

# The Theory and Ways to Build Digital Small Watershed

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**Abstract:** Small watershed is the basic harness unit of Loess Plateau, its digitalization is the rudimental premise to carry out and to realize Digital Loess Plateau, and Digital Small Watershed (DSW) is the magnified impact of Digital Loess Plateau at level of small watershed. Based on theory, technological background and feasibility analysis of DSW construction, this paper put forward the whole pattern of constructing digital small watershed, explored the technological ways of building digital small watershed in terms of the framework, basic functions, and so on. According to the concept of Digital Earth, the paper conceived three stages of developing Digital Small Watershed. We also suggested that it is the final aim to share data and realize synthetic analysis, to supply scientific technical platform and decision grounds for synthetic harness of small watershed.

**Key words** Digital Small Watershed, small watershed, GIS, Loess Plateau.

## 1 Preface

Loess Plateau is a special geographical area in the range of the World, intensive soil and water loss leads to terrain fall to pieces and gully developed freely<sup>[1]</sup>. In addition, quickly increasing population, irrational use of land are all the reasons that ecological environment of the Loess Plateau deteriorated day and day, local agriculture and rural economic developed slowly. Harness and development of the area have far-reaching influence not only on the safety of Yellow River and Huang Hai-Huai He River Plain, but also on the protection of economic construction of North of China plain<sup>[1]</sup>. Renaissance of Loess Plateau's economy will also play an import role as bridge and forerunner in the strategic framework of national economic pivot transfer to the Northwest.

Small watershed is the basic unit of occurrence and development of soil erosion in Loess Plateau, and also is the cluster of villages<sup>[2]</sup>. Study such basic problems as harness of soil and water loss and soil erosion, taking small watershed as the unit accords with natural and economic rules. It will be in favor of programming from the whole region, synthetic harness and effect a radical cure on soil and water loss from headwaters, which result in restoration of ecological balance and sustainable development of agriculture. However, there are many problems in work of soil and water conservation of small watershed such as laggardly academic research, behindhand means of experiment and observation, underdeveloped science and technology content and deferred harness pace. It will be of importance monitoring the soil and water loss dynamically and enhancing synthetic study on small watershed by using such high sci-technology as 3S to change the condition above mentioned<sup>[3, 4]</sup>. Following the advance and implement of Digital Earth and Digital China, Digital Huanghe river, Digital City and Digital Loess Plateau were put forward. Digital Loess Plateau is the development strategy and whole programming according to regional characteristics and demand of ecological construction of Loess Plateau, aiming to provide data support from all angles for ecological harness and construction<sup>[5]</sup>. As the basic unit of Loess Plateau, the digitalization of small watershed is the premise of implement and realization of Digital Loess Plateau, so construction of Digital Small Watershed is an emergent work.

## 2 Feasibility analysis of establishing Digital Small Watershed

### 2.1 Theory foundation

Because of its distinguished status and important function in the course of soil and water loss harness in Loess Plateau, study of Small Watershed differs from the Watershed in hydrology. To study

Digital Small Watershed, we not only need to take water resource science, land resource science, soil science and environmental protection as theory foundation, therefore, but also must we apply such disciplines and methods as systematic science, operational research, control theory, optimization and decision-making theory, software engineering, complex large system research and sustainable development. Especially the application of systematic science and optimization and decision-making theory are very important for implement and fulfillment of Digital Small Watershed.

## **2.2 Technology foundation**

### **Data collection, data storage and processing techniques**

The integration of RS, GIS and GPS accelerated the development of modern mapping, precipitated the construction of technical system of digital mapping. The product of 4D ( DEM、 DOQ、 DRG、 DLG/DTL) have been validated as the basic information fountain of geographical spatial framework for National Information Infrastructure, having become important means for data collection and refreshment of Digital Watershed, and supplied new method<sup>[6]</sup>. In addition, digital photographing and surveying techniques provide economic and convenient method for collection of 3-dimension data in small watershed

Now, there were big evolution in laser whole-information storage and protein storage, and the new advances in compressing techniques and laser technology will enable us to store several G data in a CD, advanced compressing techniques will also make it possible to move spatial data with great capacity through internet. As a result, small watershed will process bigger spatial data sets and remote sensing imagery with higher spatial resolution, and more complex spatial and geographical analysis model will be displayed and outputted more effectively<sup>[7]</sup>.

### **Information share techniques**

As the development of communication and network technologies, telecom net, computer net and CATV net will be synthesized and form the complete network, together with satellite communication system and mobile communication net, which will provide the external network environment for Digital Small Watershed<sup>[8]</sup>.

### **VR( Visual Reality)**

Programming wholly the construction and development of small watershed must take 3-D modeling and visualization of small watershed as the foundation, which will enable people to know all kinds of small watershed's information, appreciate the scene and enjoy the convenience information society supplied. Using Visual Reality techniques, we can simulate and display 3-D spatial reality by means of vivid watershed model and relevant pictures, and make it come true to ramble in 3-D landscapes of small watershed with the interaction between computers and individuals<sup>[8-10]</sup>.

## **2.3 work foundation**

There are rich and generous work foundations to construct digital small watershed in Loess Plateau. Such researches as remotely sensing monitoring for synthetic harness of soil and water loss in small watershed in Loess Plateau, accurate positioning and wholly digital mapping, 4D techniques and Visual Reality settled stable foundation for make up digital small watershed. Imagery with several dates, land use map with large scale (1:10000 –1:50000), land use map with medium and small scale(1:100000 and 1:200000) and DEM have covered the whole Loess Plateau. The methods of integrating spatial data, the aviation photography technology with big scale and such developments and applications of theme information systems for soil and water conservation and land management etc dealt with all aspects of spatial data management. These work have been trying from 1980s, and provided beneficial reference for setting up the Digital Small Watershed.

The comprehensive investigation, a great number of geographical data gathered by many experimental zone for soil and water conservation and field ecological station, practice experience and detailed information accumulated by researchers in soil and water conservation, ecological construction and soil erosion set up foundations for data collection and integration of information of digital small watershed. Series of classification method, principles and technology rules gave us the technology regulations and standards for constructing digital small watershed.

### 3.The whole conception of Digital Small Watershed

#### 3.1 Frame structure

To the whole view, Digital Small Watershed looks as a system to manage synthetically and analyze and utilize information of small watershed established on application and supporting plat of small watershed. We can make it possible to share and communicate all kinds of information, amalgamate, mine and synthesize the information more deeply, provide electric, digital, visualized, accurate services for all kinds of information entity and user entity inside and outside the small watershed (Figure 1).

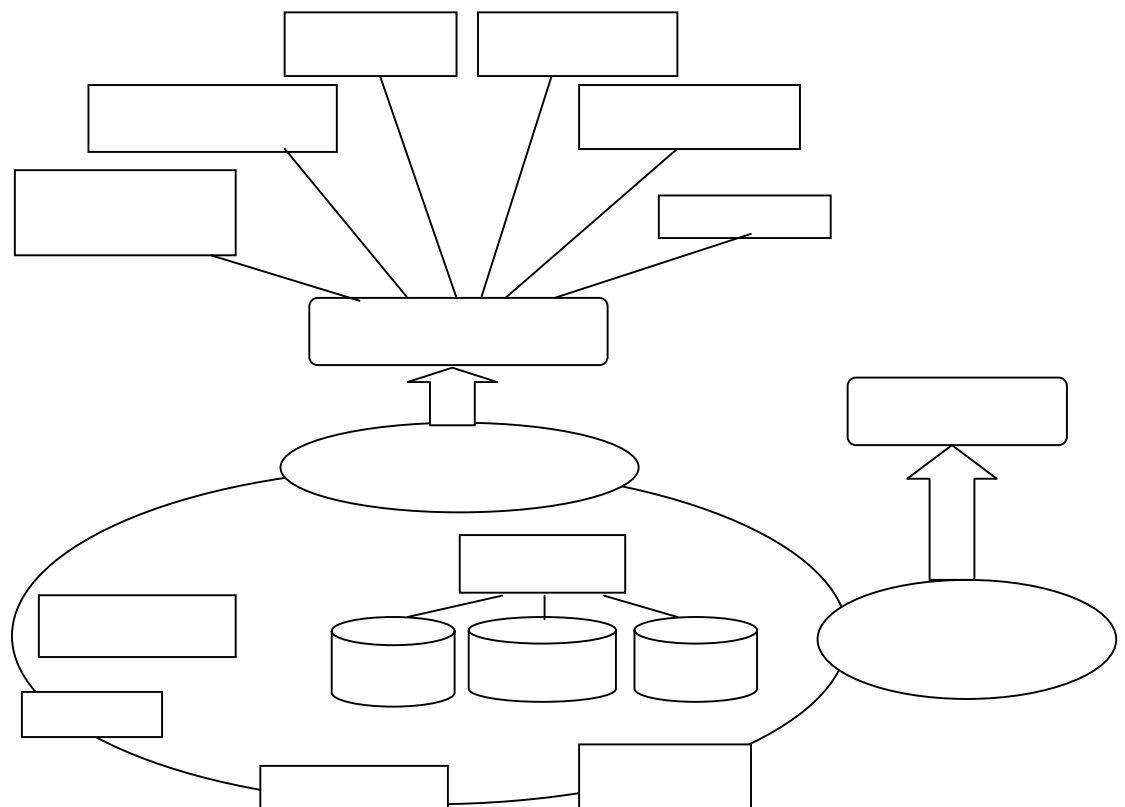


Fig1. The figure of whole frame of digital small watershed

#### Logistic structure

The digital small watershed may be show as a organism formed by electric map, spatial position, attribution features and visual reality. Electric map is to position accurately, to relate the entity in map with attributes of society and economic, to display truthfully the real small watershed using visual reality technology. Based on work above mentioned, we can simulate, imitate, display, forecast and analyze the history, today and future of real entity of small watershed in information space.

#### Information system

Information system is the key part of digital small watershed, and is the groundwork to realize the digital small watershed. It consist of database, model and method base and knowledge base, i.e. the

spatial and attribute data, model and method to analyze different theme and knowledge rules based on expert's experiences. Database consist of natural environmental data and social and economic data, among which, natural data is composed of condition of geology, physiognomy, soil, climate, hydrology and vegetation in small watershed. Social and economic data is composed of population and its distribution, economic development level of all parts, resource condition and demand for it, development level of industrial and agricultural development, advantageous situation and limitations, irrigation works and soil and water conservation facilities<sup>[11]</sup>. Model and method base is composed of DEM model, model of ecological assessment and ecological evolution and prognostication, soil erosion model, disaster evaluation model and society development model.

#### **Application support platform**

The application support platform is the foundation to integrate spatial, timely and social and economic data. The process is to apply secondary developing tools, integrate it with all kinds of analysis models to form the system platform which can input and output data, extract and analyze information, simulate reality based on the basic GIS software platforms, such as Arcview、 Supermap、 Arc/Info and MapGIS etc.

#### **Networks**

Network environments are formed by inner networks and external networks. All sorts of automation control and communication equipments are combined with basic application platform, and form inner network platform of small watershed, and supply a digital environment for application and researches in small watershed. Based on Internet, we formed external networks using TCP/IP protocols, therefore expand the range to share spatial information of small watershed.

### **3.2 Basic functions**

Digital small watershed takes the visual reality of the whole small watershed as a platform, and deems the whole small watershed as a 3-D model, from which users can select the demanded services. We can query, edit, find out the distribution of spatial attributes and their quantitative numerical values, ramble in the fictitious environment by zooming in and zooming out with unlimited scales to comprehend the dynamic changes of environment. By integrating with specialty models to analyze synthetically, it can supply the optimization and decision-making schemes for harnessing and programming small watershed. Meanwhile, by relating the fixed digital camera and appropriate appliances in small watershed, we can input the real condition of cropland, woodland and engineering project into networks. Based on the application support platform, we can get more information outside of the small watershed by means of networks. Exporting more information to outside world to make it know more about the small watershed can provide more chances for development of small watershed, to harmonize the small watershed and information society.

The basic functions of Digital Small Watershed consist of information management with several dimensions dynamically, data query and refreshment, display and output of data, analyzing and simulating of spatial process, building models, transfer and conversion of model's parameters interactively.

### **3.3 Data management and share**

Data management consists of base management of spatial map data and theme attribute data, information management and maintenance based on networks. Among which, construction or network of small watershed consists of altering database's networks according with some standards, distributional calculation operation system based on networks, distributional networks services based on objects, protocols for distributional process and interactive operation. The outfit of professional experts,

establishment of standard and specifications, the realization of data safety and inter-operation are the guarantee system to realize the Digital Small Watershed smoothly. In addition, we can realize data share and services, make the information products of small watershed commercialized.

### **3.4 Phases of design**

According to the basic theory of the digital earth, the development condition of the computer and the rate of progress in digitalization of small watershed, there are three phrases in the development phases of digital small watershed :primary phrase, secondary phrase and advanced phrase.

#### **Primary phrase**

The central work of this phrase is to design the whole frame for the digital small watershed, to study and draw out the standardization system of the small watershed and to establish information system of small watershed based on the digital information. Including contents are as followings: establishment of the basic information database, visual simulation of the multidimensional information, establish of the graphics database and construction of the spatial infrastructure etc. At this phase, multi-mode query of the information and integrative analysis and application of special information can be realized. The digital small watershed has rudimental form.

In primary stage, visual technology based on GIS is not perfect enough, the visual simulation is limited to simple display of 3-D models, rambling and selecting routes. However, the geographical analysis of it is not satisfactory, and imitating simulation is being exploring now<sup>[7]</sup>.

#### **Intermediate phase**

Intelligence is the distinguished traits of this phase. In this stage, we can carry out the refreshment of small watershed's information dynamically and simultaneously, process, analyze and manage data with computer intelligently. To utilization of visual small watershed, the 3-D spatial database based on vector and raster models with real 3-D space will be set up, and information query and searches supported by networks will be actualized to account for spatial operation and analysis with 3 dimensions. In this stage, expert system, artificial intelligence and neural net are syncretized into Digital Small Watershed to make small watershed achieve intelligence in data acquisition, analysis, management and application etc.

#### **Advanced phase**

In this stage, integrative operation of data acquisition, data management and data application will be realized, and interactivity is the salient characteristic of this phase. We can built distributional service system based on Java language, form system structure with which users can get graph elements by means of Java Applet. Users can browse and query the graph elements or map and images, edit and create new maps to make it come true to acquire and operate interactively information. In this stage, individual service for position demand and recognition and optimized decision will be fulfilled, and a pen, normative, visualized and net-around system will be established in the whole small watershed.

## **4. Conclusions**

There are substantial grounds of theory, practicing and technology for construction of Digital Small Watershed. To do it, we must take the system science and optimization and decision-making theory as theory guide based on multi-discipline specialty theory knowledge. The synthetic utilization of such modern high and new technologies as remote sensing, GIS, visual reality, networks, multi-media and database is the ultimate theory and technology guarantee to carry out the Digital Small Watershed successfully.

The construction and application of Digital Small watershed stored rich and generous data and

information for fulfilling Digital Loess Plateau with large scale at last, the whole framework and conception of Digital Small watershed can be used for references technologies, system and method of Digital Loess Plateau. Digital Small watershed is a very complicated systematical project, in content, spatial database, model and method base and knowledge base are the foundation and core part of Digital Small watershed; to development stage, according to basic theory of Digital Earth, development of computer technology and the pace of watershed digitalization, the Digital Small Watershed can be parted as primary stage, medium stage and advanced stage. To realization aim, it is ultimate aim to share data and analyze synthetically and to supply scientific, visual technology platform and decision-making basis for harness watershed synthetically.

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