CHAPTER V
COMPARATIVE EVALUATION AND DISCUSSION

5.1 GENERAL

The main purpose of this present research work is to identify a suitable technique for natural resources inventory programmes. Currently various techniques are in practice, such as preparation of thematic maps and modelling, numerical/statistical modelling and GIS modelling. In the recent years, the GIS modelling technique is gradually picking up and trying to take over the other techniques.

Though each and every technique has got its own merits and demerits or advantages and disadvantages, such techniques have not been employed in a same terrain with same data base, so that the real comparative evaluation could be done and finally a suitable technique could be identified and suggested to the future research and operational scientists for quicker and speedy solutions. Hence in the present study, the hard rock aquifer data has been taken for Vellar basin and the same data has been used for thematic, numerical and GIS modelling as discussed in CHAPTER II, III and IV.

The present chapter discusses the comparative evaluation and merits and demerits of each technique. In such comparative evaluation, all the outputs have been discussed at first and finally the special merits of each technique has been discussed.

5.2 COMPARATIVE EVALUATION

The comparative evaluation has been done for the models developed for functions of water level, aquifer depletion, storage coefficient, specific capacity, transmissivity, permeability, optimum yield, recovery rate and overall aquifer condition taking the outputs of the three techniques.
5.2.1 Functions of Water Level

The models developed through thematic modelling technique for the functions of water level mean (FIG. 5.1A), show a restricted linear domain, in the area east of Attur, south of Kallakkurichchi and south of Veppur. This indicates that these are the only regions where water level fluctuation is controlled by structural, geomorphological and subsurface geological parameters. In the area south and east of Kallakkurichchi, structural parameters control the water level mean. That is, water level is shallower because of more structural deformation, which is attributed mostly to the NE-SW and E-W trending pre cambrian lineaments. In the area east of Attur, mostly geomorphology is responsible for the shallow water level. Whereas the water level function model developed using factor varimax rotation analysis has shown two domains as follows (FIG. 5.1B and 5.1C):

DOMAIN 1: Zones where water level falls down with increase of thickness of aquifer which is restricted to the western part of the basin (FIG. 5.1B).

DOMAIN 2: Zones where water level rises with increase of geomorphology and thickness of aquifer which is restricted to central E-W axis of the basin (FIG. 5.1C).

Such numerical model almost confirms the thematic model. But the model established through thematic modelling show such function only along a narrow restricted axes and incapable of giving information on the spatial extent of these aquifer controls. But on the contrary, the numerical model developed through factor varimax analysis (FIG. 5.1B and 5.1C) has given definite additional information on the functions of water level as shown above. In addition, such numerical model has clearly shown the spatial domains clearly and critically. Further, if such functions of water level model is viewed in conjunction with local geological setting as stated earlier, there is a NNE-SSW trending major mylonite ridge along Gangavalli - Attur alignment. On the west of this dyke, water level falls down with increase of thickness of aquifer. But in the area east of such
VELLAR BASIN
FUNCTIONS OF WATER LEVEL
ROTATED FACTOR 2

LEGEND
- DEPTH TO WATER LEVEL DECREASES WITH INCREASE OF GEOMORPHOLOGY FOLLOWED BY SUBSURFACE GEOLOGY

FIG. 5.1C

FUNCTIONS OF WATER LEVEL MEAN
WATER LEVEL CONTROLLED BY
C1
C2
C1+C2
C1+C3
C2+C3
C1+C2+C3
UNF HILLS
HILLS

FIG. 5.1D
mylonite ridge, water level shallows down with increase of subsurface geology. The same indicates that this mylonite ridge running between Gangavalli and Attur has played a major role in controlling the aquifer in general.

The same model, developed for water level mean with the help of GIS (FIG. 5.1D), on the contrary shows that the area falling west of such mylonite ridge, mean water level does not show any correlation with any of the structural, geomorphological and subsurface geological parameters. And hence, it has been marked in dark colour. But on the contrary, the eastern side structural and geomorphological parameters independently and structural, geomorphological and subsurface geological parameters in various combinations control the water level fluctuation (FIG. 5.1D). This leads to again interesting conclusion that water level rising or falling is an independent phenomena irrespective of the structural or geomorphological or subsurface geological parameters in the area west of Gangavalli - Attur mylonite ridge. It follows from it that mean water level increases and decreases with rainfall as the same is totally obstructed to the mylonite dyke. On the contrary, the area east of such mylonite ridge, various parameters control the water level fluctuation. This ethics is well reflected in GIS modelling. Moreover, while the water level function model of the thematic modelling technique has shown small axes and linear domains and the numerical modelling has shown a broad buffer zone, the GIS model has shown discrete clusters showing the various functions of water level fluctuation along with controlling structural, geomorphological and subsurface geological parameters.

So the comparative evaluation of these three techniques clearly show that the GIS modelling has got greater advantages in the water level function model as shown in TABLE 5-1. Thus the evaluation table shows that the GIS modelling has got real advantage over the other two techniques, namely thematic modelling and numerical modelling.
<table>
<thead>
<tr>
<th>ITEM</th>
<th>THEMATIC MODELLING</th>
<th>NUMERICAL MODELLING</th>
<th>GIS MODELLING</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Spatial Distribution</td>
<td>Show restricted linear domains along the anomaly axis</td>
<td>Show broad buffered zones showing various controls of particular variable</td>
<td>Show a number of discrete clusters and spatial domains showing various functions of water level fluctuation</td>
</tr>
<tr>
<td>2. Special Observation</td>
<td>Western part of the basin does not reveal any connection between terrain parameters and water level fluctuations.</td>
<td>Both east and western parts of the area reflect that in the entire area some parameters controlling the water level fluctuation. Hence does not reflect the influence of mylonite ridge much.</td>
<td>Western part water level does not show any relation with terrain parameters. But eastern part different parameters control. This once again due to the control of mylonite ridge</td>
</tr>
</tbody>
</table>
5.2.2 Functions of Aquifer Depletion

The models developed for the width of aquifer depletion from thematic, numerical and GIS techniques were compared. The aquifer depletion increases means, in between post monsoon and pre monsoon, aquifer has depleted which indicates that it is a depleting aquifer system. On the contrary, if the width of aquifer depletion is less, it indicates the sustainable aquifer system. That is, various terrain parameters such as structural, geomorphological and subsurface geological parameters increase the sustainability of the aquifer system. So accordingly, three models were developed to find out which are the terrain parameters controlling the aquifer depletion and in which part of the basin. The models so developed by these three techniques were subsequently compared.

Such aquifer depletion model, developed through thematic modelling technique suggests that only in the area east of Attur, north of Perambalur and south of Valappadi there exists a relation between aquifer depletion and structural parameters. Where as in the area west of Veppur, north of Chinnasalem, geomorphology controls the aquifer depletion. On the contrary, the subsurface geology is very restrictly control the aquifer depletion. In general, only in the eastern part of the basin such structural, geomorphological and subsurface geological parameters controls the aquifer depletion (FIG. 5.2A).

The factor varimax analysis carried out between aquifer depletion data and the corresponding structural, geomorphological and subsurface geological parameters data and the resultant numerical modelling has shown that only in ROTATED FACTOR 1, there was a relation and that too, such relation exists only in the eastern half of the basin. Such relation says that "aquifer depletion decreases with decrease of subsurface geology". That is, in this entire eastern part of the basin, as the cumulative thickness of soil, thickness of weathered zone and thickness of fractured zone is less, the aquifer does not deplete much (FIG. 5.2B). Thus, while the thematic modelling has shown discrete axes, the factor modelling has shown very broad domains.
FIG. 5.2
VELLAR BASIN
FUNCTIONS OF AQUIFER DEPLETION
THEMATIC MODEL

LEGEND
- AXES OF AQUIFER DEPLETION MINIMA
- AXES OF STRUCTURAL PARAMETER MAXIMA
- AXES OF GEOMORPHOLOGICAL PARAMETER MAXIMA
- AXES OF SURFACE GEOLOGIC PARAMETER MAXIMA
- AQUIFER DEPLETION CONTROLLED BY
- STRUCTURAL FEATURES
- GEOMORPHOLOGICAL FEATURES
- SURFACE GEOLOGIC FEATURES

FIG. 5.2A

FIG. 5.2B
VELLAR BASIN
FUNCTIONS OF AQUIFER DEPLETION
ROTATED FACTOR 1

LEGEND
- AQUIFER DEPLETION DECREASES WITH DECREASE OF SURFACE GEOLOGY
The GIS modelling has again interestingly corroborated the observations made both in thematic and numerical modellings in general, but with more finer details. That is, in the western half of the basin, there is no relation between aquifer depletion and the structural, geomorphological and subsurface geological parameters (Observe Black colour in FIG. 5.2C).

In addition, the GIS modelling has suggested six types of combinations in the eastern part of the basin which controls the width of aquifer depletion:

- **C1**: Zones where aquifer depletion is controlled by structures
- **C2**: Zones where aquifer depletion is controlled by geomorphology
- **C1+C2**: Zones where aquifer depletion is controlled by both structures and geomorphology
- **C1+C3**: Zones where aquifer depletion is controlled by both structures and subsurface geology
- **C2+C3**: Zones where aquifer depletion is controlled by both geomorphology and subsurface geology and
- **C1+C2+C3**: Zones where aquifer depletion is controlled by all the three parameters namely structures, geomorphology and subsurface geology.

Thus the comparative evaluation of thematic, numerical and GIS modelling shows that:

i) Thematic modelling shows such functions only in small linear islands (FIG. 5.2A)

ii) Numerical modelling has shown that in the entire eastern part of the basin, the aquifer depletion is less due to less thickness of subsurface geology.
iii) But, GIS modelling has shown six types of domains with varying functions of width of aquifer depletion.

iv) But in one aspect, all three have corroborated with each other that only in eastern part of the basin these terrain parameters control the width of aquifer depletion.

That is, again the rate aquifer depletion is an independent phenomenon in the western part of the basin. This once again suggests that the NNE-SSW trending mylonite ridge devides the basin into two halves namely the western and eastern halves. In the western half the width of aquifer depletion totally depends upon the obstruction caused by this dyke to groundwater flow irrespective of structural features, geomorphologic features and subsurface geologic features.

However, once again GIS modelling seems to show its superiority over other two modelling and it not only shows the areas where relation between aquifer depletion and other terrain parameters exists, but also it has shown actual functions along with their spatial distributions.

5.2.3 Functions of Storage Coefficient

The model developed for the storage coefficient through thematic modelling technique has shown more number of small linear clusters again in the eastern half of the basin, suggesting that the storage coefficient is controlled by structural, geomorphological and subsurface geological parameters in small areas. Only in one location, that is, far NNW of Perambalur, structure and geomorphology, in combination control the storage coefficient. Whereas, in the western part of the basin, the area west of Attur, mostly the structure and subsurface geology independently and in combination control the storage coefficient in two large zones (FIG. 5.3A).
FIG. 5.3
VELLAR BASIN
FUNCTIONS OF STORAGE COEFFICIENT
THEMATIC MODEL

AXIS OF STORAGE COEFFICIENT MAXIMA
AXIS OF STRUCTURAL PARAMETER MAXIMA
AXIS OF GEOMORPHOLOGIC PARAMETER MAXIMA
AXIS OF SURFACE GEOLOGIC PARAMETER MAXIMA

LEGEND

A. STRUCTURAL FEATURES
B. GEOMORPHOLOGIC FEATURES
C. SURFACE GEOLOGIC FEATURES

STORAGE-COEFFICIENT CONTROLLED

ROTATED FACTOR 1

STORAGE COEFFICIENT INCREASES WITH INCREASE OF SURFACE GEOLOGY

FIG. 5.3A

FIG. 5.3B
Whereas, the numerical modelling attempted between 200 storage coefficient values and their corresponding structural, geomorphological and subsurface geological parameters data has suggested that only in rotated factor, there exists a relation. That is, "storage coefficient increases with increase of subsurface geology". Such domains were observed broadly for larger area in the western part of the basin and smaller area in the eastern part of the basin (FIG. 5.3B).

The GIS model has strictly confirmed the numerical model (FIG. 5.3C). The boundaries of such clusters are almost matching with the hatched areas of rotated factor model. But here again, such minor clusters indicating the functions of storage coefficients by various combinations of structures, geomorphology and subsurface geology was possible.

This is once again attributed to the quantitative and qualitative appraisal. The numerical model has strictly cut off the 0.30000 factor loading, where as in GIS modelling, only the mean has been taken as threshold. So, as far as discrete mathematical relation is concerned, the numerical model is best here, but in overall appraisal, the GIS has shown its superiority once again. For example, if one looks at the WNW-ESE linear domain of the numerical model, it shows that in that sector, storage coefficient is controlled by subsurface geology. But, the GIS model has suggested two clusters as follows.

1. The area where storage coefficient is controlled by geomorphology and subsurface geology

2. The area where storage coefficient is controlled by structures, geomorphology and subsurface geology.

Once again in both, the subsurface geology is a predominating and dominant controller. So, the GIS has added further classification to this model.
The mylonite dyke has shown reflectly here also. That is, the western part of the basin, storage coefficient shows correlation with the three terrain parameters. But in the eastern part of the basin, it shows relation in very small areas (FIG. 5.3C). This once again shows that the dyke has acted as barrier and as and when water got accumulated, they kept on filling the pore spaces. But in the eastern half of the basin, the storage coefficient is less than the mean, because of poor availability of water as most of the water was obstructed by the dyke.

5.2.4 Functions of Specific Capacity

The specific capacity model attempted through thematic modelling shows correlation between specific capacity and the various terrain parameters mostly in the eastern part of the basin (FIG. 5.4A).

This has also been very amply demonstrated by the numerical modelling, that the specific capacity is controlled by the subsurface geology all along the eastern fringe of the basin (FIG. 5.4B). That is, all along the eastern fringe of the basin and also small sectors in the western fringe of the basin, the specific capacity increases with decrease of subsurface geology. In the numerical modelling, the other parameters such as structures and geomorphology did not show any appreciable loading.

The GIS modelling has also clearly shown that most of the central part of the basin is an unfavourable area (FIG. 5.4C). Unfavourable means, there is no relation between specific capacity and any of the structural, geomorphological and subsurface geological parameters. The eastern rim of the basin and also the western rim of the basin show varying clusters, such as areas where specific capacity is controlled by structures, geomorphology and various combination of structures, geomorphology and subsurface geology.
Again in this case too,
- thematic modelling has shown restricted axes
- numerical modelling, a single parameter controlled vast zone
- but GIS has shown a number of discrete clusters with varying functions.

5.2.5 Functions of Transmissivity

The transmissivity model fabricated through thematic modelling technique has shown that the transmissivity is controlled by different combinations of independent parameters in the eastern fringe of the basin mostly (FIG. 5.5A).

But in numerical modelling, the factor varimax rotation analysis has shown that the transmissivity has got a mathematical relation with subsurface geology all along the eastern and western fringe of the basin. That is, transmissivity increases with decrease of subsurface geology (FIG. 5.5B).

In GIS modelling, once again there is an ample validation that in the entire central part of the basin, there is no relation between transmissivity and any of the terrain parameters. And in eastern part of the basin, transmissivity is controlled by various parameters in combination with subsurface geology, suggesting that subsurface geological parameter is the main controller supported by other structural and geomorphological parameters. Of course, in very small areas the structural and subsurface geological parameters have shown independent control over the transmissivity (FIG. 5.5C).

Thus, in this study too, the GIS modelling has shown the supremacy, as it is able to show even minor variations in the functions.

5.2.6 Functions of Permeability

In thematic modelling of the permeability, it has shown linear and very small clusters, suggesting its various functions in almost peripheral part of the basin (FIG. 5.6A). But the numerical modelling did not show any appreciable loading in any of the factors.
FIG. 5.5

VELLAR BASIN
FUNCTIONS OF TRANSMISSIVITY
THEMATIC MODEL

Legend:

- Axis of Transmissivity Maxima
- Axis of Structural Parameter Maxima
- Axis of Geomorphologic Parameter Maxima
- Axis of Subsurface Geologic Parameter Maxima
- Transmissivity Controlled, GT Structural Features
- Geomorphologic Features
- Subsurface Geologic Features

Fig. 5.5A

VELLAR BASIN
FUNCTIONS OF TRANSMISSIVITY
ROTATED FACTOR 3

Legend:

- Transmissivity Increases With Decrease of Subsurface Geology

Fig. 5.5B
But on the contrary, the GIS model (FIG. 5.6B) has shown small clusters duly validating the observations made in thematic modelling.

5.2.7 Functions of Optimum Yield

The thematic modelling, narrating the functions of optimum yield showed that only in the central axial and eastern part of the basin, there existed some relation (FIG. 5.7A).

But on the contrary, the numerical model suggested that only in the peripheral part of the basin, there exists relation between optimum yield and subsurface geology. That is, optimum yield increases with decrease of subsurface geology (FIG. 5.7B). So, it can be surmised that the model obtained from thematic modelling explain very localized and qualitative conditions.

But, the GIS modelling, again duly confirmed the observations made in the numerical modelling. But once again, in this case also, it has shown minor clusters as observed in earlier cases (FIG. 5.7C).

One more observation also coming out here is, wherever the aquifer thickness is less the groundwater yield is more. This may be due to the fact that wherever the thickness of aquifer is less, water occurs in shallow depth. Hence, yield must be more. But on the contrary, wherever it is more the water level goes deeper part of the aquifer and hence the yield could be less because of falling of pressure head.

5.2.8 Functions of Recovery Rate

The models developed for the functions of recovery rate is presented in (FIG. 5.8A,B,C). And all the three models were corroborated with each other and once again GIS model has shown more classes, suggesting various micro functions of the recovery rate.
FIG. 5.8

VELLAR BASIN
FUNCTIONS OF RECOVERY RATE
THEMATIC MODEL

AXIS OF RECOVERY RATE MAXIMA
AXIS OF STRUCTURAL PARAMETER MAXIMA
AXIS OF GEOMORPHOLOGIC PARAMETER MAXIMA
AXIS OF SUBSURFACE GEOLOGIC PARAMETER MAXIMA
RECOVERY RATE CONTROLLED BY
A. STRUCTURAL FEATURES
B. GEOMORPHOLOGIC FEATURES
C. SUBSURFACE GEOLOGIC FEATURES

FIG. 5.8A

VELLAR BASIN
FUNCTIONS OF RECOVERY RATE
ROTATED FACTOR 2

AXIS OF RECOVERY RATE INCREASES WITH DECREASE OF SUBSURFACE GEOLOGIC

FIG. 5.8B
FIG. 5.8C
5.2.9 Overall Aquifer Function Model

In the earlier cases, each and every aquifer parameter was correlated thematically, numerically and also using GIS techniques. But here all such aquifer characteristic data were added together and kept as single dependent variable and correlated with structural, geomorphological and subsurface geological parameters. The same has shown that once again, the GIS model has got greater efficiency.

While the thematic modelling has shown small linear clusters here, only in two small areas (FIG. 5.9A), the numerical model suggests that almost in the entire eastern and western rims of the basin, the overall health increases with decrease of subsurface geology (FIG. 5.9B). But again, GIS model (FIG. 5.9C) has shown that in general, in the eastern part of the basin, the aquifer health is controlled by various combinations of structural, geomorphological and subsurface geological parameters. But, it is interestingly observed that in the entire western half of the basin, the overall aquifer health is controlled by combinations of all the three parameters. This once again suggests that the mylonite dyke is playing the very major role in obstructing the groundwater flow and arrest the water and wherever porosity is there in the form of any astructural or geomorphological or subsurface geological parameters, water gets inside thus yielding more water. Hence, groundwater condition in the western part of the basin is not controlled by any terrain parameters, but it is totally controlled by mylonite dyke. But on the contrary, in the eastern part aquifer condition is controlled by structures, geomorphology and subsurface geology.

5.3 SYNTHESIS

In this chapter a thorough comparative evaluation has been done amongst thematic, numerical and GIS modellings. The evaluation has shown that overall there are agreements between the outputs of thematic, numerical and GIS modelling. But the following results/observations show that the GIS is the best and faster technique for such resource modelling.
FIG. 5.9

VELLAR BASIN
FUNCTIONS OF AQUIFER CHARACTERISTICS
THEMATIC MODEL

LEGEND

- AQUIFER HEALTH INCREASES
- DECREASE OF SUQSURFACE GEOLOGY

FIG. 5.9A

FIG. 5.9B
FIG. 5.9C
i) The thematic modelling has shown only very narrow linear strips along the anomaly axes as the various aquifer function models. But this greatly goes to the technique by itself as in the said technique all the data have been converted to axes. So it was not able to explain the spatial extent of the model. More over in manual integration of thematic maps, such multi-thematic maps can be integrated only by converting them in to axes.

ii) On the contrary, the numerical model has given both islands and vast buffer zones as various aquifer function models. In fact, such buffer zones have enveloped many axes displayed by the thematic models. But in such larger buffer zones, only one or two variables have been shown as aquifer controllers and hence these were more generalised models. The numerical model has not shown much variables and combinations of parameters. This aspect needs a deeper study. More over such buffer zones were drawn mostly on the basis of the overall mathematical relation amongst different independent and dependent variables. So this may be good for understanding the overall mathematical relation between variables and for critical spatial analysis.

iii) On the contrary, the GIS modelling has shown a number of discrete clusters in different parts of the basin, each cluster explaining the definite control of various aquifer functions. So GIS should be the best tool for precise and faster targeting.