THE THIRD GENERAL MEETING OF NARBO

INTRODUCTION TO THE STUDY VISIT PROGRAM

(February 20, 2007)

SEDIMENTATION PROBLEM AND WATER ALLOCATION WITHIN THE BENGAWAN SOLO RIVER BASIN (WONOGIRI RESERVOIR)

I. OBJECTIVES OF STUDY VISIT

This handout serves as an introduction to the study visit program which is an integrated part of the Third General Meeting of the Network of Asian River Basin Organizations (NARBO). This introduction is aimed to provide participants with background on the sedimentation and water allocation problem in the Bengawan Solo River Basin. Even though this study will only visit Wonogiri Reservoir and Colo Weir, it is foreseen that the scope of this study is at basin-wide scale.

Objectives of this study visit are as follows:

1. Sharing the present status of the reservoir sedimentation problem and countermeasures of a NARBO members' country in a typically Asian monsoon affected basin.
2. Foster learning process on challenges, solutions and lessons learned in water allocation and sedimentation, which are increasing concerns over Asia.

Study visit will be arranged as follows:

Time	Schedule	Remarks
07.45-08.00	Preparation for departure	
08.00-09.00	Travel to Wonogiri	By bus and coach
09.00-10.00	Meeting with the Wonogiri Regency Administration	
10.00-10.15	Travel to confluence of Keduang River and Wonogiri Dam	
10.15-12.00	Site visit & dialogue with reservoir management representative and dialogue with the farmer's water users association	Explanation on site
12.00-12.30	Lunch break	Wonogiri Dam Office
12.30-13.00	Travel to Colo Weir	By bus and coach
13.00-14.00	Site visit at Colo Weir	Explanation on site
14.00-15.00	Travel back to the hotel	

II. INTRODUCTION

Combination of both naturally occurring conditions and human's actions created a distinctive pressure on water resources in most Asian countries. Climate change and natural variability in the distribution and occurrence of water are the natural driving forces that complicate the sustainable development of the present water resources potentials. Climate change associated with global warming is having a significant impact on weather patterns, precipitation and the hydrological cycle, affecting surface water availability, as well as soil moisture and groundwater recharge.

At the present moment, many regions in the world are strangled by surface water availability. In Asian countries that are affected by the monsoon, disparity during the rainy season (where water is abundant and often destructive) and the dry season (where water become scarce) is becoming a growing problem. Construction of dams to create reservoirs has been a classical response to growing demands for water to provide hydropower energy, irrigation, potable supplies, fishing and recreation, as well as to lower the impacts and risks to our well-being from high-intensity events such as floods and droughts. These facilities collect natural runoff, frequently quite variable in its location, duration and magnitude, and store it so that its availability is more constant and reliable. But, the severe sedimentation in many reservoirs in the world has decreased their storage capacities which finally will affect water supply to the downstream users.

It is estimated that total of man-made water storage facilities (reservoirs) in the world is close to 4.500 km^3 and quoting Keller et.al. (2000), it is estimated that close to 1% or 45 km^3 of it is annually lost due to sedimentation (Palmieri et.al., 2003).

Sediments occur in water bodies both naturally and as a result of various human actions. When they occur excessively, they can dramatically change our water resources. Sediments occur in water mainly as a direct response to land-use changes and agricultural practices, although sediment loads can occur naturally in poorly vegetated terrains and most commonly in arid and semiarid climates following high intensity rainfall.

III. PRESENT CONDITION OF THE WONOGIRI CATCHMENT AREA

Due to the population pressure, of the Wonogiri Reservoir catchment, at the present moment about 90% of the total land has been cultivated with dry-land farming that is categorized as highly fragile to surface soil erosion. While forests covers only 10% of the catchment. These values indicate a high population density in the catchment. The Wonogiri reservoir is rapidly filled with sediments transported from the catchment.

Poor land use of its catchment and intensive farming of annual crops using poor practices on the highly erosive and steep-sloped uplands as well as highly populated and intensely farmed areas are the main causes of the sedimentation of the Wonogiri Reservoir. A preliminary assessment of the current state of sedimentation indicated that the effective reservoir capacity has decreased to nearly 60% of the original one. It could be said that, provided that any countermeasure is not taken for the sedimentation problem of the Wonogiri Reservoir, it would lose its functions such as water supply, flood control because of decrease of the storage capacity in the near future.

Especially, the intake structure that feeds water to the powerhouse and downstream irrigation system has been seriously affected by sediment deposits at and around the intake structure. There was a fear that the intake structure be completely clogged with sediments.

To cope with the sedimentation problem of the Wonogiri reservoir, the Government of Indonesia (GOI) requested the Government of Japan (GOJ) to implement the grant aid project. The request covered: (i) construction of two check dams on the Keduang River close to the dam to mitigate sediment inflow into the reservoir; (ii) urgent sediment dredging in front of the intake structure in order to assure the stable and continuous water supply, and (iii) providing a permanent dredging system to allow sustainable maintenance dredging of sediment deposited in front of the intake.

The project is dubbed «Urgent Countermeasures for Sedimentation in the Wonogiri Multipurpose Dam Reservoir» and was initiated on June 2001, but it aimed at only dredging of sediment of about 250,000 m^3 deposited at and around inlet channel and portal portions of the intake structure so as to keep the proper functions of the intake structure for about 5 years. This was mainly due to the consideration that less effect on trapping fine sediments by check dams and high operation and maintenance cost of a dredger. This grant aid project was completed in February 2004 emphasizing the urgent necessity to formulate a master plan on countermeasures for sedimentation problems of the Wonogiri reservoir including its watershed conservation plan.

However, it was just an urgent measure to prevent the intake from clogging by the sediment deposit. In order to recover the storage capacity of the reservoir, fundamental permanent countermeasures should be established and implemented. Under such condition, the GOI officially requested the GOJ to provide the technical assistance to formulate a master plan as a continuation of the grant aid project in August 2002. In response to the request, the GOJ decided to conduct the Study on Countermeasures for Sedimentation in the Wonogiri Multipurpose Reservoir.

IV. CURRENT STATUS OF WONOGIRI RESERVOIR OPERATION

Mean annual inflow volume into the Wonogiri reservoir was approximately 1.23 km^3 in 1983-2005, and mean annual water release from spillway (spill-out) was around 18% of the total outflow volume or 0.21 km^3. The remaining volume (82% or 0.932 km^3) was used for hydropower generation. Mean monthly inflow is abundant in the monsoon rainy season, where it equals to 110.8 m^3/s (0.268 km^3/month) and is the highest in February, in contrary to the dry season, where in August – as an example – it becomes to the lowest of 2.3 m^3/s (0.006 km^3/month).

For flood control, the reservoir water level is controlled not to exceed the High Water Level (elevation 135.3 m) during the flood season for eliminating the possibility of overtopping of a having a probable maximum flood (PMF) surge over the dam crest. The reservoir provides 0.22 km^3 of flood control capacity to regulate the standard highest flood discharge with peak discharge of 4,000 m^3/s to the constant outflow of 400 m^3/s.

Immediately after completion of the Wonogiri Irrigation Project in 1986, the water supply to the Wonogiri irrigation system was commenced. Irrigation water is taken from the reservoir to Colo Weir, located about 13 km downstream of the Wonogiri Reservoir. At present, the irrigation area has been extended from 24,000 ha in the original plan to 29,330 ha where triple or double cropping farming is being practiced. Mean monthly discharges at the Colo Weir in 1986-2005 are ranging from 22 to 30 m^3/s in the dry season.

V. CURRENT STATUS OF WONOGIRI RESERVOIR SEDIMENTATION

1. Sedimentation Condition in the Reservoir

The sedimentation issues and problems of the Wonogiri reservoir are: (i) sediment deposits and garbage at the intake structure; (ii) decrease of effective storage volume due to high sediment yields in Wonogiri dam watershed, and (iii) risky reservoir operation against PMF due to decrease of effective storage volume. A bird-eye view of the sedimentation condition of the reservoir could be seen in Figure 1.

Figure 1 View of the Wonogiri Dam Reservoir during Normal High Water Level – 136 m (above) and Low Water Level - 127 m (below)

An echo sounding survey with global-positioning system (GPS) for the Wonogiri reservoir was conducted over the two periods from October to November 2004 (before entering the wet season) and June to July 2005 (after the wet season) to clarify current status of the sedimentation as well as incremental sediment deposit in the wet season in 2004/2005. From the survey results, the current status of the Wonogiri reservoir is assessed as follows (see Table 2 for details):

1. There is almost no change in the flood control storage zone between elevation 135.3 m and 138.3 m. This is because of the sediment inflow occurs during the wet season and the deposition occurs dominantly in the range of the storage zone between low water level or LWL (elev. 127.0 m) and normal high water level or NHWL (elev. 136.0 m).

2. Therefore, no sediment deposits in the flood control storage zone above NHWL hardly occur, while the visible bank failures/erosions readily occur around the fringe of reservoir area due to wave actions in the reservoir. These reveal that the safety of the Wonogiri dam against a PMF is secured even under the current severe sedimentation condition.

3. In the sediment storage zone below elev. 127.0 m, a volume of 56 million m^3 in total or 49.1% of the original storage capacity has been lost due to sedimentation in 1980-2005.

4. The volume of the effective storage zone between elev. 127.0 m and 136.0 m has been reduced from 433 to 375 million m^3. The volume lost is 58 million m^3 or equivalent to 13.4% of the original storage capacity due to sedimentation between 1980 and 2005.

5. Approximately 16% of the original gross storage capacity (= 730 million m^3) below DFWL (elev. 138.3 m) was lost due to sedimentation between 1980 and 2005. The average annual rate of reservoir capacity loss is therefore around 0.64%/year (= 16%/25 years).

Table 1 Loss of capacity of the Wonogiri Reservoir by storage zone between 1980 and 2005

Reservoir Zone	Reservoir Capacity (million m^3)		Capacity Lost Due to Sedimentation	
	1980	2005	Value (million m^3)	From Original (%)
Flood Control Storage (El. 135.3 – 138.3 m)	232	230	2.0	0.9
Effective Storage (El. 127.0 – 136.0 m)	433	375	58	13.4
Dead Storage (below El. 127.0 m)	114	58	56	49.1

2. Erosion Sources and Sediment Yields from Wonogiri Watershed

Erosion sources of the sediment deposits in the Wonogiri reservoir were identified according to the visible erosion sites in the Wonogiri catchment: i) soil erosion of land surface, ii) gully erosion, iii) landslide (slope failure), iv) river bank erosion, and v) slope erosion of road side. Field investigation and GIS analysis were performed to estimate annual sediment yields from respective erosion sources. Average annual sediment yield into the Wonogiri reservoir in 1993-2004 is 3.18 million m^3. Tabulation of the erosion sources is as Table 2. Dominant erosion source is the soil erosion from land surface. Its volume is 93% of the total, while sediment yields from other sources is only 7%.

Table 2 Annual sediment yield into the Wonogiri Reservoir by source and river (m^3)

River System	Gully Erosion	Landslide	River Bank	Roadside Slope	Surface Soil Erosion	Total
Keduang	67,880	2,930	9,780	3,690	1,134,300	1,218,580
Tirtomoyo	90	11,730	19,760	2,480	469,700	503,760
Temon	30	0	11,350	600	61,000	72,980
Solo	220	440	11,040	1,990	591,300	604,990
Alang	7,330	0	66,620	730	326,600	401,280
Others	0	0	11,850	1,170	363,900	376,920
Total	75,550	15,100	130,400	10,660	2,946,800	3,178,510

VI. PROPOSED MEASURES TO COPE WITH THE SEDIMENTATION ISSUES

1. Structural Measures Alternatives

The following structural measures are proposed considering the sediment inflow characteristics of the tributaries: i) Measures to cope with the sediment and garbage inflow from the Keduang River as well as the sediment deposits at/around the intake structure as the urgent measure, and ii) Measures to cope with the sediment inflow from other tributaries as the mid-term and long-term measures. Figure 2 presents conceivable structural alternatives of respective measures and Figure 3 illustrates the concept of these alternatives.

2. Proposed Watershed Conservation Projects

The proposed basic conservation measures consisting of soil & water conservation measures and agricultural promotion measures for the targeted subject areas of upland field, settlement areas under upland field condition and settlement areas have been formulated for individual land units being classified by slope classes and current terrace type. The measures are briefly discussed in the followings.

Upland Field with Benched Terrace

Soil and water conservation measures envisaged in the upland field with benched terraces are defined as "Terrace improvement works" and include improvement of terrace structures of terrace bench, lip, riser, waterway and drop structure at different degrees depending on current terrace type and condition. Further, the works include vegetative measures of vegetating of terrace lip and riser with grass or shrub for their stabilization.

The agricultural measures are formulated as land management and agricultural promotion concepts: (i) land management for soil and water conservation; (ii) agro-forestry promotion; (iii) improvement of settlement area use; (iv) crop sub-sector measures and (v) livestock sub-sector measures.

Agro-forestry is considered as a soil and water conservation and agricultural promotion measure which is envisaged to be introduced in the entire farm land for increase of farm income and for mitigating farm labor shortage problem slated in the near future in the watershed area. The intensity of the introduction of agro-forestry is determined depending on slope class as set in the basic directions.

Upland Field without Bench Terrace, Traditional Terrace and Settlement Area under Upland Field Condition

The conservation measures proposed in upland field without bench terrace, traditional terrace and settlement area under upland field condition are similar to those proposed for upland field with bench terrace and defined as «terrace formation/upgrading works» and consist of physical measures and vegetative measures. Proposed agro-forestry development and land management and agricultural promotion measures in the subject areas are same as those proposed for upland field with bench terrace.

Settlement Area (Housing Yard)

Measure proposed to mitigate soil erosion in housing yards is to establish hedge rows at fringe of the yards and to construct side ditches along housing yard.

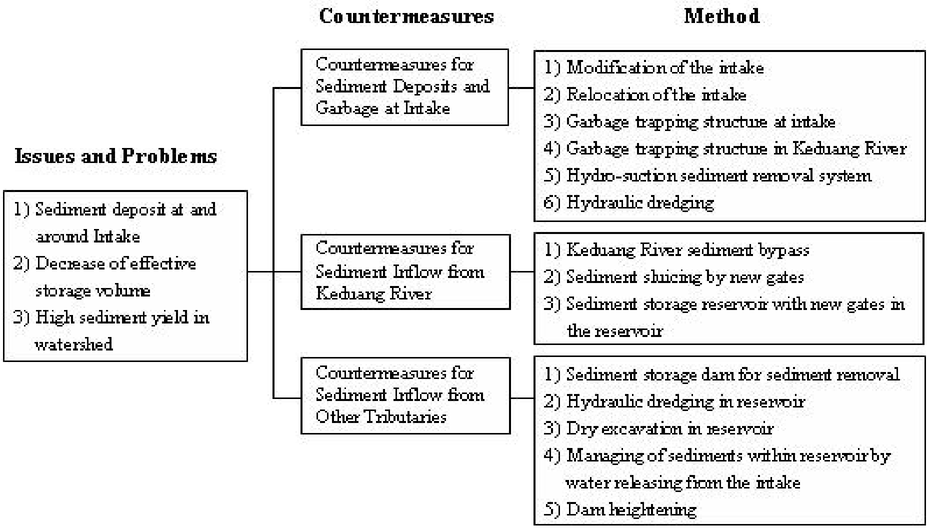

Figure 2 Conceivable structural alternatives for Wonogiri Reservoir sedimentation issues

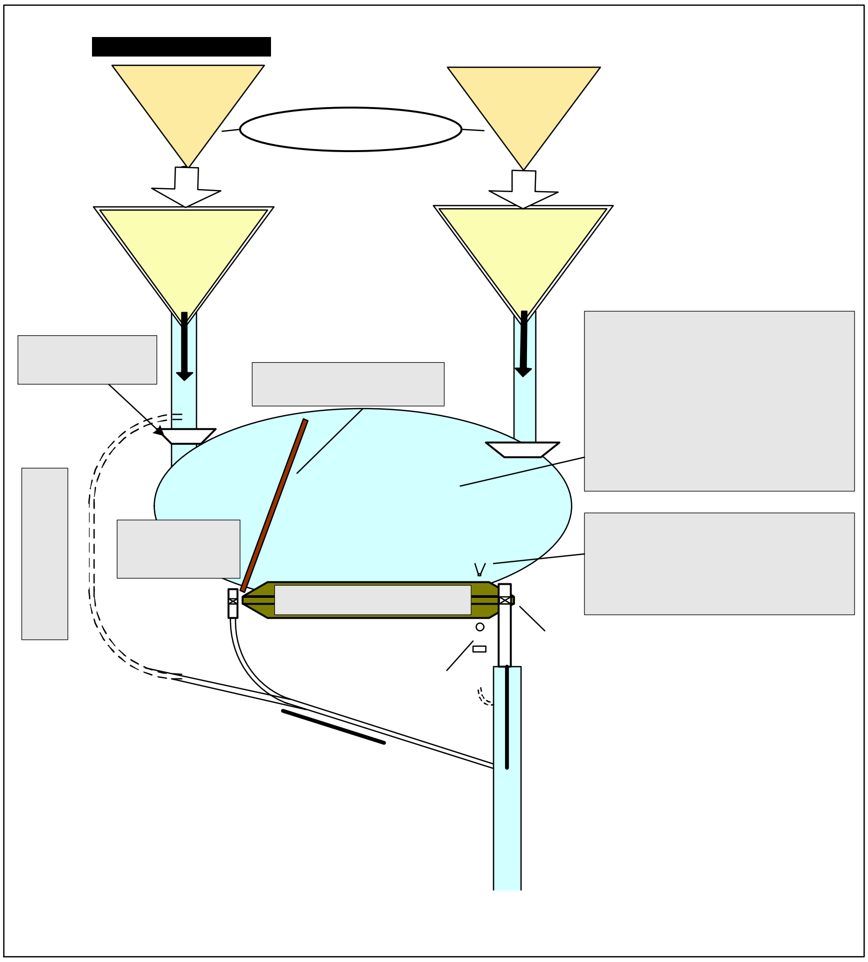

Figure 3 Concept of conceivable structural countermeasures on tributaries

In brief, the following Table 3, Table 4 and Table 5 as quoted from the GOI study (2007), will show summary of the evaluation results made on the alternatives.

Table 3 Evaluation results of alternatives for sediment deposits and garbage at the reservoir intake (GOI, 2007)

Alternative	Technical Applicability	Environmental and Social Impacts
1) Modification of intake	Not sustainable solution because sedimentation will continue year by year over the inlet elevation at the intake.	Irrigation water supply and power generation shall be suspended due to temporary stoppage of the intake during construction.
2) Relocation of intake	Sedimentation will occur at the new intake, although sedimentation rate is small compare to that at the existing intake. Periodic dredging at the new intake would be required in the future.	Irrigation water supply and power generation shall be suspended due to the connection work with the existing intake. Large disposal area will be necessary.
3) Garbage trapping structure at intake	Blocking of the intake will be solved by periodical garbage removal. Sediment deposits at the intake shall be solved by other structural measures.	Water supply shall be suspended due to temporary stoppage of the intake during construction.
4) Garbage trapping structure in the Keduang River	Periodical removal of the trapped garbage will be required. Sediment inflow flow Keduang River continues to enter into the reservoir without being trapped.	Positive impact will occur. Degradation of water quality in the reservoir will be mitigated owing to trapping of garbage from the Keduang River.
5) Dredging by hydro-suction method	There are operational constraints depending on the reservoir water level because of necessity of water head difference.	Possible negative impact on water quality of downstream Bengawan Solo River due to release of dredged sediment.
6) Hydraulic dredging	Most common measures for removing sediment deposits in reservoir. Huge spoil bank areas are required.	Relatively less impact because of lots of worldwide experiences provided with spoil bank areas.

Table 4 Evaluation results of alternatives for sediment inflow from Keduang River (GOI, 2007)

Alternative	Technical Applicability	Environmental and Social Impacts
1) Keduang River sediment bypass	Technically applicable. But due to small discharge capacity of bypass tunnel (50 m^3/sec) flood inflow from the Keduang River with high sediment concentration cannot be fully diverted. Considerable volume of sediment flow as well as garbage from the Keduang River enters the Wonogiri reservoir. Modification of intake or periodic dredging at the intake will be indispensable in view of sustainable operation of the reservoir. Huge construction cost will be required.	Serious negative impacts with larger magnitude will occur. Huge disposal areas of excavated materials (around 270,000 m^3) spawned by tunneling are necessary. It might be very difficult to secure spoil bank areas near the dam area. Impacts during construction works include topographic and geologic changes, waste of excavated materials, drawdown of groundwater level and inconvenience of well water use, air quality, noise ,unrest of local people, some conflicts/opposition from local people, etc.
2) Sediment sluicing by new gates	Technically applicable. Sluicing operation will be applicable at the beginning of wet season only when the water level is the lowest. If the gates are fully opened, considerable amount of garbage would be released to the downstream reach. However, release flow from the gates shall be controlled not to exceed 400 m^3/s according to the current reservoir operation rule. There is a risk that the reservoir water level cannot reach NHWL at the end of wet season when much water is used for sluicing. More than half of the sediment inflow from the Keduang River will be deposited in the	Highly turbid water from the Keduang River will be released. The released turbid water might cause negative impacts on aquatic organisms, especially fish. At the worse, high concentration of SS might cause a respiratory impediment of fishes. Huge disposal areas of excavated materials (around 800,000 m^3) are necessary. It might be very difficult to secure spoil bank areas near the dam area. Impacts during construction works include topographic and geologic changes, waste of excavated materials, air quality and noise, etc.

Alternative	Technical Applicability	Environmental and Social Impacts
	reservoir. Periodic maintenance dredging at the intake is necessary.	
3) Sediment storage reservoir with new gates in the reservoir	Technically applicable. Sediment sluicing (sediment routing) and flushing contemplates to effectively utilize the water power (sediment transport capacity) of a natural river with less running cost. As the sediment storage reservoir can be operated independently from the Wonogiri main reservoir, the current operation rule can be applied for sediment releasing operation. After the reservoir water level reaches NHWL, sediment releasing operation will be started without using the stored water in the main reservoir.	Highly turbid water from the Keduang River will be released through the new gates. The released turbid water might cause negative impacts on aquatic organisms, especially fish. At the worse, high concentration of SS might cause a respiratory impediment of fishes. Huge disposal areas of excavated materials (around 800,000 m^3) are necessary. It might be very difficult to secure spoil bank areas near the dam area. Impacts during construction works include topographic and geologic changes, waste of excavated materials, air quality and noise, etc.

Table 5 Evaluation results of alternatives for sediment inflow from other tributaries (GOI, 2007)

Alternative	Technical Applicability	Environmental and Social Impacts
1) Sediment storage dam for sediment removal	Technically applicable but not sustainable solution in view of practicability. Around 83 units of storage dam would be necessary for trapping the annual sediment deposition volume of 2.0 million m^3 from other tributaries. Continuous sediment removal works for 2.0 million m^3 will be necessary every year. It would not be practical and applicable.	Huge disposal areas are necessary for periodic sediment removal works. It would be impossible to secure annually spoil bank areas for spoiling 2.0 million m^3 of sediments near the reservoir.
2) Hydraulic dredging in reservoir	Technically applicable but not sustainable solution in view of practicability.10 dredgers would be necessary to dispose the annual sediment deposition volume of 2.0 million m3. Huge running cost and spoil bank areas are required. It will not be practical and applicable.	Huge disposal areas are necessary for dredging works. It would be impossible to secure annually spoil bank areas for disposing 2.0 million m3 of dredged sediments near the reservoir.
3) Dry excavation in reservoir	In view of sustainable and economical measure, dry excavation deems not applicable. So many equipments such as bulldozers, crawler loaders and dump trucks would be necessary to excavate the annual sediment deposition volume of 2.0 million m3. Huge running cost and spoil bank areas are required.	Huge disposal areas are necessary for periodic sediment removal works. It would be impossible to secure annually spoil bank areas for spoiling 2.0 million m3 of sediments near the reservoir. Possible impacts on air quality, noise and transportation during the excavation works.
4) Managing of sediment within the reservoir by water releasing from the intake	By use of the maximum intake discharge (70 m3/s) for power generation, previously deposited sediments are moved toward the dead zone of the reservoir, thereby maintaining or increasing the effective capacity of the reservoir. However, reliability of this method will be considered to be low, because of likely blocking of the intake due to garbage.	Significant amount of water must be released through power generation, and there is a risk that the reservoir water level cannot reach NHWL. This might cause water deficit for irrigation in downstream area and impacts on paddy fields in case of inappropriate water release. It might spawn people's unrest or conflict.
5) Dam heightening	This method is to raise the dam crest to secure the effective storage capacity. Dam heightening would be the option to adopt in the	This measure might cause social controversy because it would require large area of land acquisition and possibly resettlement. Not only

Alternative	Technical Applicability	Environmental and Social Impacts
	future when the storage capacity of the reservoir decreased substantially. The Steering Committee on August 22, 2005 concluded dam heightening not recommendable.	the social controversy, but also a large scale of civil work would be needed, which may cause serious negative impacts on the local residents.

3. Reduction of Soil Loss Production

The project works for watershed conservation project consist of; (i) terrace improvement works; (ii) terrace formation/upgrading works; (iii) agro-forestry development works; (iv) farming support programs; (v) hedge row works; (vi) side ditch construction works; and vii) other support programs for land management and agricultural promotion. Reduction of soil loss in the Wonogiri watershed is expected after implementation of the watershed conservation projects. The water conservation projects will be carried out about 34,400 ha of the target subject area.

4. Support Program for Promoting Watershed Conservation Projects

The primary practitioners and beneficiaries of the proposed watershed conservation are dry land farmers in the watershed area. For strengthening support for those farmers in executing the watershed conservation, technical and financial support programs for the implementation of watershed conservation have been formulated in the present study. Reflecting the proposed watershed conservation, the proposed programs are formulated being directed to soil & water conservation and land management & agricultural promotion measures. The program components are briefly summarized as follows:

Support Programs for Soil and Water Conservation Project

The proposed soil and water conservation measures are approaches having direct and immediate effect on soil conservation and support programs for practitioner farmers should be accommodated as components of development works to ensure such direct and immediate effects of the measures. The proposed support programs include: (i) empowerment of beneficiary farmers and farmer groups, and (ii) support programs for operation/implementation of conservation measures. In addition, the empowerment of field staffs providing technical guidance and support to farmers and farmer groups is an essential initial and periodical step to be taken for the efficient and successful implementation of the measures.

Table 6 Contents of support programs for soil and water conservation project (GOI, 2007)

Farmers & Farmer Groups Empowerment Package Program	
Programs	**Activities**
1. Farmer group formation program	Farmer group formation (mass guidance, socialization, workshop and support for formation)
2. Farmer group empowerment program	– Key farmers training – Demonstration activities operated by Key Farmer – Mass guidance on conservation measures to all members of farmer groups (farmer field day at demonstration site) – Need inventory of individual farmers for grasses, tree crops & trees to be introduced in the proposed measures
Package Program for Operation/Implementation of Conservation Measures	
Programs	**Activities**
1. Terrace formation guidance program	– Technical guidance on proposed soil & water conservation measures – Provision of grasses/trees for terrace stabilization – Labor cost subsidy for physical measures (terrace improvement, formation or upgrading works)
2. Agro-forestry development program	– Technical guidance on agro-forestry development – Provision of support package (seedlings & farm inputs) for agro-forestry development envisaged in the proposed measures

3. Farming support program	– Technical guidance on farming system improvement – Provision of soil ameliorant and farm inputs
4. Field guidance program	– Inception technical guidance & support to beneficiary farmers & farmer groups – Follow-up technical guidance & support
Other Supporting Program	
Program	**Activities**
1. Field staff empowerment program	Introduction and periodical refresher training and technical guidance for field staffs

Support Programs for Land Management and Agricultural Promotion

The support programs are formulated aiming at strengthening of extension activities for land management & agricultural promotion and consist of: i) technology development program, ii) demonstration program, iii) establishment of pilot demonstration field of tree crops & trees, iv) farmer & farmer group training program, v) vegetable and legume (in Javanese: palawija) seed production program, vi) livestock promotion program, and vii) strengthening of logistic support for extension activities.

Support Programs for Community Development

The support programs are formulated aiming at empowerment of village people and organization. The support programs consist of various supports for: i) village assessment based on the PRA, ii) formulation of draft village action plan, iii) establishment of implementation committee, iv) guidance and support of village grant fund, and v) education program on watershed conservation.

Monitoring and Evaluation at Village Level

The monitoring and evaluation (M&E) at village level are formulated aiming at empowerment of village people and organization for feedback and project modification. The M&E works as empowerment approach should include: i) supervision of the works by the village, ii) project impact analysis by the village, iii) necessity modification of project based on the project evaluation, and iv) knowledge building based on lesson and learn from the project.

VII. PROPOSED PROJECTS TO INCREASE WATER AVAILABILITY IN LOWER SOLO RIVER BASIN

In the Lower Solo River basin, if there is no input of water storage structure, water deficit will occur for the domestic and industrial water uses in the near future. Therefore, Lower Solo Long-channel Storage Project is considered to mainly provide the domestic and industrial water supply.

The Long-channel Storage Project aims at supplying the domestic and industrial water in the Lower Solo River basin and the north coastal area. The north coastal area covers Regencies of Tuban, Lamongan and Rembang, and seriously lack water resources as the highly upper watershed has many small rivers. These areas severely dry up and no reliable water sources are available. However, these areas have been targeted for industrial and associated sector developments to take advantage of favorable seaport facility locations for shipping and roads for inland transportation. These developments will require considerable water volumes for industrial processing and public uses. The extremely limited water resources is a these areas will be countered by transferring water from the Lower Solo River by means of a pipeline and/or the existing floodway associated with the Jabung retarding basin.

Storage structures of the Lower Solo Long-channel Storage Project consist of three barrages and one dam, which are Sembayat, Babat and Bojonegoro Barrages and Alt. Jipang dam. Out of the four proposed structures the Babat Barrage is now completed by the Lower Solo River Improvement Project, Phase I.

Table 7 Additional water supply facilities in the lower Bengawan Solo

Scheme	Barrage/Dam	Capacity (million m^3)
Lower Solo mainstream	Sembayat Barrage	40.6
	Babat Barrage	25.3
	Bojonegoro Barrage	21.0
	Alternative of Jipang Dam	50.0
Total		136.9

VIII. QUESTIONS FOR DISCUSSION

1. What are your country's strategies to adapt and deal with the effects (viz. droughts, flooding) of climate change on water resources?
2. Do you have reservoir sedimentation problems in your respective basin? If yes, how do you manage it and what is the result?
3. What is the role of the existing RBO in the affected basin or who are the parties addressing challenges on water allocation and sedimentation?
4. In case of water scarcity occurs in your basin, how do you allocate water to the users?

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