8.1 Necessity of Updating

The Three Gorges reservoir began to store water in June 2003. By November 5, the water level had risen to El.139 meters. As the formation of the reservoir has a certain impact on the hydrological regime of the Yangtze, the monitoring system and emphasis of monitoring should also change correspondingly according to the changes in natural environment conditions. At the same time, since 1995, with the changes in overall environment and policies, the shift of functions of the government, the building of major ecological projects, technical progress and the readjustment of the goals of the monitoring system itself, great changes have taken place in the environment where the monitoring system is being operated. So, all those as above require necessary modification of the monitoring program.

Changes in Environment of the Reservoir Area

After the impoundment of the reservoir in June 2003, it has brought about changes in the natural hydrological regime. The water surface of the reservoir has been widened; the flow velocity has slowed down and sediment has deposited. With the progress of the project and the rise of the water level, the TGP began to display its function of flood control. The operation of the reservoir determines that there would be a water-level fluctuating zone to the banks of the river in the reservoir area, where there would be a unique ecosystem with terrestrial and aquatic ecosystems acting upon each other. While, downstream of the dam, due to changes in the water flow during high and low seasons, there would be scouring to a certain extent, thus changing the river regime evolution.

In addition, the natural environment has also improved due to much state investment in such projects as returning farmland back to forests, protecting natural forests and building green belts around the reservoir. The water pollution control projects in the reservoir area and its upstream will lighten the pollution load of the reservoir and improve the water quality.

Now that construction and operation are going on simultaneously and will last for some time, but by the end it will be mainly on the stage of operation, the monitoring points and requirements will have to be changed according to the features of the new environment. The central task of the monitoring system should also be shifted from mainly collecting baseline information to serving reservoir management, safety operation, and sustainable development of the reservoir area and to serving the purpose of retrospective review of the environmental impact. The whole monitoring system must adapt itself to the changes of the new situation.

Changes in Policy

Since 1996, with China entering into the WTO and the development of the socialist market economy, the government has taken new steps to bring its administrative behavior and environmental standards in line with those of the world and changed its policies and rules and regulations by which the monitoring system operates. Not only have the original policies and rules and regulations been changed and modified and becoming more demanding, but also new policies and new rules and regulations have been formulated. The new “Water Law” was put into effect on October 1, 2002; Law on Environmental Impact Assessment has also been promulgated. The state has modified the standards for surface water (GB3838—2002).

It also needs further study as to how to draw on and apply the owner responsibility system, the bidding system, the project supervision system, and the contract management
system introduced for the TGP in line with market rules. In reality, apart from the contract management system, the other three systems have not been effectively implemented especially the project supervision system. The traditional administrative management still dominates the implementation of project management, making the monitoring system unable to meet the requirements of the developing situation, thus affecting the efficiency and capability of the monitoring system.

Changes in Technology

The technical progress, especially the heightening of the ecological awareness of the people, has raised higher demand on ecological and environmental monitoring. The missing out contents have to be added and such technical means as monitoring instruments and meters have to be improved.

The original system mainly does monitoring at selected points and lines. With the application of remote sensing technology, the vertical dynamic monitoring system has become a possibility so that the monitoring system may get a full picture of TPG impacts on the environment in an integrated manner and from a macroscopic angle.

The progress in the IT technologies, such as Internet, has made information exchange much easier and the databank technology has made the integrated management of tables, charts and graphics and images a possibility and made the information sharing more convenient. The data accumulation has raised higher demands on the monitoring system with regard to integrated analysis, forecast, application, and development of pre-warnings.

Necessity of the Improvement in the Monitoring System Itself

Following 8 years of operation, the TPG environmental monitoring system has completed baseline surveys and has to deal with new problems and new situations after the impoundment of the reservoir. The water quality monitoring has to be changed according to the post-impoundment hydrological regime; the pollution sources monitoring has to know the changes of discharge outlets of the new wastewater treatment plants and garbage disposal sites. The monitoring of eutrophication has to be undertaken in the backwater zones of tributaries; there are problems of repetition and drawbacks in monitoring targets among different monitoring stations.

The purpose of updating is to make the monitoring targets more complete and system management sounder, so as to make it better adapt to the administrative system and raise the efficiency and capabilities onto a new level.

8.2 Adjustment of the Monitoring Indicator System

The guideline for the modification is to proceed step by step under a unified planning and strive to bring the monitoring system to perfection according to the trans-regional, trans-sectoral, multi-disciplinary, and multilevel characteristics to make it well matched with the progress and requirements of the TGP so that it is put in better service of the ecological protection and the operation of the reservoir.

The original monitoring system started operation in 1996. After it was adjusted in 2000, it has become what it is today, with 19 major monitoring (experimental) stations, each station having its own monitoring objectives and targets and their own indices. They first established the targets of monitoring and then, according to different targets, set up major monitoring stations at authoritative units and sectoral departments, which fixed their base stations and indicators systems according to their respective monitoring targets. The whole monitoring system has, through many years of continuous work, obtained a large amount of previous baseline data on the TGP impact on the ecology and environment. But with the monitoring going into depth, some indicators have fallen short of the requirements, making it difficult to realize the monitoring goals for future development. The main drawbacks are:

The original monitoring indicator system was designed to suit the ecology and environment conditions of a given period of time before the reservoir was built. The classification was more to meet the requirements of traditional management. But changes have taken places in all the natural, social, and economic conditions in the areas affected by the TGP, which dictates the corresponding changes in the indicator system. For instance, when the preliminary water storage and power generation started in June 2003, the reservoir brought about changes in the hydrological regime and natural conditions and the pollution and eutrophication of major tributaries emerged as a major problem, hence the necessity of corresponding adjustments in the indicators for monitoring.

As the indicator system was designed according to the monitoring capabilities and habitual requirements of all major stations, a small part of the indicators were repetitive and unsystematic, with some satisfying only the requirements of the current industrial management instead of the requirements of the TGP impact or the requirements of the reservoir management. Besides, some items for monitoring were missing. It is, therefore, necessary to design a new indicator system to raise the monitoring abilities of the system, to make it capable of carrying out integrated monitoring of the TPG impact on the environment. The indicators for non-point pollution source monitoring represented fewer types of land and the scope of distribution of
monitoring points is limited, falling short of the requirements for overall monitoring. The existing terrestrial plants monitoring system did the work by using points and lines quadrates, which are not so representative with regard to monitoring scope. In addition, the frequency of monitoring is not enough and poor in synchronization. It is, therefore, necessary to add more representative land and increase the monitoring frequency and synchronization.

The monitoring indicator system after the reservoir water storage was divided into four levels: system, sub-systems, classes and subclasses. We have made further studies of the system according to the monitoring objectives. In the classification mentioned in Chap. 4, we gave more consideration to the traditional mode of management and practical needs, thus rendering the system less scientific. For instance, the “Sub-system in Table 4.5 was made both according to scientific classification such as hydrology and water quality and according to the regional classification such as estuary ecology. It is also classified according to ways of monitoring such as remote sensing and according to the work nature of stations such as eco-environmental experimental stations. In a word, the way of classification is complicated and confused, not so scientific.

With these problems in mind, we have in this section made some improvements in the indicator system, doing away as far as possible with crossed and repetitive monitoring in different sub-systems at the same level or among different classes such as is shown in Fig. 8.1.

The first level is the system, which reflects the general situation of the monitoring system.

The second level covers the sub-systems, which has been integrated from 12 before the impoundment into nine in line with the new natural and social conditions. They are pollution sources, hydro-environment, aquatic life, terrestrial ecology, wetland ecology, climate conditions, social environment, integrated, and other sub-systems. The 11 sub-systems mentioned in Chap. 4 have been reclassified into six sub-systems, with (water-level fluctuating zone) wetland ecology and the integrated sub-system added.

The third level covers classes, which are divided into 26 according to the nature and characteristics of issues.

The fourth level involves subclasses. It has 52 subclasses, giving prominence to the comprehensive monitoring indicators.

Below the fourth level are specific monitoring indicators selected according to the state standards and the actual conditions of the TGP.

The integration and monitoring of the sub-systems are shown as follows:

The pollution source sub-system remains unchanged in both sub-system and classes, with additions made only to the subclasses according to the changes following the water storage of the reservoir.

The hydro-environment sub-system has integrated hydrology and water quality sub-systems and the water quality for fisheries in the “Fisheries and Aquatic Life Sub-System” and the estuary water quality and salinization in the “Estuary Eco-Environment Sub-system” in Table 4.5 of Chap. 4. Besides, “temperature stratification of the reservoir” and “Eutrophication of Tributaries in the reservoir area” has been added.

The aquatic life sub-system has integrated the “Fisheries and Aquatic Life Sub-System”, the aquatic life part of the “Hydrology and Water Quality Sub-System” and the estuary plankton and benthos life in the “Estuary Eco-Environmental Sub-system” in Table 4.5.

The terrestrial ecology sub-system has integrated the “Terrestrial Animal and Plant Sub-System”, the “Terrestrial Plant Observation and Experimental Stations” and the water and soil loss in the “Remote Sensing Sub-System” in Table 4.5 and adjustments have been in line with the needs of the reservoir after impoundment.

The wetland sub-system has been added according to the changes of water level and the emergence of the water-level fluctuating zone, an issue that has caught extensive attention at home and abroad and is therefore very important for the reservoir as a scenic spot. After water stored, the water-level fluctuating zone has become an anti-season wetland ecosystem, with low water level in the high water season but high water level in the low water season. As a sub-system, it merits special attention.

The climatic sub-system remains unchanged as the “Local Climate Sub-System” in Chap. 4.

The social environment sub-system has integrated the “Socio-Economic Sub-System” and “People’s Health Sub-System” in Chap. 4, with the sample surveys of urban resettlement added.

The integrated sub-system gives prominence to the importance of comprehensive analysis and information integrated management in studying the impact of TGP.

Other sub-systems have not been integrated and adjusted as they belong to different management departments. They remained the same as in Chap. 4.

The third and fourth levels may be divided into sample monitoring and typical monitoring according to methods of work. Sample monitoring includes point pollution sources, floating pollution sources, terrestrial animals, people’s health and follow-up survey of the resettled people; typical monitoring includes non-point pollution sources, mainstream water quality, and eutrophication of reservoir water and local climate, which require a long-time and continuous monitoring at fixed points.

There are also regular monitoring and specialized monitoring according to monitoring frequency and organizational method. Specialized monitoring is applicable to that with low frequencies, such as pollution sources, terrestrial
| System | Sub-Systems | Class | Sub-classes |
|--------|-------------|-------|-------------|
| TGP Ecological and Environmental Monitoring System | Terrestrial Ecology | Other | Geological hazards: Specialized monitoring and precaution, mass participation |
| | | | Induced earthquake: Seismological station, earth crust deformation, underground water dynamic observation well |
| | | | Sediment deposit and scouring: Hydrology, underwater topography and sediment |
| | | | Construction site monitoring: Hydrology and water quality, air, noise, people’s health |
| | | Integrated analysis and assessment | Information management and release: Websites |
| | | | Reporting |
| | | | Information system |
| | Social Environment | | Synchrony of hydrology and water quality |
| | Climatic Environment | | Follow-up survey of resettled people: Sample survey of urban resettled people |
| | | | Socio-economy: Socio-economy |
| | | | People’s health: People’s health |
| | Aquatic Life | Landscape ecology of the water-level fluctuating zone | Integrated analysis and assessment: Sustainable development capability |
| | | | Ecology and environment security |
| | | | Socio economic environment |
| | | | Biodiversity |
| | | | Hydro-environmental |
| | Water and soil loss | Plants | Local climate: Vertical climate |
| | Terrestrial places | Animals | Regular climate |
| | Terrestrial animals | | Forest resources: Forest resources |
| | | | Agricultural ecology: Productivity of nearly reclaimed land in reservoir area |
| | | | Agricultural eco-environment in reservoir |
| | Plankton and benthos | Plankton and benthos at estuary | Plankton and benthos of mainstream |
| | Rare and endemic species | Rare species of fish | Endemic species of fish |
| | Fishing resources | Fish resources at estuary | Fish resources downstream of dam |
| | | | Fish resources in reservoir area |
| | Underground water | Salinization at estuary | Gleyed soil in midstream |
| | Tributary hydro-environment | Eutrophication of tributaries in reservoir area |
| | Mainstream hydro-environment | Water quality at estuary | Water quality for fish resources |
| | | | Stratification temperature of reservoir |
| | | | Pollution belts |
| | | | Synchrony of hydrology and water quality |
| | Floating pollution sources | Pollution by vessels |
| | Non-point pollution sources | Farm chemical and breeding industry pollution |
| | | Small catchment area |
| | | Runoff ground |
| | Point pollution sources | Sewage and garbage treatment plant outfall |
| | | Daily life pollution sources |
| | | Industrial pollution sources |
animals and plants, water loss soil erosion, which does not change much annually. Limited financial resources are unable to ensure the quality of monitoring if they spread over scattered targets. So they do not need to be monitored every year. Annual monitoring may be carried out in a few years’ interval.

This classification is the result of our study and exploration, taking into account the scientific nature and practical management convenience. But it is not hard and fast rule. In fact, during the monitoring by major stations, there are both sample monitoring and typical monitoring and both specialized monitoring and regular monitoring. It is up to various major stations to decide what kind of monitoring to be conducted according to actual circumstances.

The indicator system in this book is designed for use in assessing the TGP impact, with the main purposes of avoiding unfavorable effects. This is the characteristics of the system and the requirements of management. The developments of river management in the world show that the establishment of an indicator system for monitoring the health of an ecological system and for facilitating management, by making river, reservoir and lake as “organisms”, has gradually become a hot spot in river monitoring, study, and management [28, 29]. It is, therefore, a future development trend to monitor and assess the impact of water projects on ecology and environment by determining the health of the ecological system. So, it is that of the Three Gorges reservoir as the main objective, a monitoring indicator system has been set up.

8.3 Targets of Monitoring of All Sub-systems After Impoundment

This section mainly gives a general description of the scope and targets for monitoring by the eight sub-systems. It does include the other four specialized monitoring targets as they have their own program of action.

8.3.1 Pollution Sources Sub-system

Purpose: to get clear about the major pollutant loads and sources as well as the total pollution loads of the reservoir so as to provide the basis for controlling the pollution and protecting the water quality.

Point Pollution Sources

In order to ensure the water quality of the reservoir, the state started in 2001 to invest heavily in building a series of sewage and garbage treatment plants, which would be completed one after another after the impoundment of the reservoir in June 2003. After that, fish culture in net pen (cage culture) appeared in some places. It is, therefore, necessary to intensify monitoring of the completed sewage and garbage plants in addition to the industrial and urban sewage monitoring, so as to estimate the contributions to pollution by the cage culture.

(1) Monitoring scope

Industrial pollution sources, urban sewage outlets, outlets of sewage treatment plants, garbage dump sites and fish breeding cages.

(2) Indicators

Industrial pollution sources: industrial wastewater discharge, density and amount of major pollutants, new polluting enterprises and main pollution load and the number of enterprises passing through environmental assessment.

Urban sewage outlets: Number of urban people, urban area, tap water supply, sewage discharge and annual discharge of BOD₅, COD₅, TP, NH₃-N, ArOH, Oil; amount of daily sewage generated and discharged, and cumulative stock and position of garbage dump sites.

The third and fourth levels may be divided into sample monitoring and typical monitoring according to methods of work. Sample monitoring includes point pollution sources, floating pollution sources, terrestrial animals, people’s health and follow-up survey of the resettled people; typical monitoring includes non-point pollution sources, mainstream water quality and eutrophication of reservoir water and local climate, which require a long-time and continuous monitoring at fixed points.

Sewage treatment plants: sewage collection rate, discharge amount, and density of BOD₅, COD₅, TP, NH₃-N, ArOH, and Oil discharged.

Garbage dump sites: garbage collection rate, annual amount dumped, leakage and treatment.

Fish cage culture: type, composition and amount of baits used and their contributions to pollution.
Non-point Pollution Sources

Before the reservoir impoundment, surveys were carried out only on the use of farm chemicals and chemical fertilizers, paying not much attention to animal and poultry farming. With rise in scale of animal and poultry farming, pollution caused cannot be ignored. Farm chemicals, chemical fertilizers as well as animal and poultry farming pollute the reservoir in the form of non-point pollution. Runoff and small catchment area monitoring is important in estimating the load of non-point pollution sources. Some work was done before June 2003. But as the work was not standardized, typical or representative, it affected the accuracy of the estimation of the non-point pollution source loads. It is, therefore, necessary to carry out runoff plots observation in representative areas together with the agricultural non-point pollution sources survey and small catchment area monitoring, thus completing the non-point pollution load estimation system in the reservoir area.

(1) Monitoring of runoff plots

- Monitoring scope: It covers 64 runoff plots, including 16 existing runoff experimental plots and 48 new ones in Yiling, Xingshan and Zigui of Hubei Province, Jiangjin, Fengdu, Shizhu, Kaixian, Wushan, and Wanzhou in Chongqing.

To prevent water pollution in the Three Gorges Reservoir, the state invested a lot to build sewage treatment plants. How much sewage can be treated actually by the sewage treatment plants in the area? How much is the pollution load? Would cage culture bring about water pollution? And how about are landfill, large-scale livestock and poultry pollution, etc.? The water pollution pattern in the area has changed, so it is necessary to adjust the content to adapt to this change with the monitoring need. The picture shows the cage culture in the reservoir (Photo by Huang Zhenli).

- Monitoring indicators
  - Runoff plots: longitude and latitude, length, width, gradients, slope length, photo, and annual loss in thickness;
  - Soil fertility in runoff plots: soil type, porosity, relative density, pH, characteristics of soil cross-section, grain size (three levels), organic matters, ammoniacal nitrogen, AHN, granulated phosphate, fast-acting phosphate, fast-acting potassium, TN, TP, TK,
cooper, zinc, lead, chromium, cadmium, mercury and arsenic, lasting organic pollutants (decomposed matters from farm chemicals and herbicides).

- Daily rainfall: maximum and continuous 10, 20, and 30 min heavy rains; surface runoff and sediment content in runoff.
- The precipitation of each rainfall and lasting time; maximum continuous 10, 20, and 30 min heavy rain; surface runoff; sediment content of runoff; vegetation covered by rainfall.
- Indicators for surface runoff: pH, TN, TP, ammoniacal nitrogen, soluble phosphate, soluble potassium; persistent organic pollutants (decomposed matters of farm chemicals and herbicides).
- Monitoring indicators for surface runoff sediment: organic matters, ammoniacal nitrogen, AHN, granulated phosphate, fast-acting phosphate, quick -acting potassium, TN, TP, TK, copper, zinc, lead, chromium, cadmium, mercury, arsenic, and farm chemical remnants.

A brick-and-cement sand deposit pit is build below each runoff plot, which measures 1 m³ in volume, 1 m deep and has a cover to prevent rainwater from falling directly into the pit. The picture shows the runoff plot (yellow soil, vegetable-potato intercropping, 15° in gradient) at Longtanping Village, Taipingxi Town, Yiling District of Yichang City. Photo by Huang Zhenli

There are 48 additional runoff areas, with different soil types, planting modes and gradients to monitor the non-point pollution load of slope land. The picture shows the runoff plot (yellow soil, orange-grazing grass intercropping and 5° of gradient) at Longtanping village, Taipingxi Town, Yiling District of Yichang City. Photo by Huang Zhenli

Runoff plot in Kaixian of Chongqing (purple soil, rape-Ipomoea batatas intercropping and 25° in gradient)

Runoff plot of Wanzhou, Chongqing (lime soil, corn-Ipomoea batatas intercropping, 25° in gradient). Photo by Huang Zhenli
• Monitoring frequency: Monitoring is referred to each rainfall of a year.

(2) Small catchment area monitoring

• Monitoring cross-sections: Three hydrological control cross-sections and four side-stream current measuring weirs in the small catchment area of Laoyinggou, Tianba Township, Zigui County and a control observation cross-section at the river mouth.

Three hydrological control cross-sections and four side-stream current measuring weirs at Laotu side-stream and Chenjiagou in the small catchment area of the Wuqiao River in Changling Town of Wanzhou District, two side-stream current measuring weirs in the Laotu catchment area and two in the side-stream at Tangpu Village, with the controlled observation cross-section at the confluence of the Chengjia Stream and the Wuqiao River at Chenjiagou, a controlled observation cross-section in the Wuqiao River before it flows into Changling Town and another controlled observation cross-section in the river before it empties into the Yangtze.

• Monitoring indicators: 1:10,000 scale DEM of small catchment area, soil atlas and land cover atlas, and cross-section longitude and latitude.

Soil fertility: longitude and latitude, soil name, porosity, relative density, pH, character of soil cross-section, grain size (three levels), organic matters, ammoniacal nitrogen, AHN, granulated phosphate, quick-acting phosphate, quick-acting potassium, TN, TP, TK, copper, zinc, lead, chromium, cadmium, mercury, arsenic, and persistent organic pollutants (decomposed matters of farm chemicals and herbicides).

Precipitation of each rainfall and lasting time; maximum continuous 10, 20, and 30 min heavy rain; surface runoff; and sediment content of runoff.

Precipitation of each rainfall and lasting time; maximum continuous 10, 20, and 30 min heavy rain; surface runoff; sediment content of runoff; nutrient loss; maximum continuous 10, 20, and 30 min heavy rain; surface runoff; and vegetation covered (major crops) by rainfall.

Indicators for surface runoff: pH, TN, TP, ammoniacal nitrogen, soluble phosphate, soluble potassium; persistent organic pollutants (decomposed matters of farm chemicals and herbicides).

Monitoring indicators for surface runoff sediment:
organic matters, ammoniacal nitrogen, AHN, granulated phosphate, quick-acting phosphate, quick-acting potassium, TN, TP, TK, copper, zinc, lead, chromium, cadmium, mercury, arsenic, and farm chemical remnants.

• Monitoring frequency: Everyday and each rainfall in the whole year.

• Other requirements: Monitor 1–3 soil cross-sections for each type of soil, with the location of the cross-section marked on the soil atlas. Mode of culture should be marked in the land cover atlas.

(3) Farm chemicals, chemical fertilizer and livestock breeding pollution sources

• Scope of monitoring: 182 townships in Jiangjin, Banan, Yubei, Changshou, Wulong, Fuling, Fengdu, Shizhu, Kaixian, Zhongxian, Tiancheng, Yunyang, Fengjie, Wushan, Wuxi, Badong, Zigui, Xingshan, and Yiling District (county, city).

• Indicators: Application of farm chemicals and chemical fertilizers by townships, unit area application; areas where farm chemicals and chemical fertilizers are applied, type of farm chemicals and chemical fertilizers and in purity terms, with township as unit; unit area farm chemical and chemical fertilizer loss, ammonia loss, N₂O loss, runoff loss, nitrification denitrification loss; number of pits, large animals (cattle, mule, horse and donkey), Sheep, poultry (Chicken, duck and goose), faeces generated a year, proportion used as manure, nitrogen loss, and phosphate loss.

Mobile Pollution Sources

There are many vessels, large in number and widely distributed and strong in mobility, very difficult to monitor. In order to obtain representative and scientific data, it is necessary to carry out investigation and analysis of vessel types, number and pollutants discharged on the basis of getting clear about the basic situation of operating vessels and fix the number of different types of vessels put under monitoring and carrying out sample monitoring at different levels.

• Monitoring targets
Major targets: oil-contaminated water, cabin water and ballast water, sewage water, garbage and waste gas.

Sample number: 5–15%, with vessels having oil-contaminated water being no less than 350 and sample vessels with sewage, noise, garbage and waste gas being no less than 50 for each type.

• Indicators
Basic situation of operating vessels: name of shipping company, type of vessel, number, power, tonnage, passenger and freight transportation on major navigation routes;
Pollutant discharge: amount generated, amount treated, amount discharged, installation and use of waste disposal facilities; garbage reception and treatment at ports,
supervision and management of vessel pollution by marine departments.

Oil-contaminated water: pH, oil, and SS;
Sewage: SS, BOD$_5$, COD, TP, TN, and Bacillus coli;
Garbage: investigating the reception amount and whereabouts and estimating the total amount generated;
Waste gas: soot, NO$_2$, and SO$_2$;
Noise.

- Emergency monitoring of oil pollution accidents
  Pollution accidents by vessels may cause great damages to the hydro-environment and have a great impact on the people’s life. In order to mitigate the impact of such accidents and provide the basis for emergency treatment, it is necessary to carry out emergency monitoring.
  Indicators should include
  - Survey of basic conditions of operating vessels, type of pollutants involved, overflow of pollutants, and areas of waters affected;
  - Indicators should include Oil, pH, COD, BOD, and major pollutants loaded by culprit vessels;
  - Judgment of possible effects on the water body and impact of accident.

8.3.2 Hydro-Environment Sub-system

Purpose: to get clear about the changes of hydro-environment, accumulate data for assessment and development analysis and provide the basis for formulating control plans.

The Hydro-Environment Monitoring Sub-System was relatively sound before the reservoir impoundment. But after the impoundment, the river course has become a reservoir and there are corresponding changes in the distribution of monitoring points and the water function zoning and management and operation require unified arrangements. There should also be corresponding arrangements with regard to the monitoring targets as the water in the tributaries and reservoir bays is easy to be eutrophicated and stratified in temperature. This requires full study.

Mainstem Hydro-Environment

(1) Synchronized monitoring of hydrological regime and water quality

- Hydrological observation
  Cross-sections: 12 in all in Zhutuo, Tongguanyi, Linjiangmen of the Jialing River, Cuntan, Qingxichang, Tuokou, Guandukou, Nanjinguan, No. 37 dock of Hankou, Datong, Beipei of the Jialing River, and Wulong of the Wujiang River.
  Indicators: water level, flow volume, and average velocity at cross-sections.

- Water quality monitoring
  Cross-sections: Nine in all in the mainstream: Zhutuo, Tongguanyi, Cuntan, Qingxichang, a point 1 km downstream of Wanzhou, Guandukou, Nanjinguan, No. 37 dock of Hankou, and a point 23 km downstream of Wusongkou; Seven in all in the major tributaries: Beipei and Linjiangmen of the Jialing River, Wulong and Yulinhe of the Wujiang River, the Xiaojingxiang River, the Daning River, and the Xiangxi River.
  Vertical line and sampling points: nine monitoring points on three vertical lines of six cross-sections in Cuntan, Qingxichang, a point 1 km downstream of Wanzhou, Guandukou, Nanjinguan and No. 37 dock of Hankou, with three vertical sampling points on each vertical line, that is, at a point 0.5 m under water, 1/2 depth of water and 0.5 m from the river bed; seven monitoring points on three vertical lines in two cross-sections at Zhutuo and Tongguanyi, with one sampling point on each of the left and right vertical lines at a depth of 0.5 m and at 0.5 m from the river bed, with one sampling point at 0.5 m underwater, 1/2 of water depth and 0.5 m from the river bed on the mid-depth vertical line; 10 monitoring points and five vertical lines in the cross-section 23 km downstream of Wusongkou, with one sampling point on each vertical line at 0.5 m under water and 0.5 m from the river bed; three vertical lines and six monitoring points in the three cross-sections at Beipei of the Jiangling River, Linjiangmen and Wulong of the Wujiang River, with one sampling point 0.5 m under water and 0.5 m from the river bed of each vertical line; two vertical lines and two monitoring points in the cross-section of the mouths of the four tributaries of the Yulin, Xialaohua, Daning and Xiangxi rivers, with one sampling point as a depth of 0.5 m under water.
  Indicators: temperature, pH, oxidation-reduction potential, conductivity, SS, DO, COD$_{mn}$, BOD$_5$, NH$_3$-N, TN, TP, Total alkalinity, total hardness, Hg, Cr$^{6+}$, As, Cd, Cu, Pb, Oil, B. Coli in faeces, totaling 21, with COD$_{mn}$, TP, TAs, THg, TCu, TPb and TCd analyzed in both clear and turbid water.

- Bottom mud monitoring
  Cross-sections: the same as for water quality monitoring, with samples collected from the river bed of each vertical line of the 16 cross-sections.
  Indicators: THg, TAs, TCU, TPb, TMn, TK, TP, organic matters, organic chloride farm chemical (eight elements), and organic phosphate farm chemical (five components).
(2) Monitoring of pollution belts

- Locations: pollution belts of typical pollution discharge outlets in the reservoir area.
- Indicators: flow, velocity, water level, shape of river course of the starting cross-sections; 2–3 indicators for water quality monitoring according to the special circumstances of pollutant discharge outlets.
- Cross-sections: 5–7 each time (including background water quality cross-section), 5–7 vertical lines, with samples collected from 3 to 5 levels of each vertical line.
- Other requirements: draw a pollution belt spatial distribution map.

(3) Water temperature stratification monitoring

On the basis of the monitoring cross-sections of major stations that do both hydrology and water quality monitoring at the same time, it is to add vertical elements. The monitoring points are determined by local water depth and actually temperature observed, with 5–9 points in each vertical line.

Monitoring is done for a complete hydrological year in major areas where temperature stratification is likely to appear based on a mathematical model. Sampling points are required to be distributed according to the size of measuring area before the dam and in reservoir bays. Sampling points on the vertical line should be distributed at 0.5–1 km intervals, which should be smaller if thermocline appears in actual measuring.

(4) Monitoring of water quality for fish

- Monitoring of fishing environment in reservoir area
  - Locations: Yibin, Banan, Wanzhou, and Wushan.
  - Indicators: temperature, pH, DO, COD\textsubscript{Mn}, Cu, Zn, Pb, Cd, Cr\textsuperscript{6+}, Hg, ArOH, TP, NH\textsubscript{3}-N, Oil, cyanides, SS, and As, totaling 17; heavy-metal remnants include Cu, Zn, Pb, Cd, Cr\textsuperscript{6+}, Hg, ArOH, and As, totaling eight.
- Spawning ground of Chinese sturgeon
  - Locations: Mainstream Power Station, ship-lock, Miazui, third-channel outlet, and Huyatan.
  - Indicators: Temperature, pH, DO, COD\textsubscript{Mn}, Cu, Zn, Pb, Cd, Cr\textsuperscript{6+}, Hg, ArOH, TP, NH\textsubscript{3}-N, Oil, cyanides, SS, As, totaling 17.
- Spawning grounds of four major endemic species
  - Locations: Zhicheng, Longzhou, Sanzhou, and Wuxue.
  - Indicators: Temperature, pH, DO, COD\textsubscript{Mn}, Cu, Zn, Pb, Cd, Cr\textsuperscript{6+}, Hg, ArOH, TP, NH\textsubscript{3}-N, Oil, cyanides, SS, As, totaling 17.
- Spawning grounds in the lake area
  - Locations: East Dongting Lake, West Dongting Lake, South Dongting Lake, Poyang Lake (Duchang, Poyang and Xingzi).
  - Indicators: Temperature, pH, clarity, SS, cyanides, DO, COD\textsubscript{Mn}, NH\textsubscript{3}-N, TN, TP, BOD\textsubscript{5}, ArOH, sulfides, Cr\textsuperscript{6+}, As, Pb, Zn, Cd, Cu, chlorophyll-a, totaling 20.

- Estuary
  - Locations: Tuanjesha–Hengsha Island, Xinhe–Beicao, and Changxing–Jiuduan.
  - Indicators: pH, DO, SS, salinity, inorganic nitrogen, TN, active phosphate, TP, COD\textsubscript{Mn}, ArOH, Oil, Cu, Zn, Pb, Cb, Cr\textsuperscript{6+}, Hg, cyanides and As, totaling 19.

Air supersaturation: When the dam releases water, a large amount of air would penetrate into the water, causing oversaturation of nitrogen and oxygen. That affects the growth of aquatic life, especially fish and may even cause death in serious cases. In the 2004 flood season, as only part of the power stations was operating, a large amount of water had to be discharged through the bottom outlets, causing death of fish due to oversaturation of nitrogen and oxygen. It is, therefore, necessary to intensify the monitoring of nitrogen and oxygen contents of water so as to discover problems timely and adopt corresponding measures.

Scope of monitoring: to be decided on the flood release situation.

Targets of monitoring: nitrogen and oxygen contents of the water body, saturation, respiratory and blood of fish, and the environmental factors for hydrology and water quality.
Gas oversaturation appeared in part of the downstream area in June, 2003 when the dam released water, causing significant fish biological effect.

Hydro-Environment of Tributaries (Eutrophication of Tributaries in Reservoir Area)

(1) Monitoring scope

Select ten first level tributaries each with a catchment area larger than 1000 km² (Xiangxi, Daning, Meixi, Changtan, Modaoxi, Tangxi, Xiaojiang, Longhe, Longxi, and Yulin rivers), with three cross-sections set in each tributary: entry into the reservoir (175 m in water level), river mouth and in the middle.

(2) Requirements for sampling points distribution

Number of vertical lines and sampling points is determined by river width and depth, with one mid-depth vertical line in rivers less than 50 m wide; two in rivers with width ranging 50–100 m; and three for rivers with width bigger than 100 m. Each vertical line should have a sampling point 0.5 m under water surface on each vertical line with a depth less than 5 m; two sampling points 0.5 m under water and 0.5 m from the

Dissection of dead fish discovers a large amount of bubbles in the heart and other organs.

Seawater chemistry: \( \text{PO}_4^2- \), \( \text{SiO}_3^2- \), pH, DO, TN, TP, COD\(_{50}^\text{m} \), BOD\(_5 \), \( \text{NH}_3^+ \), total salinity, TON, granulated organic carbon.

(5) Estuary water quality

- Monitoring scope and distribution of monitoring stations: 121°10’E–123°30’E, 30°45’N–32°00’N. Samples should be no less than 30.
- Indicators
  - Hydro-physics: temperature, salinity, water depth, clarity, color, frontal surface, thermocline, and SS.
river bed in vertical line with a depth of 5–10 m; and three sampling points 0.5 m under water, 1/2 depth and 0.5 m from the river bed in vertical line deeper than 10 m.

(3) Indicators

- Hydrology: flow volume and flow velocity.
- Water quality: pH, color, temperature, clarity, turbidity, SS, DO, CODMn, BOD₅, NH₃-N, Cl⁻, TP, TN, TK, Carbon, TCu, TPb, THg and TAs, totaling 19.
- Bottom mud: color, granule size, organic matter content, TN, TP, TK, THg, TAs, TCu, TPb, TMn, organic chloride farm chemicals (eight components) and organic phosphate farm chemicals (five components), totaling 13.
- Phytoplankton: chlorophyll-a, population, biomass, and algae amount.
- Zooplankton: species and numbers.
- Microorganism: Total bacteria (number/L), B. coli (number/L)
- Net primary bio-productivity (C) [mg/(m³ · d)].

Ground Water

(1) Soil gleization in midstream

- Monitoring scope: Four lakes area in Hubei: two groups of observation points from Xiaogang Farm of Honghu City to Stone Dock.
- Indicators
  Ground water: pressure water level, phreatic water level, and temperature.
  Meteorology: atmospheric temperature and geo-temperature (5 cm).
  Water balance: rainfall and evaporation.
  Gleization of soil: pH, oxygen reduction potential, active reduction matters, and total reduction matters.
  Soil fertility: pH, characters of soil cross-section, organic matters, NH₄-N (ammonium nitrogen), AHN, granulated phosphate, quick-acting phosphate, quick-acting potassium, TN, TP, TK, copper, zinc, lead, chromium, cadmium, mercury, arsenic, lasting organic pollutants (decomposed farm chemicals and herbicides).

(2) Soil salinization at estuary

- Monitoring scope: Three cross-sections are set in Yinyang Town, Daxing Township and Xinglongsha Township of Qidong city, Jiangsu Province, with three monitoring points at each cross-section.
- Targets of monitoring: Regular survey and analysis of surface water, ground water and soil salinity. Dynamic monitoring is done of water level and salinity and of inland waterways and ground water at the typical sections. Dynamic change pattern is followed of moisture and salinity of typical sections. Follow-up survey and monitoring of soil evolution is done at typical and sensitive sections.
- Indicators
  Moisture and salinity: EC of mainstream, EC of inland waterways, EC of soil (nine monitoring points, six levels at each point), negative pressure of soil (nine points, three levels in each), ground water table and EC of ground water.
  Soil salinization: EC of soil, pH and salt ion composition.
  Soil fertility: name of soil, porosity, relative density, characters of cross-section, grain size (three levels), organic matters, NH₄-N, AHN, granulated phosphate, quick-acting phosphate, quick-acting potassium, TN, TP, TK, copper, zinc, lead, chromium, cadmium, mercury and arsenic, lasting organic pollutants (decomposed farm chemicals and herbicides).
  Hydrology and meteorology: daily meteorological data of Qidong city, including rainfall and evaporation and daily water level (tide position) data of the Yangtze at Santiao Port and Qinglong Port.

Expert seminar on August 29, 2002 discussing eutrophication of Three Gorges Reservoir, an issue that had been the focus of attention. (Photo by Huang Zhenli)
8.3.3 Aquatic Life Sub-system

Purposes: To know the current conditions and annual changes of aquatic life and assess the TGP impact on aquatic ecology and aquatic life so as to provide the scientific basis for policy decision taking.

Fish Resources

(1) Fish resources in the reservoir area
- Monitoring scope: Yibin, Banan, Wanzhou, and Wushan.
- Indicators: Composition, ratio and amount of catches, biological features of major fish species of economic value (body length, weight and age); composition of fish fauna, fish community structure, and resource amount.

(2) Resources of the four major endemic species in Yichang–Hukou section
- Monitoring scope: Jianli, Sanzhou, Wuxue, Zhicheng, and Longzhou.
- Indicators: Production of spawner (fry) and conditions of spawning.

(3) Spawning ground and fish resources in the lake area
- Monitoring scope: Dongting Lake (east, west and south), Poyang Lake (Duchang, Poyang, and Xingzi)
- Indicators
  - Spawning ground: area of lake, area and habitat of the four major endemic species.
  - Catches: composition, ratio and amount of catches, biological features of major fish species of economic value (body length, weight and age);

(4) Fish resources in the estuary
- Monitoring scope: 121°10'–123°30'E, 30°45'N–32°00'N, trawler sampling should be done in at least 15 monitoring stations.
- Indicators
  - Swimming life: community structure, species composition, and fauna features.
  - Characteristics of resources: Catches, resources and biomass of major species [Crab (Decapoda)] of economic value.
  - Characteristics of fishing grounds: Fish catch and resources developments in the fishing zones.
Rare and Endemic Species of Fish

(1) Endemic species
- Monitoring scope: Yibin, Hejiang, Mudong, and Wushan sections of the Yangtze.
- Indicators: Fish species, type, amount, weight structure, total catch, and annual change in the resources of endemic species; food base composition and their habit of reproduction and the relations with the environment; artificial breeding of endemic species.

(2) Early resources of fish
- Monitoring scope: Yidu section of the river.
- Indicators: Composition and ratio of species of early resources; time and spatial distribution of early resources, fishing season of the four major endemic species, runoff of early resources; sources of early resources of endemic species (contribution by major spawning grounds).

(3) Survey of rare species
- Monitoring scope: Mainstream section from the lower reaches of the Jinsha River to the Chongming Island at estuary, including two fixed points in Yichang and Chongming.
- Indicators: Resources of white sturgeon, Dabry's sturgeon and Chinese sucker (Myxocyprinus asiaticus), number and size and location of fish caught accidentally. Number of Chinese sturgeon breeding, time and scale of reproduction, composition and amount of egg-eating fish and egg-eating intensity, resources of Chinese sturgeon larval and juvenile at Yangtze estuary.

Plankton and Benthos Community Survey

(1) Mainstem plankton and benthos communities
- Monitoring cross-section (points)
  Mainstream: two sampling points at Cuntan, Qingxiang, and a point 1 km downstream of Wanzhou, Guandukou, and Nanjinguan. Tributaries: two sampling points, one on the left and one on the right, at Jialingjiang mouth and the Wujiang River mouth and one sampling point in the mouth of four tributaries of the Yulin, Xiaojiang, Daning, and Xiangxi rivers.
- Indicators: Chlorophyll-a, Phytoplankton, zooplankton, benthos animals, attached algae and aquatic vascular plants.

(2) Plankton and benthos community at estuary
- Monitoring scope: 121°10'–123°30'E, 30°45'–32°00'N. Survey and sampling should be done in at least 30 monitoring stations.
- Indicators: Chlorophyll-a and primary productivity; zooplankton, Phytoplankton, benthos; fish type zooplankton: fish egg, larva and juvenile.

8.3.4 Terrestrial Ecology Sub-system

Purposes: Terrestrial ecosystem covers agricultural ecology, forest resources, terrestrial plant and water loss and soil erosion, which are interdependent and mutually influencing each other. The monitoring of the TGP impact on the five types of ecological factors and finding out their mutual relationship and influence will help put forward policy recommendations for improving and protecting the terrestrial ecosystem.

It is suggested that the monitoring of agricultural ecology and environment should increase the monitoring and survey of productivity of newly reclaimed land for the resettled people on the basis of the monitoring of rural energy structure, cropping system, planting structure, pests and plant diseases and gleyed soil so as to adopt timely measures to raise land productivity while protecting the ecology and environment and help farmers achieve wealth and prevent new problems to be caused by newly reclaimed land.

The monitoring of terrestrial animals and plants before the impoundment of the reservoir mainly focused on species, amount and distribution of animals and plants, with emphasis on rare, endangered, and endemic species, famous ancient trees and typical communities in the reservoir area below the 175 m water level. It is, therefore, necessary to add forestry survey on the basis of what has been done and use remote sensing technology to monitor the plant physiological parameters and habitat quality and strengthen the survey of flora in the reservoir area, especially surveys of the impact of the reservoir on the terrestrial ecology.

Agricultural Ecology

(1) Agricultural ecology in the reservoir area
- Monitoring scope: 182 townships, including Jiangjin, Banan, Yubei, Changshou, Wulong, Fuling, Fengdu, Shizhu, Kaixian, Zhongxian, Tiancheng, Yunyang, Fengjie, Wushan, Wuxi, Badong, Zigui, Xingshan, and Yiling.
8.3 Targets of Monitoring of All Sub-systems After Impoundment

- Indicators
  - Rural energy structure: area and amount of firewood forests; number, distribution and per-household number of biogas pits.
  - Cropping system and plant structure.
  - Pests: areas affected by rice blast, Rice borer, late blight of potato, corn leaf blight, big and small scab and rats, areas under control, areas of disaster, output and economic losses.

(2) Productivity of newly reclaimed land

- Monitoring scope: Shuitianba Township of Zigui County, Changling Town of Wanzhou District, totaling five monitoring points.
- Distribution of monitoring points: Monitoring points should be evenly distributed at different elevations; each point should be no less than 100 mu (some six hectares), made up of 5–10 sampling points, including different cropping systems.
- Indicators
  - Survey: plant pattern and cropping system, crop (fruit) types, crop (melon) output.
  - Monitoring: phenology calendar, leaf area index, biomass and pests and plant diseases.
  - Monitoring of soil fertility: soil name, porosity, relative density, pH, characteristics of soil cross-section, grain composition (three levels), organic matters, NH₄-N, AHN, granulated phosphate, fast-acting phosphate, fast-acting potassium, TN, TP, TK, Cu, Zn, Pb, Cr, Cd, Hg. As and lasting organic pollutants (decomposed farm chemicals and herbicides).

Forestry Resources

- Monitoring scope: 55,000 km² administrative area in 18 counties (city) and districts actually inundated.
- Indicators: Forest land area by county, forests (natural and artificial), open forests, shrubs (evergreen and deciduous) area and coverage, standing stock of timber, forest area and standing stock by type of forests, forest area and standing stock by age-group, annual artificial afforestation area and survival area of artificially created forests.

Area and standing stock of timber forests, economic forests, green belt, firewood forests, and bamboo groves by county and areas suitable for afforestation.
Logging area and amount by county, area affected by pests and fire, and areas of regeneration.
Growing stock and growth rate of major forest types; 1:50,000 forest type atlas and forest zoning atlas; Major rare and endangered plants and species and distribution of endemic plants in the reservoir area; Major species under protection, type, amount, and distribution of famous ancient trees.
Impact of resettlement activities and construction of endemic species and typical communities.

Terrestrial Animals

- Monitoring scope: 55,000 km² administrative area in 18 counties (city) and districts, with 30 fixed sampling lines, 20 random sampling lines and 50 random survey sampling points.
- Indicators: Type, distribution, number, and habitat conditions of terrestrial animals.
Types, distribution, amount and habitat conditions and changes of animals, birds, amphibious reptiles, especially rare and endangered species (animals include leopard, cloud leopard, golden-haired monkey, black-leaf monkey, Tibetan macaca, Rhesus macaque, and black bear; birds include crimson-bellied tragopan, koklass pheasant and golden pheasant; amphibious reptiles include giant salamander, Wushan salamander, Tylototriton wenxianensis, Oreolalax lichuanensis and Oreolalax rhodostigmatus.)
Types, distribution, and number of water fowls in wetland.

Terrestrial Plants

(1) Plant community in reservoir area

- Monitoring scope: Sampling fields are arranged according to plant communities and sampling is done by sampling at every layer, totaling about 300, each measuring 100 m × 100 m, with five arbor sample blocks each measuring 20 m × 20 m, 10 shrub sample blocks each measuring 5 m × 5 m and 10 herb sample blocks, each measuring 1 m × 1 m. Each sample block has a lasting
mark, such as cement pile, including the three water-level fluctuating zones at Shuitianba Township in Zigui, Wuqiao River in Wanzhou and Xiaojiang in Kaixian.

- **Indicators**
  - Sample fields: longitude and latitude, place name, area, surroundings, sampling point chart and photos.
  - Environment: Name of plant communities, types, elevation, topography, slope orientation, gradient, slope position, local topography, geological conditions, base rock, moisture conditions, interference and dominant species.
  - Soil: organic matters, pH, TN, TP, TK, fast-acting nitrogen, fast-acting phosphate and fast-acting potassium.
  - Arbor layer: three layers, recording top canopy, height, average age, height and chest diameter, number of tree species, amount and abundance, dominant species, gaps distribution map, forest layer cross-section map, leaf area index, biomass, photos of constructive species, name of each tree, positioning of each tree, canopy projection map, canopy layer area, size of canopy, chest diameter, height, age, and photos.
  - Shrub layer: canopy, layer height, average age, name and number, leaf area index, biomass, constructive species photos, name and number of each species, average height, average cover, abundance, growth period, average leaf area index, average biomass, and photos.
  - Herbal layer: canopy, height, leaf area index, biomass, constructive species photos, name of species and amount, height, canopy, abundance, growth period, and photos.
  - Profile charts of plant community structure, average leaf area index and total biomass.

(2) **Plant physiological parameters**

- Monitoring scope: 55,000 km$^2$ administrative area in the upper reaches of the Yangtze above Yichang.
- Indicators: Monthly plant physiological parameters such as NDVI, LAI, fCover and fAPAR; monthly net primary productivity and net ecology productivity.

(3) **Habitat quality**

- Monitoring scope: 55,000 km$^2$ of 18 counties (cities) which are actually affected by inundation.
- Indicators: Area and ratio of arbor, shrub and grassland, age of arbor, plant coverage, abundance, complexity, and surface biomass.

**Water Loss and Soil Erosion**

- Monitoring scope: One million km$^2$ in the upper reaches of the Yangtze, with emphasis on the reservoir area.
- Targets of monitoring: Area, spatial distribution, intensity of water and soil loss, harm and development trends of water loss and soil erosion, implementations of water and soil conservation projects and results.

8.3.5 **Wetland Sub-system**

To ensure flood control capacity and sediment discharge, the reservoir operates at the 145 m level in the June–September flood season in normal year. After October, the reservoir operates at the normal pool level of 175 m. When the inflow is smaller than the release flow, the water level drops but does not drop lower than 155 m before May. So, there is a 145–175 m water-level change, which is very important to the water and ecology as well as landscape. Before the impoundment, the monitoring system carried out overall baseline material surveys of animals and plants at/below the 175 m inundation line and of land utilization. After the impoundment in June 2003, the area below the 175 m inundation line has become a wetland ecosystem with water-levels fluctuating. The evolution and development of this ecosystem has become an important issue of public concern and in reservoir management. It is very important to carry out special monitoring.

Monitoring scope: 145–175 water-level fluctuating zone of the mainstream and tributaries in the reservoir area.

Targets of monitoring: species of animals and plants and the evolution of their communities, changes in the way of land utilization, especially the pollution of water caused by the agricultural utilization and cultivated land soil leaching.
The reservoir impoundment has given rise to a water-level fluctuating zone, with water level being higher in winter than in summer. When the water level of the reservoir reaches 175 m, the ecology and environment issues of the 30 m high water-level fluctuating zone have caught attention. (Photo by Huang Zhenli at the Little Three Gorges of Daning River in Wushan County on July 16, 2005)

8.3.6 Climate Sub-system (Local Climate)

Conventional Climate

(1) Monitoring scope and distribution of monitoring stations

Reservoir area, with emphasis on areas relatively seriously affected by TGP (a dozen kilometers around the reservoir); choose a number of weather stations to carry out contrast observations in order to analyze and compare the climatic changes before and after the reservoir is built.

There are 16 local meteorological stations. They are Chongqing, Changshou, Fuling, Wanzhou (Longbao), Fengjie, Wushan, Badong, Zigui, Bahekou, Yichang, Zhongxian, Fengdu, Yunyang, Jianshi, Liangping, and Enshi. Among them are ten base stations along the river and the reservoir, with Jianshi, Liangpin, and Enshi as the contrast stations.

The six stations of Chongqing, Fuling, Wanshou, Fengjie, Badong, and Yichang, where industrial pollution is concentrated, have to monitor acid rain in addition to routine monitoring.

(2) Indicators and statistical indices

- Monitoring indicators: air pressure, maximum temperature, minimum temperature, mean temperature, relative humidity, wind velocity, wind direction, precipitation, evaporation, daily sunshine hours, and weather Phenomena (fog, thunderstorm).
- Statistical indices: average monthly air pressure, mean temperature, average maximum temperature, average minimum temperature, average relative humidity, average wind speed, wind direction frequency, precipitation, evaporation, daily sunshine hours, foggy days, and thunderstorm days.
- Acid rain indices: pH value and electricity conductivity, monthly average acidity of rains and average conductivity of rain.

Vertical Climate

(1) Monitoring scope and distribution of monitoring stations

- Yichang cross-section: Tanziling, Sandouping, Sujia’ao, Guizhou, Xiaoxita, Changyang, Xingshan, Shennongjia, Yidu and Taiyangbao, totaling ten observation points.
- Fuling cross-section: Zhongxian, Shizhu, Wulong, Dianjiang, Fengdu, Fuling, Liangping, Pingxiba (Jiangxin Dao), Nantuo, Baisheng and Yutaishan, totaling 11 observation points.
- Low altitude observation points: Sujia’ao of Yichang and Pingxiba of Fuling.

(2) Observation indicators

- Ground observation: temperature, humidity, wind direction, wind speed, precipitation, weather phenomena (fog and thunderstorm), as well as air pressure, evaporation, daily sunshine hours and geo-temperature.
• Low altitude probing indicators: Air pressure, air temperature, humidity, wind direction and wind speed.

8.3.7 Social Environment Sub-system

Purposes: To analyze the TGP impact and other influencing factors on the economic and social changes, study the people’s work and life before and after their resettlement, centering round the goal of people relocation, “Not only being able to move and stay steadily in new place but also embark on the road to wealth”, healthy economic and social development; provide a scientific basis for the government at all levels to formulate strategies and supportive measures for the development of the reservoir area after resettlement; and modify policies and plans for economic and social development of the reservoir area.

The pre-dam social environment monitoring focused mainly on the general survey and the follow-up monitoring missed out the follow-up monitoring of the resettled urban people. It is suggested that this be added in the monitoring system after reservoir impoundment by selecting 500 urban households as samples to carry out surveys in 89 statistical indices, including family structure, population structure and employment, housing and living conditions, income and expenditure in order to reflect the work and life of the resettled urban people.

Socioeconomic Monitoring

(1) Monitoring scope

Four counties in the Hubei reservoir area, five towns of Xiaoxita, Sandouping, Taipingxi, Letianxi, and Maoping around the dam area, 15 districts and counties (cities) and seven major urban districts of Chongqing in the reservoir area.

(2) Indicators

- District (county, city): population, resources, environment, economy, social development, and resettled people, totaling 104 statistical indices and 40 assessment indicators.

- Dam area: basic situation, integrated economic development, people’s life, science, education and culture and health, social security and others, totaling 86 indicators.

Survey of Resettled People

(1) Sample survey of resettled rural people

- Scope of survey: Sample survey of 300 rural households resettled.
- Indicators: Population, environment, economy and social development, resettled people (totaling 236).

(2) Sample survey of resettled urban people

- Scope of survey: Samples survey of 500 resettled urban households.
- Indicators: Family structure, population structure and employment, housing and living conditions, durable consumer goods, income and expenditure, totaling 89 statistical indices.

(3) Follow-up survey of resettled people

- Scope of survey: 50 households in the Changling Town of Wanxian and Liangshui Township; 10 resettled households and 10 non-resettled household in Longkou of Shuitianba Township of Zigui County as contrast.
- Indicators: Family financial situation, including annual income, expenditure, per capita net income and family income structure, agro-household labor employment structure, land use structure, changes in the cultivated land and means of production, quality of living and health conditions of original residents and the resettled people.

Monitoring of People’s Health

(1) Monitoring scope

Five disease monitoring points along the Yangtze and surrounding resettlement areas in the reservoir area: They are Chongqing City (Jiangbei, Banan, Yubei and Changshou districts), Wanzhou district (Longbao district), Fengjie
County, Fengdu County and Yichang City of Hubei Province (Xiangshan County, Shazhenxi and dam area of Zigui County), each point covering about 100,000 people.

(2) Indicators

- Population data, total population, birth, death and immigrants and emigrants at the initial year, annual average population and age and sex structure, annual birth and annual death, death by age-group, and causes of death (according to the ICD-9).
- Medical organizations and staff: Number of medical organizations, number of hospital beds and number of medical workers to be listed separately at county, township, and village levels.
- Disease monitoring
  Infectiously diseases: 36 types of communicable diseases of the A, B, and C categories, including plague, cholera, virus hepatitis, dysentery, typhoid fever and paratyphoid fever, AIDS, gonorrhea, syphilis, polio, measles, whooping cough, diphtheria, epidemic cerebrospinal meningitis, scarlet fever, epidemic hemorrhagic fever, rabies, leptospirosis, brucellosis, anthrax, typhus, epidemic encephalitis B, black fever, malaria, dengue fever, neonatal tetanus, TB, schistosomiasis, filariasis, echinococcosis, leprosy, flu, epidemic parotitis, rubella, acute hemorrhagic conjunctivitis, infectious diarrhea and SARS.

- Bio-vector monitoring
  Rats: Rats include Brown rat (Rattus norvegicus), House mouse, Rattus flavipetus, Rattus losea Swinhce, Striped field mouse (Apodemus agrarius), and others, taking catch rate as the density index; rat density = (catches/ effective rat-catching devices) × 100%.

- Mosquitos: Identify such species as Culex pipiens pallens, Culex pipiens quinquefasciatus, Culex tritaeniorhynchus, Anopheles sinensis and Armigeres subalbatus and other species for integrated statistics.

- Epidemic breakout report
  File timely report on epidemic outbreak and public health events with unknown causes and carry out epidemiological surveys after receiving reports, find out causes and isolate the epidemic points, sterilize the surroundings, give out preventive medicines, carry out emergency inoculation and spot sampling to control the spread of epidemic.

8.4 Comprehensive Analysis

TGP environmental monitoring system is a complicated and massive system, with most sub-systems covering multiple disciplines and sectors and all sub-systems are mutually influencing and relating to each other directly or indirectly. The TGP ecological and environmental problems are very complicated, too, with many influencing factors, both engineering and non-engineering. It is, therefore, necessary to carry out comprehensive analysis of the changes in ecology and environment at a higher level of the whole system on the basis of the analysis by different sub-systems in order to identify accurately the causes for the changes in the ecology and environment and make both quantitative and qualitative, both objective and accurate judgments. Otherwise, it is easy to arrive at biased conclusions and make unreasonable judgments without support of monitoring data.

In line with the objectives, functions and monitoring targets as well as the monitoring work that has been done and the achievements, and in consideration of the constant accumulation of materials in the future, the framework of comprehensive analysis and requirements should cover the following:

8.4.1 Hydro-Environment

Analysis of Pollution Load

On the basis of the hydrology and water quality monitoring and the monitoring of pollution sources in both the mainstream and tributaries in the reservoir area, it is necessary to calculate the load of all pollutants that enter the reservoir every year, get clear about the load and its distribution in both time and space, know the types of pollutants, density and pattern of discharge so as to provide a scientific basis for controlling pollution sources in a comprehensive manner, and assessing the hydro-environmental quality and protecting the water sources.

The following special analyses are needed to make a comprehensive estimation of the pollution load:

(1) Based on the data of urban sewage, industrial wastewater, urban garbage, industrial solid waste and other major point pollution sources, it is to calculate the sources, total amount and changing pattern of different pollutants from all point pollution sources (all urban industrial pollution, sewage and removed and newly constructed pollution sources) and estimate the total
pollution load in the reservoir area, analyze the annual change of pollution load and regional distribution pattern.

(2) Based on the data from the actual measurement of agricultural runoff zones and small catchment area and the survey data about the application of farm chemicals and chemical fertilizers and the data about the LULC, together with the analytical technology of remote sensing and geographical information system (GIS), it is to construct a non-point pollution calculation model on the basis of land used as landscape units, estimate the total pollution load of agricultural zones, cities and towns and poultry farms and the non-point pollution sources in the reservoir area and analyze the annual change and regional distribution pattern; demarcate areas for controlling non-point pollution and put forward countermeasures for managing and controlling non-point pollution in the reservoir area.

(3) Based on the data about the number and structure of vessels and pollutant types and amount discharged by all types of vessels in the reservoir area, it is to calculate the sources, total amount and changing patterns of different pollutants from floating sources, estimate the total floating pollution load and analyze the annual change of the floating pollution load.

(4) On the basis of estimating the load of point, non-point and floating pollution sources, it is to estimate the total pollution load in the reservoir area and, according to the development trend of different pollution sources, to use model to analyze the pollution situation and forecast the changing trend.

(5) On condition of satisfying the reservoir water quality control objectives and according to the total pollutants control scheme and in line with the principle of fairness, rationality, economic optimization and the actual local conditions, it is to calculate the allowable load of controllable pollution sources and construct related optimization and distribution dynamic model to distribute the pollution load as the scientific basis for formulating water pollution control plans.

Analysis and Assessment of Eutrophication

It is to devise a unified assessment method, select indicators that can give an overall picture of the water quality and carry out mathematical and physical calculation of the data obtained from monitoring to get the all kinds of statistical characteristic values and representative values of environmental quality and use the water quality monitoring data bank to assess the water quality.

The focus of hydro-environmental quality assessment should be:

1. Use the data obtained from the synchronized monitoring of hydrology and water quality and in line with the water functions and protective goals, carry out assessment of the water quality as a whole in the reservoir area; make goal-attaining assessment of individual indicators according to different water seasons, carry out classified assessment (natural, organic and toxic), and adopt different models in comprehensive assessment (such as water quality co-efficient, comprehensive pollution index, organic pollution comprehensive assessment value, Ross water quality index) and analyze the current conditions of water quality and annual changing trend.

2. In conjunction with the monitoring of pollution belts, assess the water quality of typical areas (such as city sections) and analyze the impact of pollution sources on the water quality of the area and the influencing pattern.

3. Analyze and assess the TGP impact on the sources of drinking water.

4. Assess in a comprehensive manner the water quality of the reservoir area, analyze the bearing capacity of water sources and hydro-environment, construct hydro-environmental bearing capacity control model so as to provide the scientific basis for protecting and utilizing the hydro-environment in a sustainable manner.

Hydro-Environment Quality Analysis and Assessment

Eutrophication is one of the major water pollution problems in the reservoir area. It is, therefore, necessary to put forward major control indices for preventing and controlling eutrophication on the basis of analyzing the mechanism, set up a complete set of comprehensive assessment indicator system covering water quality and flow pattern, analyze the mechanism and conditions for eutrophication, carrying out multi-objective prevention and control studies.

The occurrence and development of eutrophication of the reservoir is the result of the concerted action by many factors. It is planned to carry out the following analyses according to the characteristics of the reservoir area:

1. Current condition analysis. Eutrophication is caused by such nutrients as nitrogen and phosphate when they exceed a certain limit, thus causing algae to proliferate extraordinarily under a given hydrological and climatic conditions. Chlorophyll-a is a comprehensive index that reflects the amount of algae and often used as a leading factor for assessing eutrophication. But the changes in chlorophyll-a are closely associated with TP, TN, COD, transparency (SD), and other pollution indices. So, the analysis of eutrophication of the reservoir should include distribution pattern of nutrients, assessment of the state
of nutrients, indicators of zooplankton to the state of nutrients.

(2) Assessment of the harm done by eutrophication. Analyze the impact of eutrophication on the physiochemical features, hydro-ecological balance, aquatic life, fish breeding and people’s health and estimate the economic losses.

(3) Analysis of mechanism of eutrophication. Eutrophication is a process in which the imbalance of the whole hydro-environment system has led to excessive proliferation of some dominant algae. It is, therefore, necessary to analyze the expression of eutrophication according to the geographic features, natural climatic conditions, aquatic ecosystem and pollution to get to know the different dominant algae communities that have caused the imbalance of different types of aquatic life and, according to the necessary conditions for eutrophication, analyze the distribution and changing patterns of such nutrients as TP and TN, the flow pattern such as velocity and water depth and the suitable temperatures for eutrophication.

(4) Analysis of the development trend of eutrophication and measures against it. Based on the mechanism of eutrophication and analysis of the changing patterns of nutrient sources, it is to forecast the development trend of eutrophication, devise anti-eutrophication measures and comprehensive monitoring and assessment systems so as to provide the scientific basis for the building of an ecology-friendly reservoir.

8.4.2 Biodiversity

Diversity of Terrestrial Animals and Plants

TGP will change some ecological and environmental factors, such as climate, moisture and soil, which will, in turn, affect the biodiversity of terrestrial animals and plants. The analysis of the diversity of terrestrial life at all levels and objective assessment of the TGP impact on the terrestrial animals and plants and their habitats will be helpful in taking measures to mitigate the unfavorable effects.

(1) Diversity of terrestrial animal communities and plant communities: This mainly includes the types, number, habitats, and distribution of such animals and plants and their succession under the influence of the changes in the environmental factors.

(2) Diversity of species of terrestrial animals and plants: this covers the analysis of the relationship between their spatial distribution and environmental factors, abundance and diversity and evenness and spatial and gradient distribution of diversity of species and development trends.

Diversity of Aquatic Life

The habitats of aquatic life would be affected to varying degrees by the reservoir as it would bring about big changes in the hydrological regime. The comprehensive analysis of the current conditions of aquatic life and their annual change pattern and assessment of the TGP impact on the aquatic ecology and biological resources will provide the scientific basis for taking policy decisions.

(1) Diversity of aquatic ecosystem: This includes a comprehensive analysis of the communities of aquatic animals, Phytoplankton, microorganisms or their community structures, number, habitats, population and their annual change patterns and the characteristics of the habitat change after the reservoir is built.

(2) Species diversity: This includes analysis and forecast of species structures of aquatic life, level of diversity, diversity index, richness and abundance and construction of mathematical model.

Diversity of Rare Animals and Plants

Animals and plants are rare because of their narrow biotopes, weak migration ability and high sensitivity to environment. The TGP and corresponding human activities will bring about changes to the ecosystem and corresponding damage and interference in the biotopes of rare animals and plants. It is, therefore, necessary to get clear the changing trend of the types, habitats, and number of the species of rare animals and plants so as to work out specific measures for protecting species endangered.

(1) Eco-diversity of rare and endemic animals and plants: This mainly includes analysis of the scales, biotopes, density, community diversity and their changing patterns and forecast the development trends of community structures and number.

(2) Analysis of the species composition, existing number, speed of reduction in population, distribution area, threat they face and protective measures.

Diversity of Agricultural Ecosystem

Agricultural ecosystem is an agricultural production system of different forms and development levels established in a
given time and area under an artificial regulation and control by engaging in agricultural production and by utilizing the relationship between agricultural life and nonlife environment and among different species. Like natural ecosystem, it is also a material circulation and energy conversion system composed of four major basic factors, namely, environment, plants, animals, and microorganisms. It has three major characteristics of productivity, stability, and continuity. The analysis of the diversity of agricultural ecology, knowing the mutual influence of agricultural environment, production model, and hydro-environment of the reservoir will provide the basis for raising agricultural ecological productivity and adjusting the agricultural production structure and serve the purpose of sustainable development of agriculture and grain security in the reservoir area.

(1) Diversity of agricultural environment: This includes analysis of the changes of the non-biological factors in the agro-ecosystem, including soil, irrigation water, air, sunshine, and temperature and other natural factors as well as land degeneration, water loss and soil erosion, pollution of water for agricultural use and soil pollution resulting from it and the pollution by farm chemicals and chemical fertilizers.

(2) Diversity of agro-ecosystem. This is an analysis of the diversity of agricultural planting system, such as single cropping, mixed cropping, crop-domestic animal mixed system, crop-tree intercropping, crop-silk worm-livestock breeding system, aquatic breeding, pasture, grazing ground, and optimal control policy.

(3) Diversity of crop species in cultivation. This is mainly an analysis of the plant species diversity (including semi-domesticated cultivation, cultivated breed, and managed wild breeds), pests and plant disease management and high-efficient utilization of plasma resources.

8.4.3 Socioeconomic Environment

An in-depth analysis and study of the economic and social changes and their influencing factors, determination of the trend and degree of the influence of various factors and giving a comprehensive assessment of the social and economic development level of the reservoir area are of great significance in revealing the economic and social development pattern and ensuring the smooth-going of the TGP and a healthy and stable economic and social development. They are also of very high application value for the governments at all levels in working out development strategies, improve economic and social development policies and plans.

People’s Health Analysis

The changes in the natural environment due to the dam and reservoir would cause occurrence of diseases and public health problems. A comprehensive analysis of the data obtained from monitoring and an accurate assessment and forecast of the TGP impact and timely discovery of problems and finding-out solutions will provide the basis for controlling diseases and for local health administrative departments in working out health development plans.

(1) Effect of TGP on infectious and other diseases of natural epidemic foci. This is an analysis of the incidence and causes of virus hepatitis, dysentery and typhoid fever and other water-borne infectious diseases, leptospirosis, epidemic hemorrhagic fever, epidemic encephalitis B, anthrax, Brucellosis, typhus, relapsing fever, Lyme disease and black fever, the impact of ecological and environmental change on the spread of infectious sources and epidemic foci, vectors (rat and mosquito) breeding places and biotope of epidemic foci and measures for controlling infectious diseases.

(2) Impact of TGP on schistosomiasis, malaria, and other worm spread diseases. This is an analysis of the possibilities of an outbreak of schistosomiasis and malaria that might be caused by the expansion of the mosquito breeding habitats.

(3) TGP impact on endemic diseases. This is an analysis of the distribution, harm and preventive measures of such endemic diseases as fluorosis, goiter and Keshan Disease and their changes after the change of natural factors.

Analysis of Socioeconomic Development

This aims to sort out data obtained, analyze comprehensively the speed, quality, and coordination of social and economic development so as to find out the constraining factors, reflect the impact of TGP and resettlement of one million people on the social and economic environment and give a quantitative comprehensive assessment of the social and economic environment of the reservoir area.

(1) Analysis of the basic conditions of social and economic development, covering population and population density, industrial structure, economic aggregate, economic structure, regional disparities, financing and investment, social environment, people’s living standards, and mineral reserves.

(2) Comparative analysis of economic development space, covering economic aggregates of different areas,
economic development levels, economic development quality, and economic strength.

(3) Historically comparative analysis of social and economic development, covering development speed, quality, and economic strength of different historical periods.

(4) Comprehensive assessment of social and economic development, covering population and employment, economic and social development, environment and basic conditions, people’s life and resettled people by the comprehensive index method.

(5) Analysis of the socioeconomic conditions of the resettled people, mainly covering their production, living and other changes as well as problems still existing with their life and production.

Distribution and Utilization of Resources

A comprehensive mastery of the distribution, changes and utilization of resources in the reservoir area, and an in-depth study of the resources and industrial development will facilitate the working out of policy recommendations on the reasonable and effective utilization of resources for reference by the governments at all levels in formulating correct industrial policies for realizing sustainable development of the economy. It is planned to carry out studies in the following aspects:

(1) Spatial distribution and change of resources. This is an analysis and study of the spatial distribution and changes of mineral resources, ecological resources, and tourism resources and advantages and disadvantages of resources in the reservoir area.

(2) Rational utilization of resources. This is aimed at putting forward policies for the rational utilization of resources and for industrial development based on the resource advantages and advantageous and disadvantageous industries.

Studies of Human Resources Development Strategy

The massive number and low-quality human resources are the most outstanding problem in the reservoir area and the root cause for its difficulty to shake off poverty and backwardness and also the biggest obstacle to the current and future economic and social development.

(1) Carefully investigate into the number, quality, and distribution structure of human resources in the reservoir area and correctly understanding the supply and demand gaps.

(2) Use Chinese and Western human resources management theories, new economic growth theories and labor and employment theories to analyze the relations between human resources and economic growth of the reservoir area.

(3) Use the research achievements to help governments and departments at all levels to formulate regional human resources development strategy and improve the general quality of human resources.

8.4.4 Assessment of Ecology and Environment Security

Analysis of Geological Disasters

The land surface of the reservoir area has been cut up seriously; the topography varies greatly in elevation; rainfalls are concentrated; the land is fragmented, eroded and easy to be weathered; and eroded rocks are extensively distributed. This, plus faults, especially active faults, makes the geological environment very fragile. It is one of the areas where geological disasters are easy to occur. This problem has become even more outstanding after the reservoir is built. A comprehensive analysis of the types, features, distribution pattern of geological disasters and their impact on water storage of the reservoir would be conducive to working out policy recommendations for preventing and controlling geological disasters after the operation of the dam and reservoir.

(1) Determination of the types of geological disasters. The aim is to find out such disasters as earthquakes, landslides, collapses, dangerous rocks, mudflows, cave-ins, fractures and unstable slopes and make an overall analysis of these disasters with the support of geographical information.

(2) Analysis of the distribution pattern of geological disasters. This mainly includes the spatial distribution of disasters and concurrence, non-stable cycle and lagging nature and the assessment of possible harm done on the basis of differentiation of disasters.

(3) Analysis of major patterns of geological disasters. This is to mainly analyze the place, magnitude, and damages of the past geological disasters and the relations between geological disasters and other natural factors and the operation of the reservoir.

(4) Studies of measures against geological disasters. This includes studies of measures for controlling existing disasters, anti-disaster GIS construction and assessment of the possibilities of the reservoir induced earthquakes.
Water and Soil Loss Analysis

The reservoir area is one of the areas with strong water loss and soil erosion, which has not only damaged the local ecology but also seriously threatened the service life and efficiency of the reservoir. The aim is to get a complete picture of the current conditions and development trend in water and soil loss through comprehensive analysis and analyze the results of the water and soil conservation facilities so as to provide the scientific basis for controlling water loss and soil erosion.

1. Assessment of the current conditions of water and soil loss. The task is to build a soil erosion amount estimation system based on the existing geographical information and monitoring data and draw maps on water and soil loss and damages that it has caused and, on this basis, estimate the total amount of soil erosion.

2. Analysis of water and soil loss pattern. This is to analyze water and soil loss pattern of different types of vegetations, land covers, land utilization, topographical types, and landscape types under different intensity of rainfall and carry out assessment of the potential danger of water and soil loss and build a databank accordingly.

3. Analysis of the result of water and soil conservation projects. This is to analyze the progress of water and soil conservation projects and results already obtained and carry out monitoring of such projects.

4. Water and soil loss control plans. The aim is to work out measures for controlling water and soil loss according to different influencing factors.

Climate Analysis

Climatic changes have a direct impact on social and economic development and on the ecosystem. It will bring either harm or opportunities for economic and social development. Climatic changes have affected or will seriously affect the resources and ecosystem on which people depend on for survival and development and will have a great impact on different sensitive areas or resources, such as water sources, biodiversity, wetland, natural reserves, forests and grassland.

In order to carry out studies of the impact of climatic changes on the reservoir and the impact of reservoir on the local climate, it is suggested to do specialized analysis in the following aspects:

1. To set up a time sequence of major climatic factors over the past century and built a basic database and information management system concerning climatic changes according to the facts and causes on the annual to century scale.

2. To develop local climate model. This is to study how to use the medium-scale regional climatic pattern and local climatic model by the nesting method to carry out the changing mini-climate forecast, carry out minute climatic resources zoning and, in conjunction with the climatic resources and changing patterns in the reservoir area, map out development plans for agriculture, forestry and livestock breeding and rationally developing the climatic resources.

3. To study the impact of climatic change on the frequency and intensity of climatic disasters and get clear the impact of climatic changes on the anti-flood and power generation capabilities of the reservoir so as to do a good job of climatic risk assessment of the operation in low water seasons.

4. To develop methods and models for comprehensive assessment of the impact of climatic changes. This includes the setting up of the climatic change bearing capacity assessment indicator system, the study of the comprehensive assessment information system on climatic change bearing capacity and forecasting of the possible impact of different climatic changes during different time scales on the ecology of the reservoir area.

5. To carry out studies of climatic disasters and their impact. This includes forecast and warning of mountain torrents induced by rainstorms, the impact of fog on road and shipping traffic and the impact of high temperature, drought, thunderstorms, and hailstorms on agriculture and ecology.

6. To carry out comprehensive assessment of the climatic, ecological, and environmental resources. This means to use the general advantage of the TGP environmental monitoring system to carry out studies of the mutual relationship between climate and hydro-environment, terrestrial plants and agricultural ecology and establish a system for assessing the impact of climatic, ecological, and environmental resources.

Soil Environment Analysis

The changes of the original natural biotopes with the formation of the reservoir will bring about corresponding changes in soil, which is the dynamic reflection of the soil nature in time and space. It is, therefore, necessary to know the differences in characteristics of the soil during different periods of time on the basis of the monitoring data obtained and use them to judge the impact of TGP on the soil of the reservoir area, assess the soil fertility, land utilization, and degeneration. It is suggested to carry out the following analyses based on the data obtained.
(1) Conditions of soil salinization of the soil at the estuary. This is mainly to analyze the secondary salinization and dynamic situation of the soil due to backflow of sea water as the result of the changes in hydrological regime after forming the reservoir.

(2) Analysis of soil gleization on the plains in the middle and lower reaches of the Yangtze. This mainly covers soil gleization and dynamic development that might be caused by the increased replenishment of the ground water and the rise of phreatic water level during the natural low water seasons with the reservoir full of water.

(3) Assessment of the changes of soil nature. This mainly covers analysis of such indicators as organic matters, nitrogen, phosphate, potassium, salt-based saturation, acidity, nutrients and organisms in soil, assess the soil changes quantitatively and establish a databank on soil change and draw a soil change atlas.

(4) Assessment of the change in soil quality. This should cover analysis and assessment of the current conditions of soil quality and dynamic development on the basis of natural characteristics by selecting representative assessment factors, such as soil layer thickness, texture, gradients, organic matter, TN, HN, fast-acting phosphate, fast-acting potassium, TP, TK, ion exchange, and pH.

(5) Analysis of factors causing soil change. This should cover analysis of the causes of soil degeneration based on the ecological and environmental factors and the ways of land utilization and the working out of measures for preventing soil degeneration, improving soil fertility and protecting ecology and environment, which can serve as the basis for taking policy decisions on sustainable development.

Comprehensive Analysis of Terrestrial Ecosystem

(1) Analysis of the historical background and evolution process of the formation of the terrestrial ecosystem, covering ancient geography, ancient climate and relations between man and land.

(2) Analysis of landscape structure of the terrestrial ecosystem, mainly including spatial relations between different ecosystems and factors, that is, the distribution of energy, materials and species associated with the size, shape, amount, type, and structure of the ecosystem.

(3) Analysis of the functions of terrestrial ecosystem, mainly including mutual action of spatial factors, that is, the movement and changes of energy, materials, and species of the ecosystem.

8.4.5 Remote Sensing Analysis of the Ecology and Environment

The purpose is to use remote sensing technology to carry out baseline survey and dynamic monitoring of the ecology and environment of the reservoir area and accumulate a large amount of basic geographic information, baseline data about the ecology and environment and, through comprehensive analysis of the spatial data, get to know the basic conditions of the Three Gorges ecology and environment and their dynamic changing trend, which can serve as the basic materials and scientific basis for related research and for taking policy decisions by related departments. The remote sensing analysis should cover the following aspects:

(1) Estimation of soil erosion and non-point pollution. The aim is to set up a soil erosion intensity assessment model and a soil erosion control result remote sensing monitoring technical system and, in conjunction with the studies and analysis of the non-point pollution load and the ways of its entry into the reservoir by ecological laboratories and the influx, study the pollutant load remote sensing calculation model and establish a GIS-based non-point pollution load estimation and analysis system with the support of the remote sensing monitoring baseline databank and related databank of experimental monitoring.

(2) Analysis of the quality of terrestrial ecosystem. This is to study and develop monitoring methods and a technical line based on remote sensing and GIS-based terrestrial ecosystem quality monitoring indices, estimate the bearing capacity of different types of land, study land environmental capacity on different scales so as to provide the scientific basis for the development of the resettlement areas and for restoring of the ecology mainly by returning farmland to forests and grassland.

(3) Analysis of the changes in land productivity. This is to set up a remote sensing estimation model for net primary productivity and terrestrial biomass, develop methods for estimating the net primary productivity and terrestrial biomass and integrate them to become land productivity monitoring system and carry out ten-day, monthly, and annual changes of primary productivity and regional difference analysis and the comprehensive factor analysis of primary productivity and biomass, monitoring the spatial annual changes of biomass and the development trend of ecological security of the reservoir area.

(4) Analysis of the biotope quality of plant communities. This is to set up a remote sensing monitoring indicator
system for the biotope quality of plant communities, study and develop remote sensing monitoring methods and technology for monitoring indicators, develop dynamic change monitoring of the biotope quality of plant communities and, on the basis of the assessment of the impact of TGP on the vegetation ecosystem, explore the responsive mechanism of plant communities to the ecological and environmental changes in the region.

(5) Dynamic analysis of land resources. This should cover the remote sensing dynamic monitoring of the land resources in the reservoir area, analysis of the total cultivated land and dynamic changes and, through annual remote sending sample survey, carry out dynamic monitoring of the areas of land use by cities and towns and by the resettled people so as to provide the scientific basis for the eco-environmental assessment of the resettlement areas and for formulating land resources policies.

8.4.6 Development Sustainability

Analysis and Assessment of the Environmental Capacity of the Resettlement Areas

The analysis and assessment of the resettlement capacity should cover the following aspects as backed up by resources and socioeconomic environment data:

(1) Analysis of resource bearing capacity. This includes the current conditions of climate, cultivated land, grassland, wood land and exploitable water quality and potential production capacity and the spatial distribution pattern of minerals and tourism resources and the bearing capacity of resources in different types of natural zones under the current economic and technical levels.

(2) Analysis of pollution-bearing environmental capacity. This mainly includes analysis of the pollution load under the current living and economic operational model, and whether or not it is harmful to the water quality of the reservoir and the constraining conditions on the population, resources and the ways of living and production in line with the environmental bearing capacity.

(3) Forecast of economic development and population growth. The resettlement capacity will change with the change in economic development levels and living standards and it is necessary to use a dynamic view to analyze the changes of the resettlement capacity so as to provide the basis for mapping out and adjusting resettlement plans and policies.

(4) Analysis of the development of the regional resource environment. This is an analysis of the changes in environmental capacity resulting from the changes in natural and artificial factors and the ways of adjusting and expanding the resettlement capacity by making full use of locally available resources.

The above analysis would result in an objective assessment of the environmental capacity for resettlement and answer the questions on how to improve or raise the living standards of the resettled people under the current policies and how to carry out post-resettlement support and its impact on the ecology and environment.

Assessment of Development Sustainability

The objective of sustainable development is the harmony between man and nature. The poor basic conditions, the fragile natural economy and environment and limited environmental capacity will greatly restrict the economic and social development. The reservoir area will face a stern situation as to how to protect the ecology and environment in its future development.

The assessment of the development sustainability in the reservoir area should cover the following:

(1) To set up a time and spatial information databank of the assessment indicators. This databank should be built on the basis of databanks on specific topics and by constructing a spatial model to mix the nonspatial natural resources environment and social and economic data with the basic geographical spatial information to make them acquire the attribute of spatial distribution and at the same time, integrate all the spatial resources data so that they all go to form a basic databank for the assessment of development sustainability. Based on the established database, it is necessary to use the comprehensive assessment model to develop indicators for sustainable development, such as vulnerability index, capacity building index, sustainable development comprehensive index and the index of the change in future scenes of sustainable development, which are used to describe sustainable development. They can also serve as the basis for further comprehensive assessment of sustainable development.

(2) Spatial analysis of the overall state of sustainable development. This requires the construction of a vulnerability index model based on the irrational utilization of land (reclamation of slope land), vegetation damage, water and soil loss and pollutants discharge, which is used to assess the vulnerability of the development sustainability. Second, it also requires the construction of a capacity building index model according to the enhanced development sustainability such as infrastructure, socio-economic development, rehabilitation of ecology, and improvement of the environment, which is
used to make a comprehensive assessment of the capacity building for development sustainability. Then, it is necessary to make a comprehensive analysis and assessment of the vulnerability of development sustainability and capacity building. The assessment results are used to classify the state of vulnerability, capacity building and general development into different levels of sustainable development, such as non-sustainable development zone, feeble sustainable development zone, moderate sustainable development zone and strong sustainable development zone.

(3) Analysis of the future scenes of sustainable development. This includes the construction of a simulated model of sustainable development scenes to simulate the spatial pattern of future scenes of sustainable development, the determination of different simulation schemes and compare them to seek the optimal scheme.

(4) Comprehensive zoning of sustainable development. This is the integration of the above analysis results to construct a sustainable development zoning model, which covers vulnerability index, capacity building index, comprehensive development index, dynamic change index and future scene simulation and then carry out spatial cluster analysis on the basis of ecological landscape unit or administrative unit to do the zoning of sustainable development.

(5) Comprehensive analysis of sustainable development policy recommendations. Policy recommendations for sustainable development should be put forward on the basis of the comprehensive assessment and zoning. These recommendations should include assessment and modification of the policies and measures concerning resettlement, returning farmland to forests and grassland, natural forest protection, adjustment of agricultural structure and pollution source control to evolve into a series of new policy recommendations and measures.

Planning of Sustainable Comprehensive Utilization

It is an arduous task for a long period of time to come to promote economic development, protect and improve the environment and strive for sustainable development. The basic work to ensure sustainable development in the reservoir area is to analyze all the factors of the ecology and environment in a given period of time in the future, divide the ecological function zones and plan for sustainable development of different landscape units and, on this basis, ensure correct implementation by effective management.

The planning of sustainable comprehensive utilization work should include:

(1) Analysis and assessment of the current conditions of the ecology and environment in the reservoir area. This involves a comprehensive assessment of the current conditions of the ecology and environment of the reservoir area and the zoning of ecological functions.

(2) Fixing the objectives and principles for the comprehensive utilization and management, such as ensuring reservoir security, the display of the anti-flood, power generation, and shipping functions of the project, ensuring the security of the ecology and water quality and sustainable development of the reservoir area, rationally utilizing the water and soil resources and tourism resources. The objectives may be divided into immediate future, medium-term and long-term.

(3) Fixing the scope of comprehensive utilization and management, such as incorporating the surrounding land, river banks, water-level fluctuating zone and water surface of the reservoir into reservoir planning.

(4) Planning by county. It requires the planning of resources utilization with county as the basic unit so as to facilitate management and operation.

(5) Planning of functional zoning. This requires the functional zoning of the surrounding land, river banks, water-level fluctuating zones and water surface to determine the ecological functions of every small zone, the way of development and utilization and technical requirements. For instance, the limitation of the application of chemical fertilizer, land development and prevention of landslide, scope and scale of fish breeding in cages, and the scope of the natural or ecological landscape protection zones. Only with detailed functional zoning is it possible to formulate corresponding and operable management system.

(6) Utilization of recreational (including tourism) resources. After the formation of the reservoir, the area is bound to become a new type of tourism attraction, with the tourism pattern mainly featuring sightseeing likely to be turned into one featuring mainly recreation and vacationing. It is, therefore, necessary to attach much importance to the value in recreation of the reservoir area and give it full consideration in planning.

(7) Fixing the major areas and projects for priority implementation of the ecological restoration and environmental improvement, such as the fixing of such projects as water and soil loss control of all ecological functional zones, green belt around the reservoir, returning farmland to forests and grassland, and natural forest protection and the determination of the purposes of the use of the land and bank lines, water-level fluctuating zone and water surface in a given scope.
Formulation of policies and laws concerning sustainable comprehensive utilization. This includes the formulation of the “Three Gorges Reservoir Management Regulations”, which should make clear the objects, scopes, and principles of management, the management system after the reservoir is completed, including management organization and related departments and their relations with related provinces, cities and departments and their division of responsibilities and powers. In addition, it is necessary to formulate Planning on the Sustainable Comprehensive Utilization of TGP Reservoir, planning of the functional zones and special resources utilization, which should be matched with specific management system, such as “Management Rules on Riparian Land Utilization of Three Gorges Reservoir”, “Management Rules on the Utilization of Water-Level Fluctuating Zone of the Three Gorges Reservoir”, “Management Rules on the Utilization of the Water Surface of the Three Gorges Reservoir” and “Management Rules on the Extraction and Use of Water from the Three Gorges Reservoir.”