Use of Statistical and Geographic Analysis in a Farmer-Managed Irrigation System Study

Olivia Aubriot[1]

INTRODUCTION

This paper presents an example of how geographic analysis techniques can be applied to study a Farmer Managed Irrigation System (FMIS). It describes the methodology used to analyze the data collected during my field research. The methodology, developed by Mr. Sabatier[2], my scientific director, appears to be very useful and accurate when applied to irrigation studies. The purpose of this paper is not to present all the research findings, but to give some examples of the geographic system in use.

The objective of the study is to analyze the present water management dynamics of a particular FMIS, its evolution, and to present some hypotheses on its origin. We looked at technical and social aspects of the system, and analyzed it according to the following constraints: What are the evolution possibilities of the system? What is the impact of the village's political and social organization on community water management?

To address those questions, we analyzed primarily water distribution. Water is common property and is essential to everybody, yet no one can be sure of their own access to water (due to damage of the canal, appropriation of the resource by others, etc.). As a result, water is often a reason for conflict. Through studying water issues, tensions among people as well as the various social groups within the community, were revealed. In order to analyze the present water management, we observed the organization of water distribution, canal maintenance, resolution of conflicts, social organization in the village, etc. In relation to the evolution of the system, we focussed on modifications of water distribution, population growth, lineage organization, and the evolution of land use.

METHODOLOGY

We have divided the methodology into the following four phases:

Phase I

A preliminary village study was conducted from April to November 1990, to obtain a general understanding of the complex water management of one particular FMIS: the system of *Aslewachaur* in Gulmi district. This system can be rapidly characterized as follows:

- Initiated by a villager about 100 years ago, this FMIS is a 6 km long canal which brings water to 45 hectares of paddy.
- There are 150 houses now, comprising mainly *Bahun* or Brahmin (95%) with 90% being from the *Pande thar* or clan. The latter are divided into two groups, locally called *Jaisi* and *Bagale*.
- There is a canal committee whose responsibility is to maintain the canal.
- The particulars of water distribution are:

  a) The presence of a proportioning weir or *sacho* on the main canal which divides the water into 3 secondary canals;

  b) The presence of water-turns reflecting the lineage organization of the village;

  c) Direct access to the secondary canal for each terrace; one irrigator diverts all of the canal water to his field at once. He has fixed water rights allocated in *ghadi*, the name of the water-clock (1 ghadi = 24 minutes).

Phase II

The second phase involved analyzing the data by computer, using statistical and geographic methods of analysis as explained below. Several questions appeared from these analyses. The comparison with other FMIS in Nepal, and in other parts of the world, broadened the sphere of research.

Phase III

A second stay in the FMIS was necessary to answer the previous questions, and to go deeper into the analysis. Moreover, we brought with us computer-produced maps to give to the villagers. They were pleased to have them, and corrected them where needed. This second stay was completed in two periods: a) two separate months in 1991, and b) 7 months in 1992. Both periods were during the rice-cropping season.

Phase IV

The last step involved analyzing the final data, using the same method as in the second phase. We are still in the process of analyzing the data, so we can only present some partial results here.

THE USE OF STATISTICAL AND GEOGRAPHIC ANALYSIS

Geographic Information Systems can be used for two primary purposes: the more simple use is purely for cartography; the more complex is to relate and analyze statistical data with maps.

Using GIS for Mapping Purposes Only

One of the first steps in our research was to develop a map on the computer with the necessary base line information, including information from a cadastral map, spatial delineation of land owners, plots of land irrigated per day, and water-rights of each plot. The advantage of using a computer, as opposed to hand-drawn maps, is that the area of study needs to be drawn only once. Once it is drawn, one can quickly and easily view desired information on the map.

For example, in the case of Aslewachaur, we first digitized the cadastral map and gave a number to each unit we wanted to distinguish, namely the individual plots of land. In a data base, we then listed information that could be directly mapped, such as land partitioning between clans and water-turns. For land partitioning, we distinguished between ethnic groups and clans by classifying them into 8 classes: 5 classes representing the 5 clans within the Bahun, 1 class representing the *Chetri* from the *Aryal* clan, and 1 class for the *Newar*. We then linked the database to the digitized map and each class to a specific feature code[3]. The map is then automatically shaded as shown in **Figure 1**.

Another example can be demonstrated by mapping water-turns. In Aslewachaur, we found that water is distributed on a rotational basis, by water-turns. Each water-turn lasts twelve hours, during which a fixed area of rice fields receives water. A water-turn represents not only the time during which the water can be used by the farmers who have access to that water-turn, but it also represents the water itself, and the land irrigated by this water. Each secondary canal provides four water-turns. These twelve water-turns can be easily mapped as they are distinct from one another. We completed the database with information concerning the location of the water-turns, and created a second map as shown in Figure 2.

These two examples show how the software can be used solely for mapping purposes. Using this type of mapping system, it is easy to quickly map these rough data. The next section describes a more complex use: how the software can relate statistical with the geographic information acquired.

Relating Statistical Analysis and Geographic Information

The second way of using geographic information systems on a computer is to develop a statistical database, then present that information graphically. Not only does the map present the results of statistical analysis spatially, but the map itself, in relation to other data, can be used as a basis for further analysis. In irrigation studies, it is particularly useful because the subject can be easily mapped.

For example, let's suppose we need to identify the various agricultural yields from a designated area. Such studies are frequently conducted on a regional scale, but have never focused on details of specific plots. This geographic system can be used not only to display data on maps, but also to analyze agricultural production yields on a local scale. When studying the evolution of irrigation, and present water management in Aslewachaur, the maps again serve as useful tools for analysis.

Evolution of water management in Aslewachaur. Because the FMIS in Aslewachaur is not very old (one hundred years), records of past sales and purchases of these water-rights were limited. To study the evolution of irrigation, we therefore decided to focus on individual water-rights. With respect to social data, in particular kinship relations, we thought the villagers could give us some information on the evolution of land partitioning, and on water-rights transactions. We applied factor analysis techniques to analyze the relationship among these variables. Plots having the same global characteristics were gathered together. With the help of the geographic information system, we displayed the results, and obtained **Figure 3**.

With further analysis of the map, we developed several hypotheses about the evolution of the irrigation system. For example, plots numbered 1 and 2 in **Figure 3** show an area where it appears that kinship cohesion has been lost, whereas plots numbered 3 and 4 look united. Number 1 and 2 plots that appear split, belong to certain kinship groups whose cohesion had been lost. As a result, plots that used to be whole, but are now split, we hypothesized, can not be irrigated according to the same water-turn schedule nor necessarily by the same individual.

When we went back to the field, we tested this hypothesis which appears to be acceptable. One of the consequences of this land partitioning is the resulting different management techniques of the various water-turns: the more united a group is, the easier it is for them to make decisions. This point has a strong meaning from a conceptual point of view: this small society has a model of organization that creates a distinction between the various kinship groups. This can be clearly seen in the water management practices, since originally a water-turn corresponded to a specific lineage group. But it appears that the community has not yet found how to adapt this model to the evolution of land partitioning. This was clarified during the study; the water-turns, composed of various lineages, had not changed their irrigation scheme.

Current water management in Aslewachaur. As far as present water management is concerned, we studied the exchange of water between the farmers. Although it is clear which plot is to be irrigated during which water-turn, irrigators often misuse their water-turn; a result of the land fragmentation. For example, in order to limit the drying of the paddy field due to frequent canal damage and subsequent lack of irrigation for a few days, they try to irrigate their field every day instead of every two days. They use, therefore, the water of one water-turn not only in the designated plots, but for many other plots that do not belong to this water-turn.

There are potentially several ways to alleviate this problem. For example, a farmer that possesses two rice fields (A and B) in separate water-turns, could use his water-right of water-turn A in both fields A and B. The other solution is to exchange water with somebody who has a water-right in another water-turn.

In order to study these water exchanges, we followed the distribution of water along one canal, and noticed the rice fields irrigated by the specific water-turns. We have not yet finished analyzing the data; until now we have one map, **Figure 4** showing the fields irrigated on 26 August 1991 during the *Jaisi-Pareri* water-turn. We intend to use these maps to analyze the dynamics of water exchange including a) with which field the exchange has been done and b) who is the person who exchanged the water etc.

Figure 4 also demonstrates how diverse the presentation of results, created by using a geographic system, can be displayed. This map, for example, is more detailed in the design of each field, house and cowshed location. It was a handmade map that was put into the "Apple" computer through a scanner, and used as a back draw. On this back draw, the plots of interest were simply marked with a stripe. The other three maps were drawn on a plotter linked with a "IBM compatible" computer.

CONCLUSIONS

Through the case study presented above, we wanted to show that:

- Maps are very useful to present clear results of a study, especially in the case of irrigation studies where the subject is easily mapped.

- Geographic information can be used as a tool of analysis. Relating statistical and geographic information enables us, through analysis, to identify certain facts difficult to discern without a global study.

- Studying water distribution can be extremely useful in understanding community water management. Indeed, water distribution is not only a technique used to fulfil the physical needs of the crops, but it is also a "social technique", in the sense that it distinguishes different groups from one another. Water also reveals the social structure of a society, its conflicts, and its ability to cooperate.

Notes

[1] O. Aubriot received a scholarship from the Fyssen Foundation for her PhD research in Nepal during 1992-93.

[2] Jean-Luc Sabatier, an irrigation expert, is currently working at the ESAT (Ecole Supérieure d'Agronomie Tropicale) in Montpellier, France.

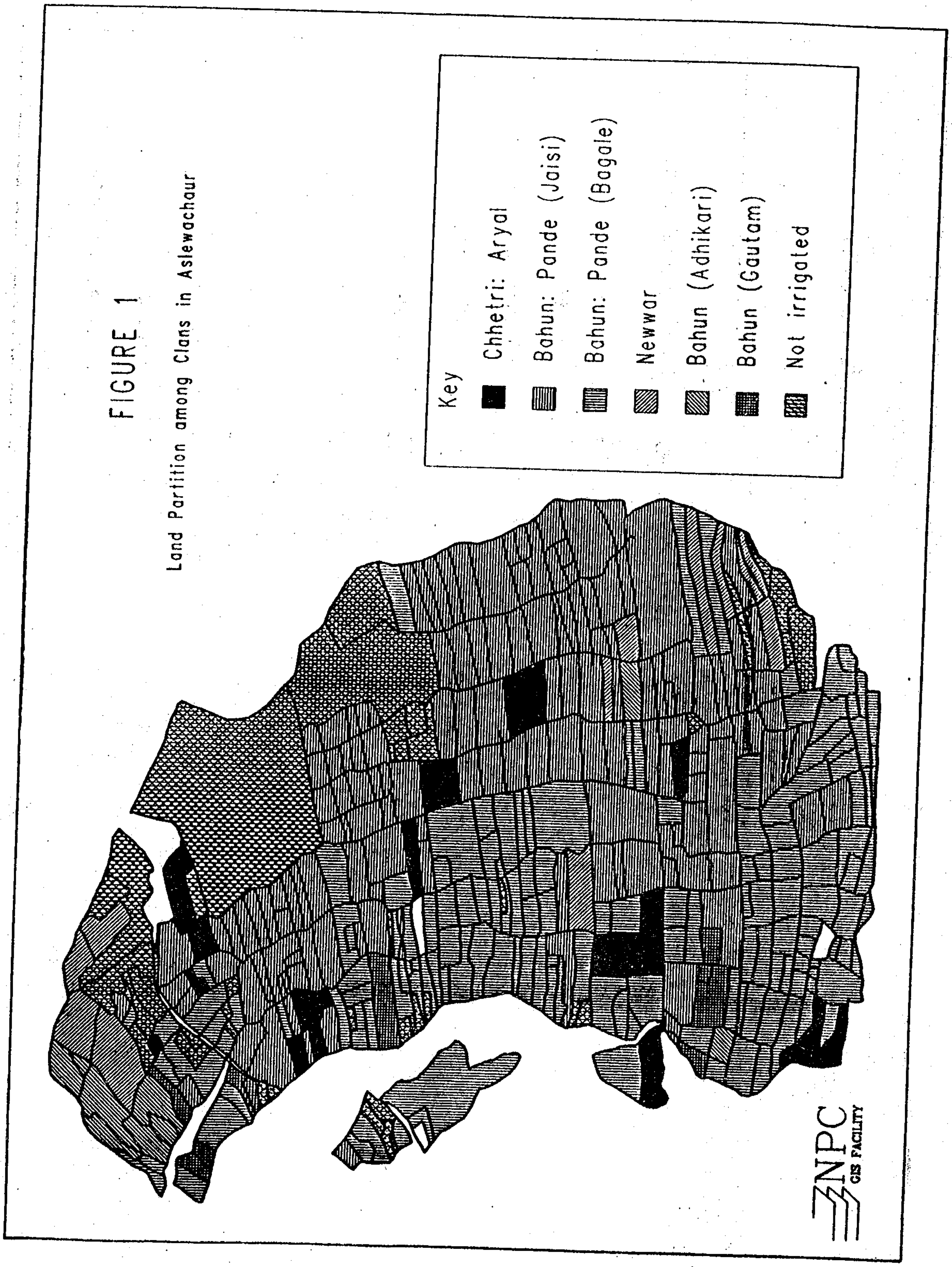
FIGURE 1
Land Partition among Clans in Aslewachaur
Key
Chhetri: Aryal
Bahun: Pande (Jaisi)
Bahun: Pande (Bagale)
Newwar
Bahun (Adhikari)
Bahun (Gautam)
Not irrigated
NPC
GIS FACILITY

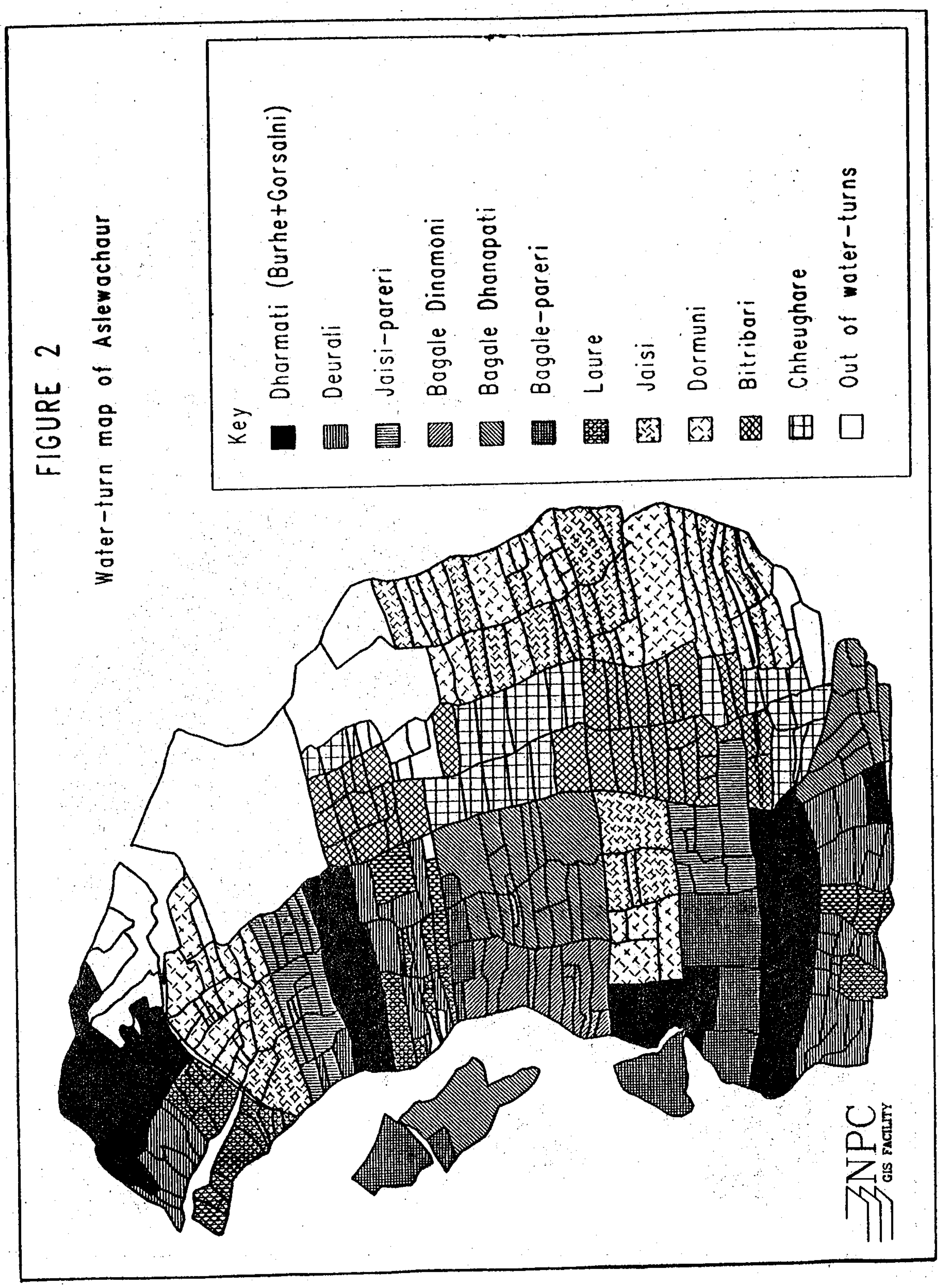

FIGURE 2

Water-turn map of Aslewachaur

FIGURE 3
Impact map

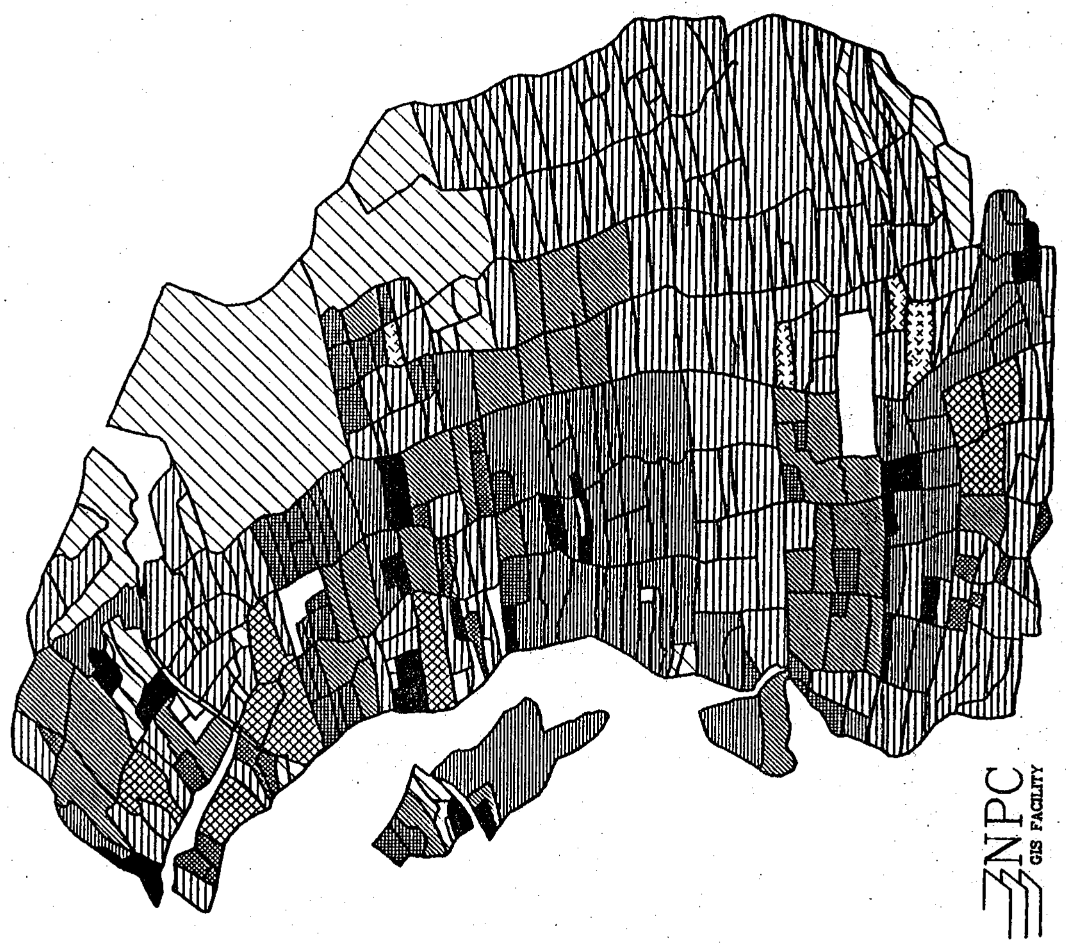

FIGURE 4

Observation of the *Jaisi Pareri* water-turn (26/08/1991)