private operators price of water than the DWASA tariffs. Only when connections are significant increased to avoid ‘supply monopolies’ and billing directed to/metered at individual households, the end user tariffs will approach DWASA tariffs.
Besides, the improvement of the DWASA water supply to 24-hours supply at standard pressure, will eliminate not only the convenience of sucking pump installations, that is accounted for in the analysis. However, when new building are constructed the said improvement will also eliminate the convenience of basement reservoirs, why buildings constructed after year 2013 are expected only to be constructed with a roof tank.

60. Moreover, the health situation is most probable to be improved as an impact of the improvement of the water quality. Hence, probably the amount of sick leaves and medical expenses and maybe even infant mortality are declining.

61. Any economic long-term projection is of course not to be considered without uncertainty, however by the assessment of the resulting EIRR to be definite a ‘conservative’ measure, the resulting EIRR is most probable a reliable indication, that the project is economically viable.

62. The estimate of the EIRR is presented in more detail in the final section of ANNEX-2.

## I. Conclusion

63. The planned ADB-project is within reasonable certainty found to be economical viable. Besides, it will temporary support the reduction in the now utilisation of ground water sources to more sustainable level.

64. The ADB-project is even not in combination with other projects planned on short to mid-term sufficient to ensure also on long-terms a water supply to satisfy customer demands approaching the now experienced level in more developed countries, unless more surface water plants are succeeding established on mid to long-terms. The requirement of more such surface water plants is even more extended, if at the same time the utilisation of now ground water sources is not to return again to the actual unsustainable level. One alternative more economical viable on long-terms not only separate for the water sector might be the establishment of urban centres outside the now DWASA service area in order to reduce population growth and hence the water demands in the area.

65. It is most critical for the economic viability of the ADB-project, that the quality of water is improved to customer recognized drinkable standard, and that tariffs are defined and billed efficient to support the reduction of unit customer consumption. In the latter case, improvements in the DWASA billing system and procedures in combination with more individualized customer consumption metering are of utmost importance. Critical is also the extension of household connections to ensure more direct DWASA supply, and hence reduced opportunities for indirect distribution stages at tariff extended conditions.