LANDSCAPE FUNCTIONAL ASSESSMENT PROCEDURE FOR ECOLOGICAL SYSTEM OF TAI CANG REGION –A CASE STUDY

1- Introduction

Tai Cheng region is a representative part of economic development zone of Tai Lake basin of agricultural and river landscape. The Landscape functional concept of Tai Cheng region is established to describe landscape ecology, ecological system and environmental scenario of water bodies. In general landscape function is defined as interaction among the spatial elements i.e. the flow of energy, material, and species among the components of ecosystem. (Forman & Godron 1986). According to central Europe landscape ecology, it is defined as biological, morphological and chemical process in the Landscape. Dutch ecologist Degroot referred as the environmental function as the capabilities of natural system as it provides the goods and services that satisfied human needs (De Groot 1992). The landscape function concept has provided the methodological framework where landscape ecological assessment of the region meets the duties of spatial planning in steering and differentiation the societal functions of landscape. Landscape function combines landscape ecological and planning methods within sound theoretical framework. Environmental sectors such as soil, water and air are strongly interconnected with different type of land use by landscape process and structures. In this report the more emphasis is taken as human ecosystem enabling usages of landscapes for agriculture, drinking water supply, water environmental pollution and amenity reasons. As in the existing ecosystem of Tai Cheng region considering potential of agriculture and water, as for example agriculture benefits from landscape function for biomass production. On other hand agriculture threatens it own function by causing soil erosion and land degradation. Keeping in view of this a new concept is used for the interaction between different functions as well as two aspects of each functions in term of sensitivity and suitability need to be use used in landscape analysis of Tai Cheng ecosystem (Daniel Petry). In this paper, geographical information system is also used as tool to provide a powerful basis for developing such procedure to retrieve information and to present and visualize the functional assessment in the Tai Cheng ecosystem.

2- Topography of the study region

This region is covering a total area of 822.926 square kilometer located in city the southeast part of Jiangsu province on the south bank of Yangtze River with the Northern latitude of 31022, ~31044 and eastern longitudinal of 120058, ~121020. In the East, there is Shanghai City and mountain region in the West and North. Among this, Yangtze River is covering 173.89 square kilometer. Among the total area of Tai Cheng, municipality occupies 75%. Tai Cheng region is belonging to the Yangtze River plain delta of which whole geography is flat, and showing inclination from northeast towards west to south. Local area has seven river sources, which is flowing into mail river course to Yangtze River. The major rivers are Xin Jin River, Qian Jin River, Dan Xi Jin River, Lu Ming Jin River, Lang Gang River, Xi Jin River, Wu Tang River, and Ban Jin River. Tai Cheng is belonging to subtropics area having four seasons. Average air temperature is 15.40 ^{0}C with average rainfall 1011 mm, highest rain fall was recorded 1564 mm in 1960s, and minimum is recorded 619 mm in 1978.

3- Landscape function Assessment Procedure for the Tai Cheng Region

3.1- Ecological functions of agricultural landscapes

There are many environmental functions of Tai Cheng landscapes, which are affected by the current land use. Different land uses, like agriculture, urbanized areas, and industrial land use, are affecting different sets of landscape functions because of the variation of actual relations with the region and the spatial configuration of land use types within a given landscape. In case of agricultural land use, this has substantial impact on many essential landscape functions. However, an exhaustive analysis is necessary to assess the impact. For example, soil conservation seems to be high or low through agriculture, depending on the existing crops and adaptation of soil conservation measures. Obviously, in many cases a type of agricultural land use is found to meet the desired performance of each given landscape function. This can be explained as “production” and “regulation” functions.

3.2- Structure of environmental functions

Environmental functions of agricultural landscapes are organized in different ways. While some functions are described irrespective of scale, while others are scale dependent. For example, biomass production of an agricultural landscape is composed by the properties of the different vegetation units, which might be adequately characterized by soil and land use. Such environmental function seems possible by the aggregation of the identified spatial units. Consequently, it seems sufficient if indicators of such function are restricted to one scale.

3.3- Urbanization

A total population of 300,000 is concentrated in the Tai Chen region and other related towns and small counties. The region has dynamic economic change since the China has reformed and making lot of economic development including urbanization, industerlization, education, and water conservancy management and planning. Since the economic development is of major concern of policy and environmental planner particular the water conservancy and water deterioration of existing regional river network in term of demand and supply of water resources. Therefore, for the variety of landscape type and dynamic land use process, therefore Tai Cheng region is chosen for the explainary application of methodological procedure designed to strengthened the comprehensive regional planning as party of Tai Cheng water conservancy plan to study the landscape functional assessment procedure for ecological system of the region. The major pollution inputs from urban systems are related to;

(i) water runoff and groundwater flow, which may be contaminated as well before steeps into rivers network and finally into Taihu Lake.

(ii) Land disturbance during economic development of the region, especially on sloppy sites, frequently leading to large inputs of sediment, which contains nutrients, organic carbon, and results in the increase of water turbidity.

(iii) Runoff from roads, parking lots, lawns, parks, and other urban areas may be highly enriched in dissolved nutrients even though it contains no visible sediment.

(iv) Urban pollution from surface runoff, which is included sediments, agro-chemicals and chemicals from automobile emissions that attach to road surfaces. Urban runoff contains nutrient, organic matter, and bacteria associated with pet wastes.

3.4- Agriculture Production

The total agriculture production of the region and their sensitivity to deterioration is found to be accomplished by regional landscape scenario and their characteristics formed through the combination of existing hydrology, climatologic, and ecological factors. They determine whether landscape delivers fertile arable land, is prone to soil erosion and has a sensitive water balance.

3.5- Water retention in the region

Existence of retention of water in term of ponds and lakes in the region has key importance regarding sustainability concept for spatial development in the landscape. Landscape functions such as the regulation of retention water and matter fluxes, which are directly used for regional economic development. The assessment procedure is required to ensure practicability within planning and transferability to other regions of similar nature in the Jiangsu province. For this region, only available information and data is used which is easily assessable. Table 1 shows the selected data for landscape analysis during the assessment procedure.

Table 1 Database for landscape function analysis

Available data	Type	Scale	Sources
Land cover and uses	Land cover period of	1:343,768	Tai Cheng water
	recent economic		resources bureau
Soil morphology	development	‘	“
	Spoil type and texture	‘	
Hydrology and	Precipitation,	‘	“
Climate	evaporation and floods	‘	“
	Water conservancy	‘	
Planning strategy	Planning	‘	“

4- Landscape analysis and evaluation methodology

Suitable method and procedure is adopted to achieve the study objectives integrated with established Ecological Risk analysis (ERA), which was developed in 1970 for the promotion of decision-making process in the spatial planning. The research group headed by Bachfischer in the year 1980 established this method (Figure 1). The method was established because of the need of ecological risk analysis during 1980 to 1990 after the introduction of the EU legislation on environmental monitoring methodology. This method enables the identification of environmental assessment of environmental; sensitive area such as soil erosion, groundwater protection and area confronted by conflicting demands for functional priorities as for example agriculture water use verses drinking water supply, and also with area with complementary functional characteristics like water conservation and water retention. Landscape function analysis (LFA) and assessment procedure in this study is a modified form of ERA procedure, which is adopted from Kuhling (1992). In modified version, suitability and sensitivity (SAS) criteria is considered as key parameters for the assessment of Landscape capacity in order to full fill LFA. SAS criteria is described as lacking consideration of ‘potential conservation values’, in which is potential is defined as existing landscape impairment and their impacts, while conservation value stand for planning and management of sustainable development of landscape. Both described the development aspect of improving LSF. The whole modified system is described in Figure 2.

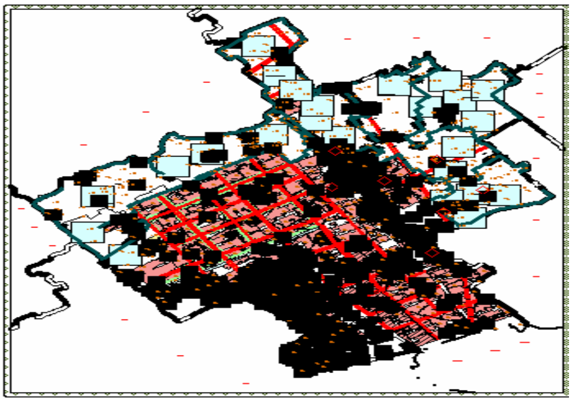

Figure-1 Ecological risk analysis procedure (form bachfischer 1980)

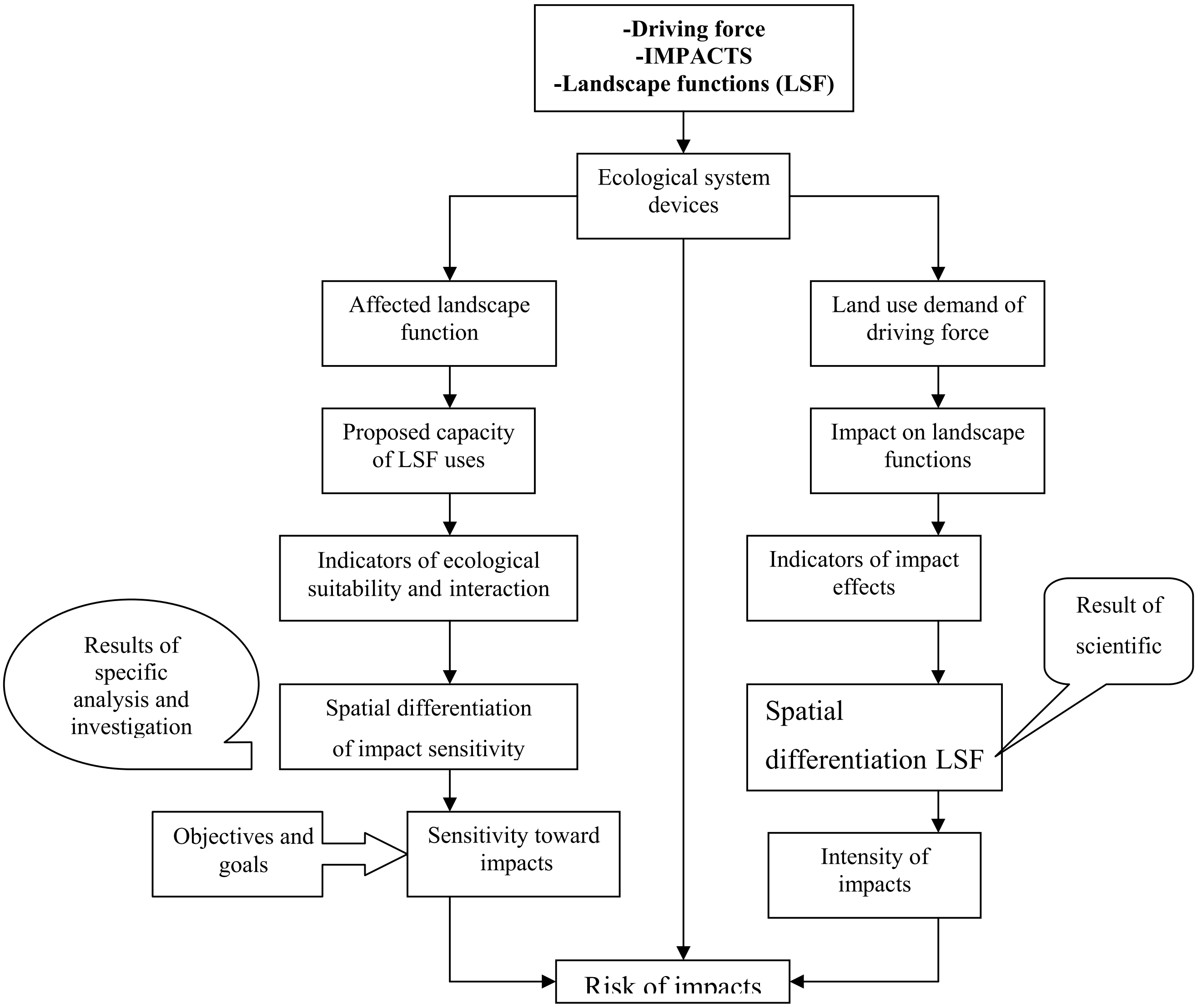

Figure 2 Landscape function analysis (LFA) and assessment procedure in this study is a modified form of ERA procedure (Kuhling 1992).

In fact ERA described the link between landscape ecological analysis and the definition of planning target, its measurement and implementation. The complete procedure is described as integrated landscape function assessment procedure showing stepwise operation from data management to evaluation and analysis of landscape functions. Evaluation of function is carried out selecting certain evaluation criteria using methodology for normative standards objectives. While, function analysis are fully depends upon SAS indicator with choosing methodology after selecting certain parameters. SAS criteria for the assessment landscape capacity in fulfilling certain functions to potential conservation values using SAS indicator is further defined as combined integrated assessment procedure, which is described in Figure 3. Table-2 shows the evaluation procedure of the potential conservation value of landscape for the assessment of water retention and matter flux in the SAS criteria.

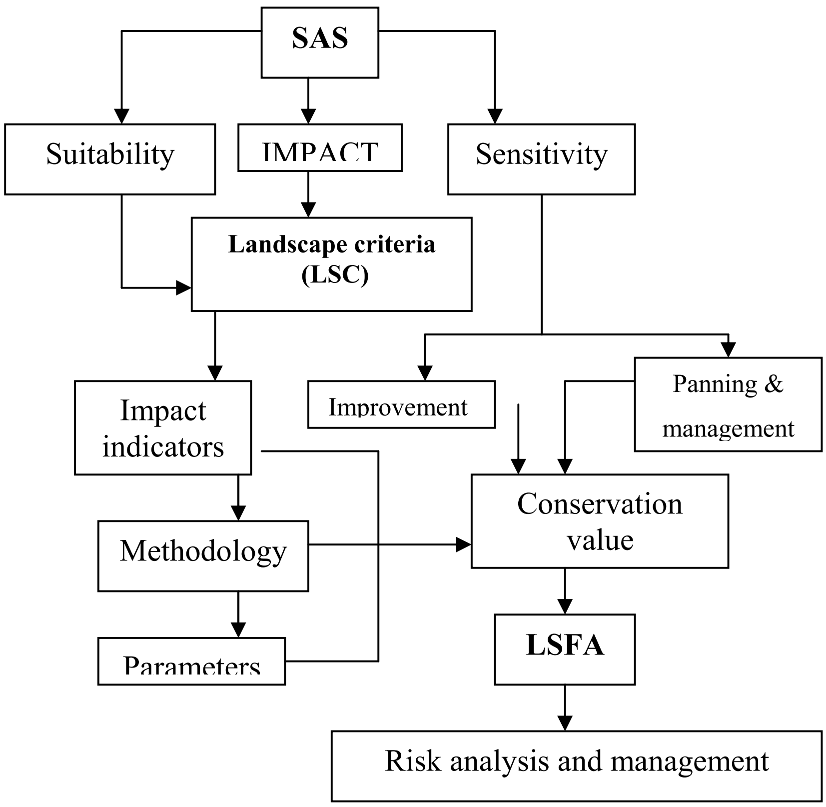

Figure-3 Modified SAS criteria for landscape functional analysis

A- Protective aspect of conservation value-Suitability

Simulated areas of high water retention capacity combination with low annual soil water turnover have high suitability for water and matter retention and low sensitivity against impacts (soil erosion). Water conservancy planning still needs to concentrate to protect the landscape functions. In the Tai Chang region most of the agricultural lands, which already protected through agro-forestry, which is not proved a part of water conservancy planning.

Table-2

Evaluation procedure of the potential conservation value of landscape for the assessment of water retention and matter flux in the SAS criteria

Potential conservation value of landscape function For water retention and matter flow	Importance of protective aspects		
	High	Moderate	Low
Runoff retention	Very high-high (1-2)	Moderate-low (3-4)	Vey low (5)
	Importance of development aspects		
	High	Moderate	Low
Surface runoff retention	Very low-moderate (5-3)	High(2) 100-200% >1.5-<2	Very high (10
Nitrate leaching risk	>200%		<1.5
Runoff proportion	>2		
Matter deposition	high		

B Development aspect of conservation values-Sensitivity

Some area in Tai Chang region is identifies as with low to moderate retention capacities values are evaluated to need for high potential improvement. High soil erosion risk with higher potentials of surface runoff indicating erosion risk in grasslands areas (Figure 4).

4.1- Assessment of Agriculture Production capacity

SAS criteria are used for the evaluation and analysis of landscape potential for the capacity of agriculture production in the Tai Chang region. This assessment provides the suitability of landscape for agriculture. In this assessment point rating system is used, developed by Mark et al, (1992), in which relative factors are represented by ore or more parameters. In this study the number of parameters are reduced while considering all relative factors. So method is simplified with using parameters including slope for relief, soil texture, rooting depth for soil, ground water level and available field capacity for landscape water balance, annual mean temperature, and mean annual precipitation for climatic conditions. In rating system, five different classes are used from 1 to 5 for each parameters and introduced a minimum factor system for the parameters combination i.e. parameters classified the lowest determines the result. In the SAS criteria, sensitivity of landscape is assessed through deterioration of their productive potential through risk potential of soil erosion in the agriculture field. The stochastic model is applied to calculate average soil loss as ton per hector per year (Henning 1994). Evaluation of the potential conservation values of landscape for agriculture production capacity by SA criteria is used for which results are shown in the Table 3.

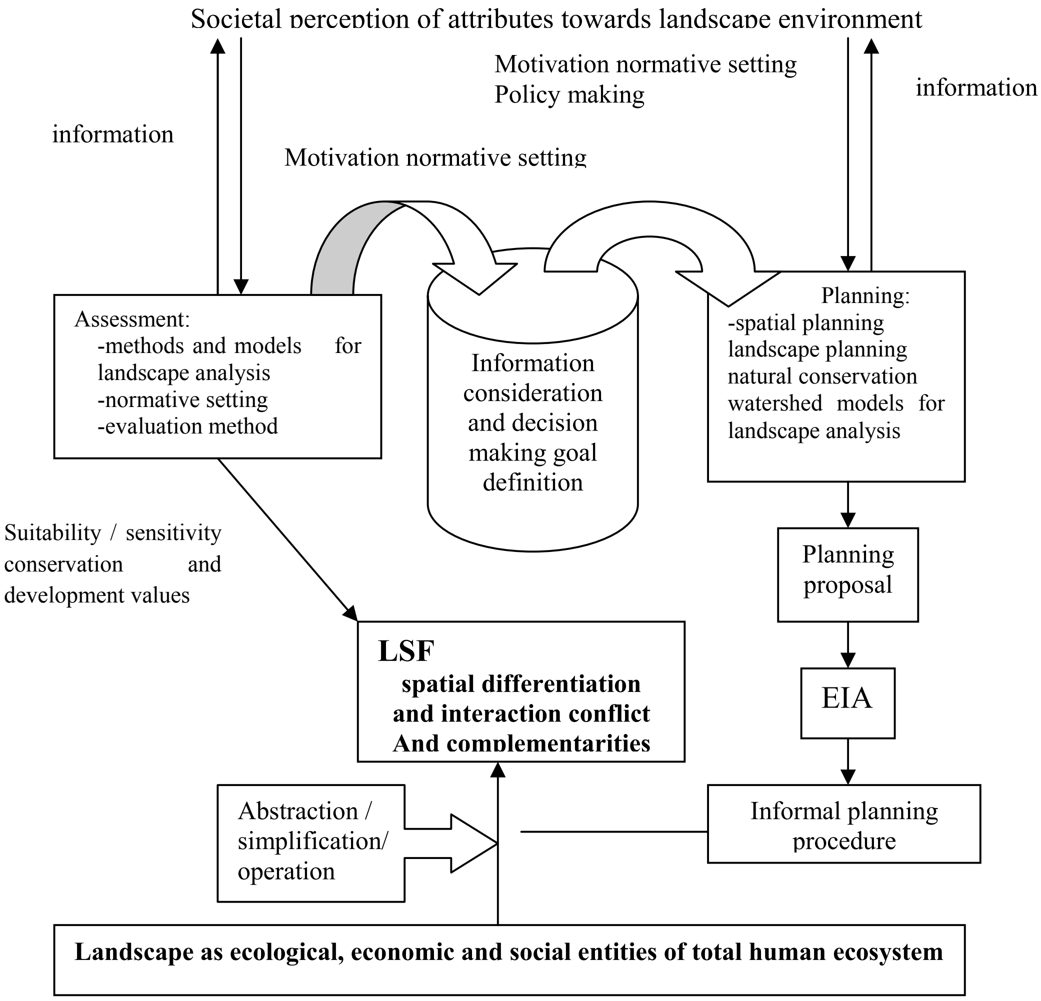

Figure-4 Implementation of landscape function in landscape related water conservancy panning

Table-3
Evaluation procedure of the potential conservation value of landscape for the assessment of agriculture production capacity in the SAS criteria

Potential conservation value of landscape function	Sensitivity of deposition of soil		
	Low (1) 5	Moderate (2) 3-4	High (3) 1-2

Suitability low (1)	<50	Low 1	Low 2	Moderate 3
Potential biotic Productivity	moderate (2) 50-<100	Low 2	Moderate 3	High 4
	High (3) >100	Moderate 3	High 4	High 5

Above Table 3 shows the matrix combining the landscape suitability for and sensitivity to the impairment of its function for agriculture production with its potential importance for this landscape function. Results very much clear for the spatial differentiation of potential conservation values within the Tai Chang region.

4.2 Assessment of water and matter retention

In the SAS criteria, the assessment of water and matter retention within landscape is described as regulation function which directly concerned to societal use and value As described by De Groot 1992. The link is explained rather indirect as for example water retention contribute the reduction the flooding peak since it reduces runoff peak consistent with direct runoff components. Moreover, matter retention contributes the maintenance of number of landscape components including bio mass productivity. Matter retention is prerequisite for the reduction of eurtophication in the Taihu Lake.

5- Assessment of Integrated Landscape Functionality of Tai Chang Region

The assessment of individual landscape function of Tai Chang region is described in the above section. In fact this assessment is inadequate for then both the definition of comprehensive water system and understanding of ecological system. The most important part of this study is the further understanding of interaction among the function and uses of landscape. In this regards, geographical information system (GIS) is used, which allows the spatial overlay of the information desired for selected function as described in the above section; including their potential importance as well as the landscape suitability and sensitivity for SAS criteria. Study is carried out describing in what ways functional overlay (in term of GIS) or interaction (in term of landscape ecological system), which mean the functional integrity of landscape and need for planning action concluded for the water conservancy project of the region. It describes the landscape ecological knowledge has to be met with normative setting such as water environmental quality standards (GB 8333-88) and objectives.

5.1- Water and water retention versus agriculture or mass production

Certain part of Tai Chang region exhibit high sensitivity towards soil erosion and therefore found high importance for water and matter detention within the region. Potential conflict with mass production are arisen and are intensified by large scale agricultural farming and lack of natural features such as agro-forestry, buffer zone and or buffer strip along the water courses.

5.2- Surface water impairment verses urbanization

Since in the river channels water quality is getting worse in the region, the water loss drinking value finally and inlet of water plant have to be moved again. For instance, as water quality of Bai Min Jin River. But urban river stretch sewage flowing upstream, water quality of Ban Jin River getting worse too. The decisive distinction comprises medium to moderate soil permeability and average annual precipitation of 44 inch. The nature and extent of pollutants contributing impairment in the surface water quality due to flow of sediments and pollutants from land uses, urban and agricultural runoff, seepage from various land uses landfills and hazardous waste facilities, spills on land or water, and seepage from underground injection sites. River water toxicity is caused by acid rain, which occurs when airborne contaminants are absorbed by clouds and return to earth during rainfall.

5.3- Surface water verses agriculture mass production

Most of the surface water resources are included town and main rivers. Xin Jin and Qian Jin rivers are highly affected by sediments and are silt up to affect the irrigation potential and agriculture production. The rapid economic growth due to agriculture and industrial development is causing severe impairment in the main rivers of region. The climate is tropical with warm wet summer and cold dry winter with average rainfall of 1050 mm per year. The major sources of nonpoint pollution in the region are agricultural and rural/suburban residential activities. Rural/suburban residential NPS pollution results from increased amounts of runoff due to hydrologic modifications, fertilization of lawns, pet populations, solid waste accumulation, and combustion by-products. NPS pollutants from transportation corridors include heavy metals, such as copper, lead and zinc, asbestos, PCBs, petroleum products from spills, nutrients, suspended solids, BOD, sediment and debris. Net pollution load concept, describing the pollutants concentration (N, P and COD) from point and non-point sources pollution in the watershed, which is increasing with rising trend of fertilizer application, irrigation and annual rainfall. It shows the negative correlation between the net load of nitrogen and phosphorus from agriculture non-point sources and their content in irrigation water. The dominant crop in the study area is paddy field, which is calculated as about 72% of total area. The result of these assessment procedure from knowledge base for regional water conservancy planning in the Tai Chang region in order to develop and maintain multifunctional landscape. Integration assessment results into planning system of water conservancy of the region, described as below;

(a) Area with specific demands or standard for surface water protection
(b) Area with specific demands or standard for soil protection
(c) Area requiring the maintenance of landscape functions and characters
(d) Area requiring enrichment of landscape with ecological system integrity

6- Conclusion

With growing awareness of the feasibility of water conservancy planning, landscape functional assessment is proved steering factors. The complexity of landscape is presented by landscape function concept. Landscape functions are the result of intracting factors such as hydrology, precipitation, soil, land cover, water uses, and related environmental components. The assessment procedure in this study defines parameters, which enable the landscape functional analysis (LFA), which is established as set of data, methods and model. In this regards GIS served as primary framework / platform for initial data integration, and the linkage the all methodology and modeling to provide coherent system. The selection of methodology and model is case dependent as fpr example in the present study BASINS model has provided the integrated framework to collect all information for the assessment landscape function of iconological system during water conversancy planning of Tai Chang region in the Taihu Basin. This has provided the more flexible and practical rather then to provided the isolated modeling system to have various components work independently with out any coherent system. Moreover, data integration has resulted in the form of polygons pertaining all related trivalent information. Therefore, spatial analysis is easily adopted to vary different planning objects in spatial water conservancy planning. The key water conservancy components of Tai Chang region do not only function for surface water impairment and sustainable economic but also can improve the urbanization regarding development of lively ecological system for water environment. As result the landscape, functional capacity of urbanization, surface water, agriculture potential and water retention is to be increased during water conservancy planning. The requirement of environmental improvement, water environmental improvement by water distribution among landscape functions and strengthening landscape functional capacity is considered in optimizijng zing measures for the ongoing conservancy planning of three region. It is suggested that that in some water system and rivers channels water conversably component should be built in order to improve water environment such engineering construction design work. The landscape functional analysis is concentrated on physical and urban landscape features for their importance for species and population. The landscape function concept of the assessment procedure integrates both landscape view since landscape function compiles land use and land resources aspects. Therefore, it is necessary to define priority areas for as example agriculture in term of mass production and soil fertility criteria, by means of sensitivity to soil and water degradation, which remanded key important in current study of the region.