CO-055

THIRTY YEARS OF SEMIOLOGY OF GRAPHICS AT THE SERVICE OF DEVELOPMENT IN INDIA

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BACKGROUND AND OBJECTIVES

Andhra Pradesh (A.P.) is the fifth largest state of the Indian federation in terms of population, estimated at 85 millions in 2011, and fourth in terms of area with 275,000 sq km, with a density of 309 persons/sq km. Agriculture in 2001 occupied 70 % of the main workers but accounted for only 30 % of the Gross State Domestic Product that has further gone down to 26 % in 2008-09. The average size of holding was 1.2 ha in 2005-06, barely sufficient for economic viability, posing a real challenge for rural development, the more so when it is compounded by adverse and unpredictable weather conditions.

The state is divided into 23 administrative districts covering two of the largest and fertile deltas of India, a relatively well endowed coastal belt backed by modest hills, the Eastern Ghats, a semi-arid southern region prone to droughts and a north-west granite plateau traversed by the mighty Godavari and Krishna rivers and in some places covered by rich volcanic black soils. Rainfall varies from 341mm in the south-west to 1623 mm in the north-east. Hence geographic heterogeneity is important and has a great impact on the development of the state. Understanding the spatial distribution of the state therefore is vital for planning.

Roughly forty years ago the Planning Department of the Government of Andhra Pradesh was headed by a visionary Civil Servant, Mr. B.P.R. Vithal. He introduced the use of Bertin Semiology of Graphics as tools for analysis and aid to decision-making in 1979 through a cooperation with Rouen University laboratory IMAGE[1] that had for the first time developed a computerised package based on Bertin's work. J. Bertin himself visited the Indo-French Compu-Graphics and Planning Project, participated in the training and lectures of the Indian team and officials.

During the project a computer generated State Planning Atlas of A.P. and District Planning Atlas of Guntur were prepared with up-to-date information. Bertin himself actively participated in the preparation of theses atlases, both in Hyderabad during his visit and in Paris in his laboratory, where he helped in the final stages of type setting and photography.

This work was presented in ICA – Perth[2] , Auto-Carto London[3] and Auto-Carto VII – Washington D.C.[4] It was subsequently scaled up to ensure the scientific (versus political) and very crucial analysis necessary for the application of a new administrative-cum-developmental reform that replaced 179[5] Taluks with 1106 Mandals in 1985. The shift from Taluks to Mandals meant more administrative head quarters that in turn meant that the people could be close to government assistance. There were several political reasons behind this move but the ostensible reason is the one mentioned. The head quarters had to be in places where there was some degree of infrastructure; also these centres had to be equitably distributed over the state. The choice of proper new headquarters, was a politically volatile issue for both the parties in power and those in opposition. But that is another story. The analysis for this reorganisation was done using Semiology of Graphics. While working on this project the nature of work changed from analysis (more an academic exercise), to decision support. For Bertin, this was the first instance of a non-academic use of his theory.

"Bertin argues that the cartographer's role is to define the smallest possible number and types of maps and diagrams ... to answer the pertinent questions posed by the decision makers… The challenge for cartography is the relevance of the discipline and its products to the development process." In D.R.F. Taylor[6]

The tradition continued, even after the closure of the Indo-French project in 1985, in different Departments—Tribal Welfare (1995-1997), Social Welfare (1996-1999), Rural Development (2000-2004), Irrigation & Command Area Development (2005-2010), Women and Child Welfare (2009-2011).

The aim (and challenge) here is to provide a spatial understanding of a complex socio-enviro-economic reality, with unreliable and incomplete data, for decision-makers as well as stakeholders. The tools and methods provide support for decision, communication, planning and monitoring. This paper presents two experiences from the departments of Rural Development and Irrigation.

APPROACH AND METHODS

Bertin’s work covers three areas—cartography and the rational use of “visual variables”; knowledge discovery through comparison of indicators using “reordable” diagrams and the visual matrix; organising data and selecting indicators. All three are relevant to understanding the development process and communicating the findings to the stakeholders at every level.

Communicating the results to the stakeholder, the layman, the villager, the primary-level worker, who is the target of development/improvement schemes but rarely an actor was the next big step. Though participatory approaches are encouraged and happening more and more many villagers still do not have access to all the relevant information. Much of the information today is now available on the Internet but how can endless figures and listings be used by people with limited literacy and education ?

No single method or tool answers the requirements. A combination of and interaction between different methods and tools give the best results:

- Semiology of Graphics
- Geographic Information System
- Management Information System
- Statistics and Cluster Analysis
- “Reordable” Visual Matrix

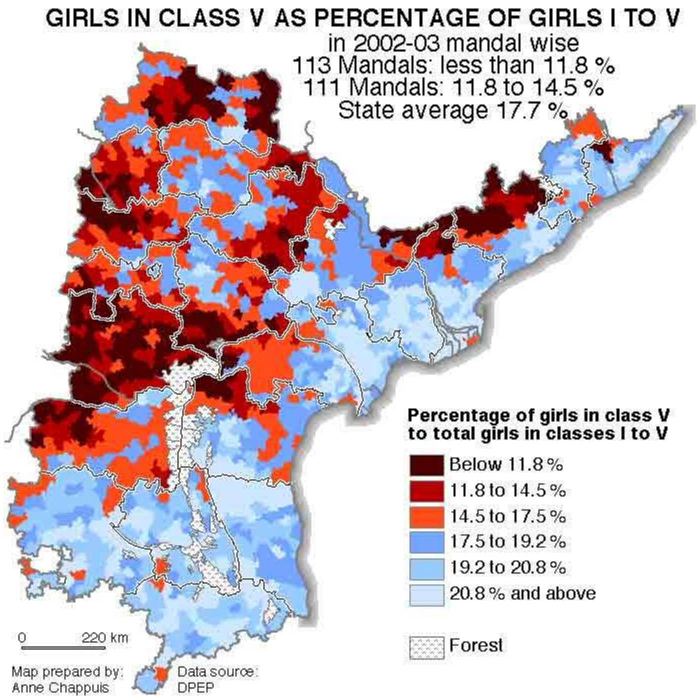
No single stakeholder has the full perspective. It is the interaction and dialogue between the different stakeholders, with different perspectives/perceptions that helps and shapes to produce a holistic efficient visual output. Here academics play a minor role.

- Senior Civil Servants
- GMIS practitioners
- Local stakeholders
- Academics

Cartography and the unconventional use of visual variables

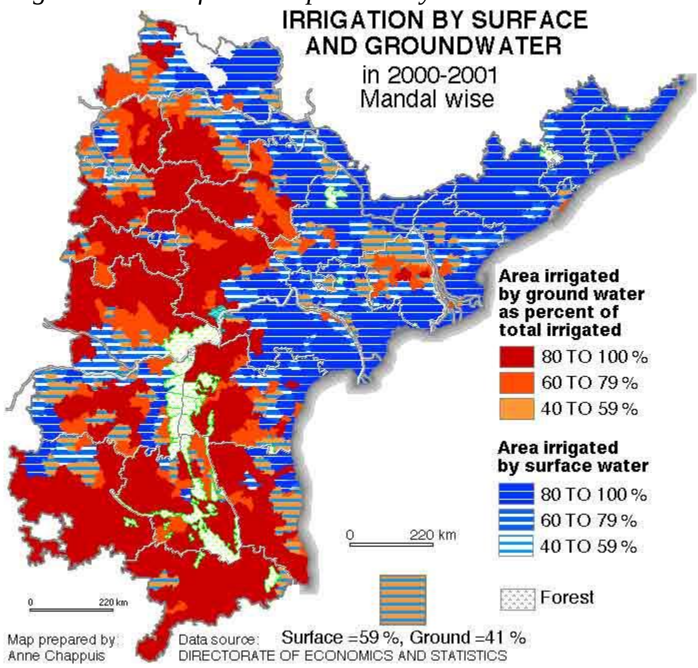
There is a conflict between the academic's and the decision-maker's approach to the issue of development. The former would like to do in-depth analysis, but the latter would like to know “which is the priority area that needs immediate attention?”. One compromise is combining visual variables with two levels of reading: a qualitative one showing the high-priority areas versus low-priority through the use of two colours, and a quantitative one using value within the colour to respect the data order. In this way the number of classes do not have to be reduced drastically to two. Although the approach is unconventional, it was approved by Bertin who thought that maps must answer the questions raised by decision-makers. In **Figure 1**, the decision-maker can decide whether to consider the first three classes or concentrate their efforts only on the first two classes, that are geographically interwoven, giving lower priority to the third class that is on the periphery.

Figure 1: Single data



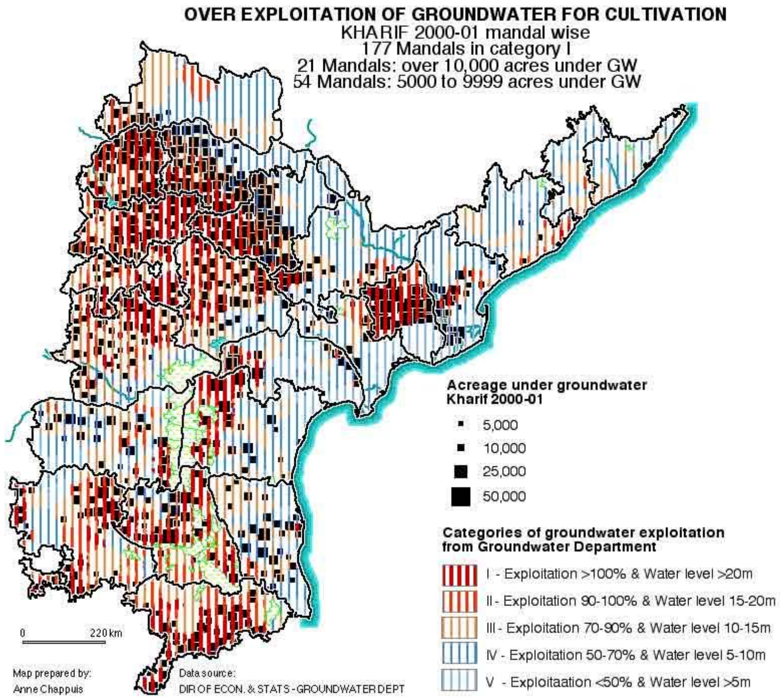
In **Figure 2**, two sets of complementary data have been combined on the same map to offer a dual reading. Here three visual variables have been used for a more dramatic impact: two colours, and two shapes for the two types of data, and shading for the classes. While presenting maps to overburdened decision-makers it is important to grab their attention immediately by giving them all the relevant information at a glance.

Figure 2: A set of two complementary data



In **Figure 3**, the challenge was to highlight a very critical issue—the over-exploitation of groundwater that can lead to non-reversible situations. Again to make an immediate impact on the minds of both decision-makers and water-users the map had to be dramatic. To achieve this, two different indicators were superimposed, (i) the area irrigated with groundwater and (ii) the level of groundwater exploitation. Grain was used to provide transparency. Two colours were combined to show danger/no-danger zones. Below that, size translated the actual area utilising groundwater, and the colour black to emphasise the impact.

Figure 3: A set of two different data



Bertin's semiology in government decision-making

This section of the paper is derived from the experiences gained by the authors over one and half decades of working together in A.P. The authors, a data visualization expert and a bureaucrat, have led teams of government and non-government staff working with Bertin's semiology in the fields of natural resource management by community: (i) self-help movement among rural women and (ii) farmers using water for irrigation. The two case studies of self help groups and water users' associations show the concept being applied in a government set-up.

In the mid eighties a small initiative was started in A.P. This was a thrift initiative where women formed groups of about 15 called self-help groups (SHG). Each woman gave Re.1 per day to the group towards building a corpus fund. From its humble beginnings it is now a mass movement covering about 10 million women in about 1 million groups with a combined corpus of more than 4 billion US$. Women use the corpus fund to give loans to a member for meeting urgent economic needs. The women meet regularly, share the savings and deliberate on the loan applications received by the group. These groups are now federated at three levels to provide access to formal financing institutions and have been given recognition for accessing various other facilities. Monitoring the performance and the health of these groups was a key political and administrative challenge. The Bertin methodology was extensively used for behavioural analysis of the groups that led to future administrative and policy actions for improving their performance.

The other case study is of farmers under an irrigation project organized into water users' associations (WUA's) to manage their irrigation system in coordination with the Irrigation Department of the government. About 6 million of these farmers managed about 4 million ha of irrigated land through about 10,800 groups. Here again, monitoring the performance of these farmer associations was a key for monitoring the irrigation performance that was critical to the state's economy and food security—about 5 billion US$ worth output out of the total agricultural output of about 12 billion US$ in the state.

One immediate challenge before the data gatherers, sifters and those involved in presenting this visually, is to have a team leader who is aware of the potential, scope and role that visual semiology can play in their routine decision-making. There will be many who will not want to experiment with this system being set in their ways. Yet the potential power of this tool is too powerful to be neglected for want of demand from policy makers or team leaders. This trend is changing, albeit slowly, as visual representation and analysis of facts is gradually gaining ground and wider acceptability because of its sheer utility. Before it becomes a necessary tool for decision-making at various levels in government, non-profit and profit organisations, it is essential to create demand for its application by proactively selling the idea and the tool. There can hardly be one single universally applicable idea to generate the demand, but this is a tool that can accommodate any and unique set of circumstances/data.

Start with the available data set—Often the information available in the organisation may not be sufficient to bare the facts and behavioural pattern that the leaders in the organisations are looking for.

Sometimes the information available may be suspect. Under both circumstances, it may be essential at a later time to acquire a new data set. Nonetheless, trashing available information or its absence is not a positive way of initiating a new relationship. Our experience has been that it is better to start with the available information and proceed with analysis and draw the trends. This initial exercise will help in establishing the power of the tool and also immediately highlight the necessity of acquiring a new data set and/or validating the available information, thus creating an in-house demand for improving the available information system. It is a win-win situation.

Establish a dynamic system for learning organisations—Organisations are "live" organisms and act. Each action leaves certain imprints that can be weighed in terms of impact and efficacy. Thus organisations continuously evolve, throwing up new types of data sets that emerge from the new sets of action carried out to improve performance of the same old job. Dynamism and evolution are thus intrinsic and intertwined in organisations. This dynamism and evolution need to be captured and presented visually bringing to the fore that which has so far been hidden.

Peter Senge in his seminal work The Fifth Discipline: The Art and Practice of the Learning Organization (1990) has defined the learning organisation as follows.

"…organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together."

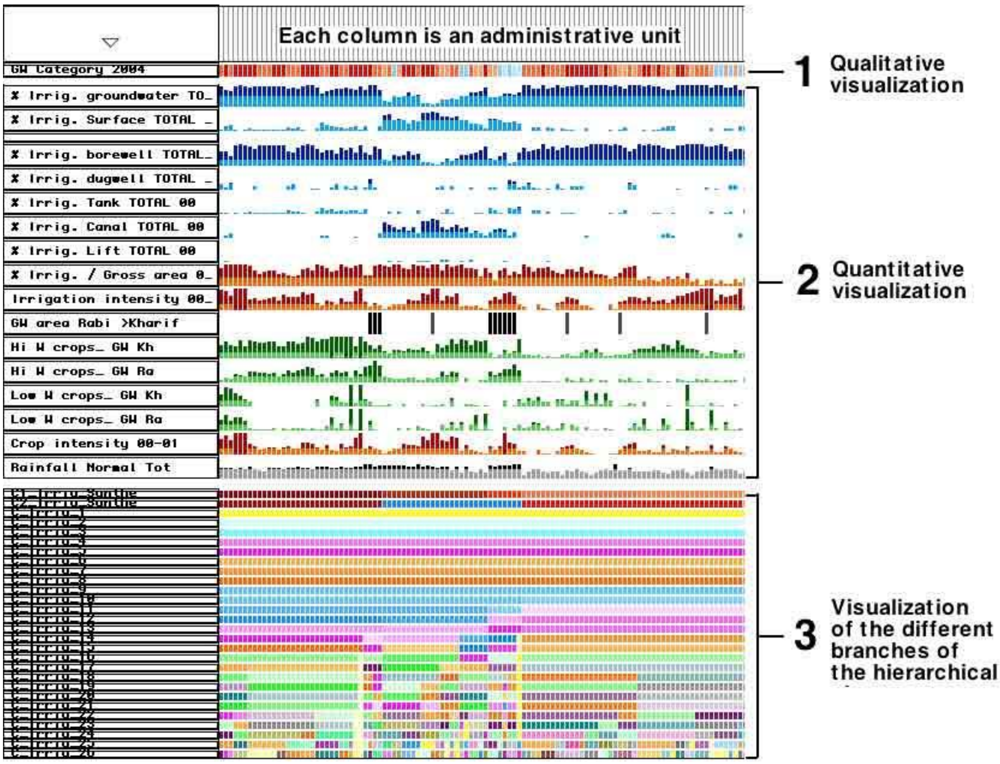
By definition the learning organisation works continuously to improve performance by enhancing their capacity and allowing new patterns of thinking. The empirical base for this new thinking to evolve lies in the data set of the organisations as well as in other areas. For such organisations, continuous and concurrent analysis of data is key to decision-making as is reviewing earlier decisions. Visual presentation of analysis helps show the impact, efficiency and sufficiency of ongoing efforts of the organisation and also highlights the areas where improvements can be effected in the future.

Create a multi-disciplinary team—As we will see in the following paragraphs, developing a hypothesis out of the trends revealed through analysed data is one important step in the process. Intrinsic and extrinsic information sets need to be established. To some extent intrinsic information can probably be identified by the visual data analyst, but extrinsic information requires an in-depth knowledge of the domain of operation. The availability of information or the lack thereof will be seen immediately while establishing these information sets. It is therefore essential that the existing persons in charge of data and future surveyors (those who will collect the missing information), be part of a team. The team thus involved in this exercise will comprise of a data visualization expert, a senior domain expert, the existing team responsible for data management and future surveyors. Creating such a team will also assist in creating institutional memory of the steps followed and assist in internalising the basic processes that can be used in routine operation plans of the organisation.

The process flow—The first step is to consult the senior management to understand the mission and objective of the organisation/department, and to review the available data set with those in charge of managing information. Further, to understand the distribution of responsibility in the hierarchy of the organisation so that appropriate output can be provided to each level linked to their area of operation and current set of responsibilities.

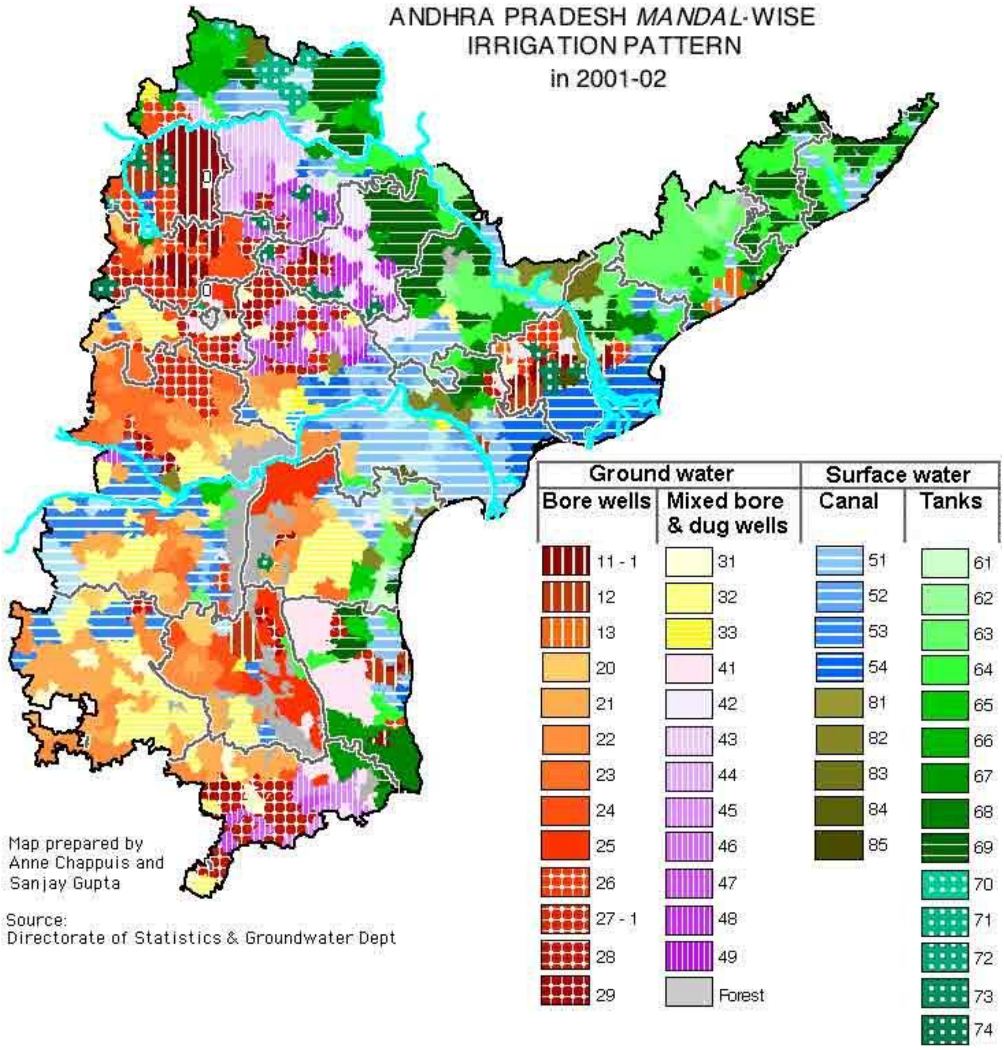
Knowledge discovery and the "reordable" visual matrix—Understanding a complex reality requires an iterative process, where time and discussion with the decision-maker is essential. The results of a first visual analysis nourish the thinking process and raise more questions. This leads to the integration of new indicators and new analysis. This process is repeated till the understanding that emerges allows links to be established and discover models that lead to strategies being constructed and actions planned.

Figure 4: Use of the "reordable" visual matrix as an output of a statistical cluster analysis



The data set is reorganised using a hierarchical clustering and the output is a visual matrix (**Figure 4**) with different visualizations: qualitative with colours (for instance the categorisation of groundwater exploitation), or quantitative with bar diagrams where the data above the average, or a particular level, is highlighted in dark. These bar diagrams can be coloured based on the "family" of indicators, water related in blue, agriculture related in green, etc. The down part of the visual matrix shows the different levels, or branches, of the hierarchical cluster. The user can immediately SEE the relationship between indicators. The 49 classes are visualized on the map in **Figure 5**.

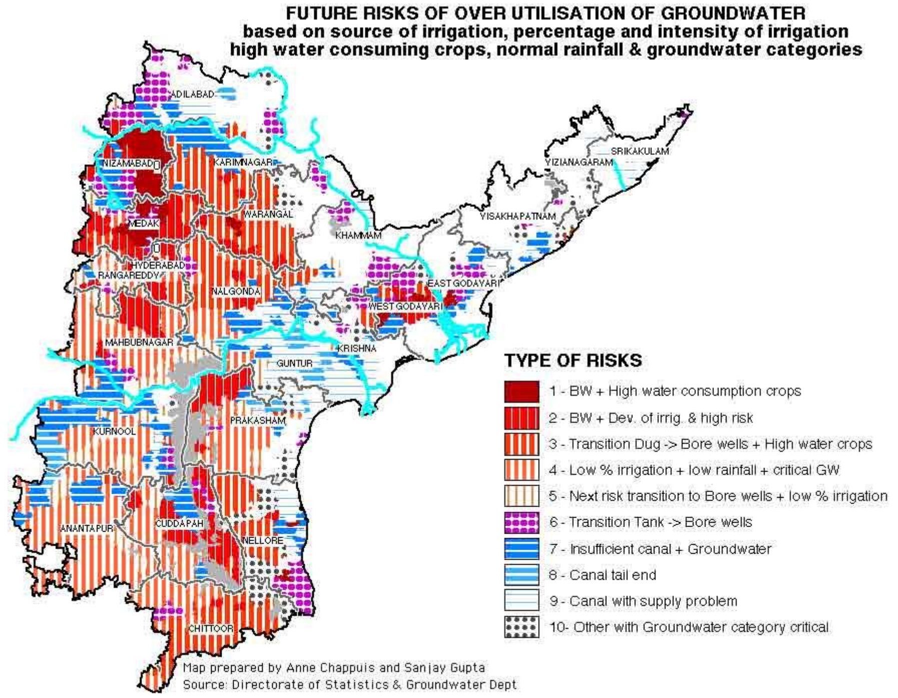
Figure 5: The challenge of building a map with 49 classes

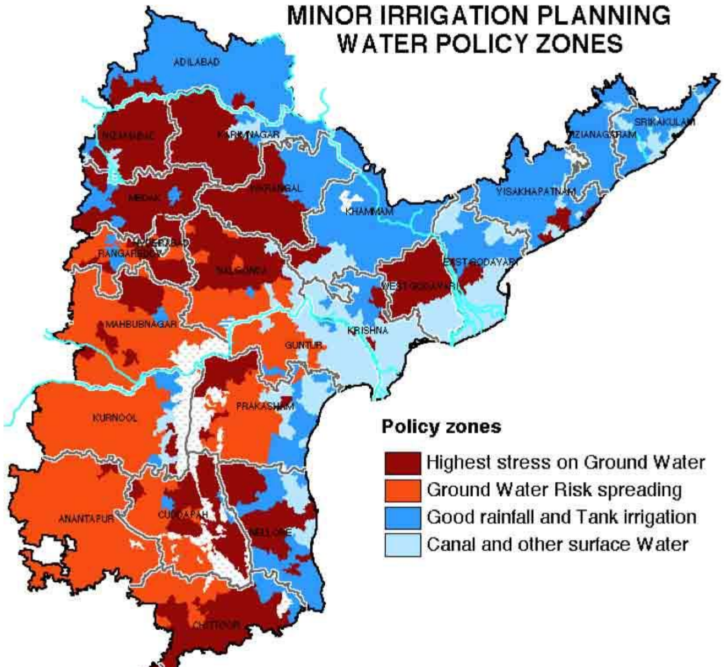


To build a map with 49 classes one has to use all the resources of the visual variables and combine them. But first the classes have to be organised in broad groups or themes, like ground and surface water, then subdivided into sub-groups. Warm and cold colours are used to differenciate between the two main groups, and colours within each category differenciate the sub-groups. Within a sub-group shade, orientation, shape and grain are used to create clusters of categories with similar trends. This allows multi-level reading of the map. One can zoom in and out, associating all the reds, or looking at a particular sub-set, like the vertical lines, or at a detailed level of one category, the darker vertical lines.

Interpreting results and building strategies and policies—From this first understanding of the links between indicators one has to interpret and assess the implied risks and potentials. Areas where the main or only source of irrigation is from the ground (deep wells), where two or more crops grown in a year are water intensive, with only medium rainfall then clearly these areas fall under “high risk”. Or even past that, beyond reclaimable. Going beyond the obvious, one can try a dynamic reading and identify the areas that are at an early stage of developing the same high risks. These areas can then be categorised in the main water-policy zones. In Figure 6 the whole process reduced 1100 geographical areas into 49 water usage categories, then 10 risk categories and ultimately 4 manageable policy zones.

Figure 6: Importance of dynamic thinking to identify risk and potential areas





These maps can be further compared with socio-economic indicators. Special plans can be prepared for areas where both water potential and high socio-economic vulnerability coincide.

Organising data and defining indicators—Bertin used to complain that most scholars who came to him did not know how to organise their data and did not know how to derive relevant and meaningful indicators. Preparing data is essential, but only after the right questions have been raised. Since the process is iterative, not all the right questions are raised in the beginning. The more so, as most decision-makers are captives of pre-conceived ideas about what should be done. It is often only after the first analysis, that the mind opens to unforeseen relationships, and that the right questions are raised. One example is the assumption that, as a bureaucrat in charge of developing irrigation, one should not look into areas that are already well irrigated. But the analysis showed a large area at risk of unsustainable irrigation forcing one to think of different policies.

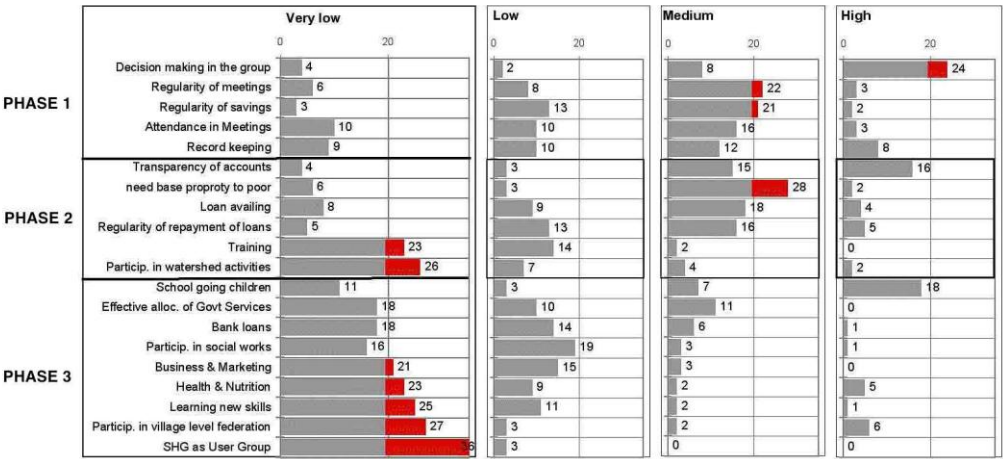
Selecting key indicators that reflect performance metrics for each level of hierarchy is very important. Normally it has been our experience that about 10–15 indicators are sufficient to capture the whole gamut of performance and health of the organisation. It is a crucial step requiring team operation as decisions regarding what questions to ask the data set and what answers are to be expected are made here. The indicators selected should be able to capture the growth and evolution of various constituent units of the organisation to form a dynamic system of information management.

In the case of the SHGs, 20 indicators were finalised from a list of hundreds of data fields. Usual plotting of information from thousands of SHGs in various percentage level of performance could not bring out a trend. After continuous exploration a visible trend emerged when we arranged the indicators in a sequence of evolution through which a group ordinarily passed through (**Figure 7**).

During the initial stage the groups were busy sorting out the logistical issues and setting up administrative protocol. Therefore the indicators reflecting the administrative performance were grouped and placed as phase one of the evolution. In the next phase the groups were focusing on the collection and rotation of money, thus the indicators capturing the fund collection and rotation were grouped as phase two. In the third phase of the evolution the groups started using the funds for asset building and moved away from economic needs and emergencies. This phase highlighted the improved quality of life. The indicators capturing the larger social issues were placed for this phase three. Grouping the indicators on these phases of evolution of group from formation to fund rotation to asset building and quality of life immediately provided a self-explanatory picture on a single sheet.

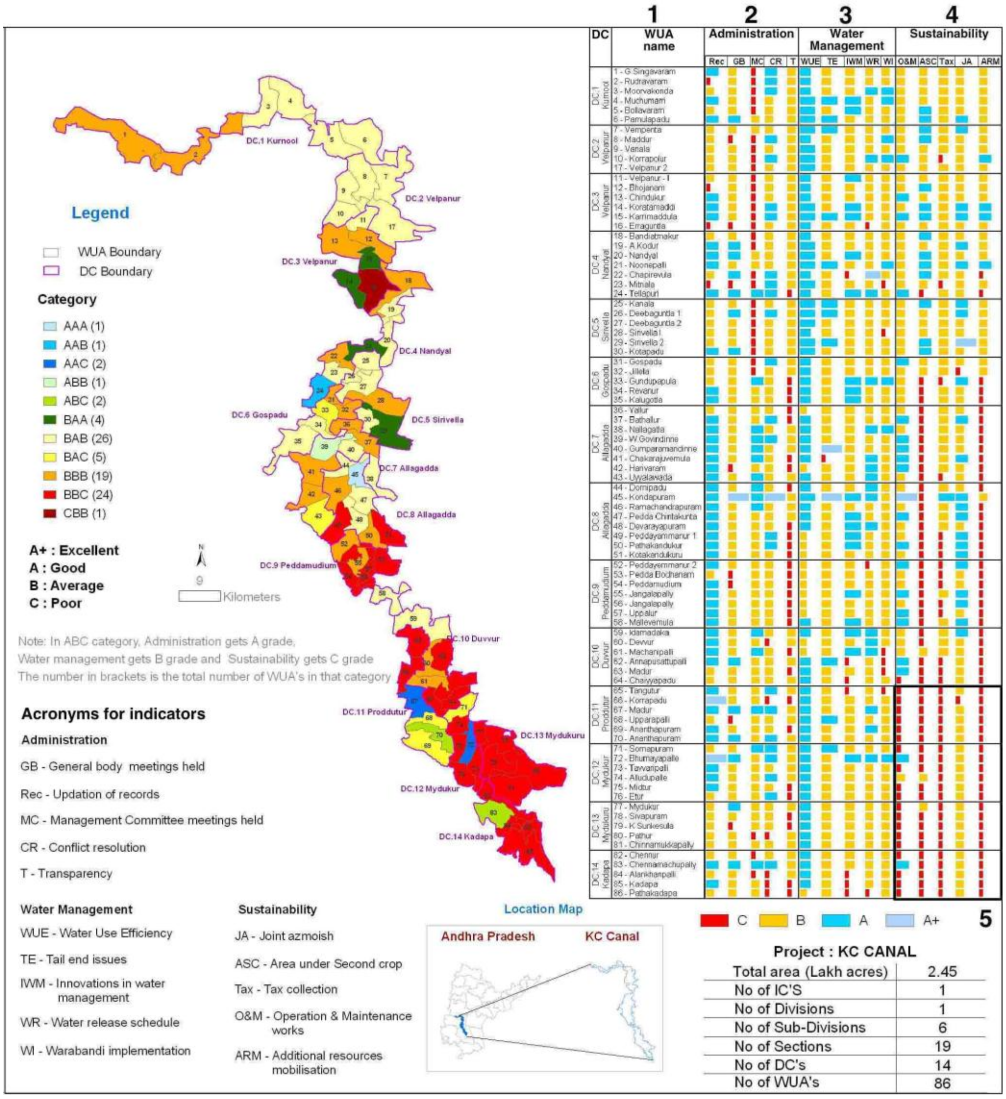
Figure 7: Self Help Groups performance metrics

The indicators on Y axis show a possible sequence of evolution. Larger number of groups in very low indicators show the SHGs in their earliest phase of evolution



Similarly in case of the water users' associations (1) as shown in **Figure 8** the 15 finally selected indicators were grouped in three themes of administrative issues (2), water management related (3) and sustainability related (4). The key concern is on those 24 WUA's (5) where sustainability shows poor performance, and where a specific action plan can be prepared.

Figure 8: Performance of Water Users'Associations in K C Canal Irrigation Project



The presentation of information on grouped indicators, in both the cases, clearly revealed the percentage of groups in each phase of evolution. Obviously during the initial phases the logistical issues were settled followed by the initiation of the core activity, followed by the sustainability related performance or impact of the core activity. The percentage of the groups or units in each phase indicate the present level of the organisation in the overall achievement of the objectives envisaged. Capturing information regularly will highlight the movement of the various constituent units over time and space.

RESULTS

The visual documents initiate a thinking process that challenges preconcieved ideas and bring in fresh perspectives, both conceptual and spatial. It starts a knowledge process with additive loops that raises questions and integrates new indicators that look at the edges and transition zones to arrive at the evaluation of risks and potentials. It helps build predictive models or prospective scenarios and induces new strategies and policies. It also allows a more meaningful dialogue between the stakeholders. It enables better governance.

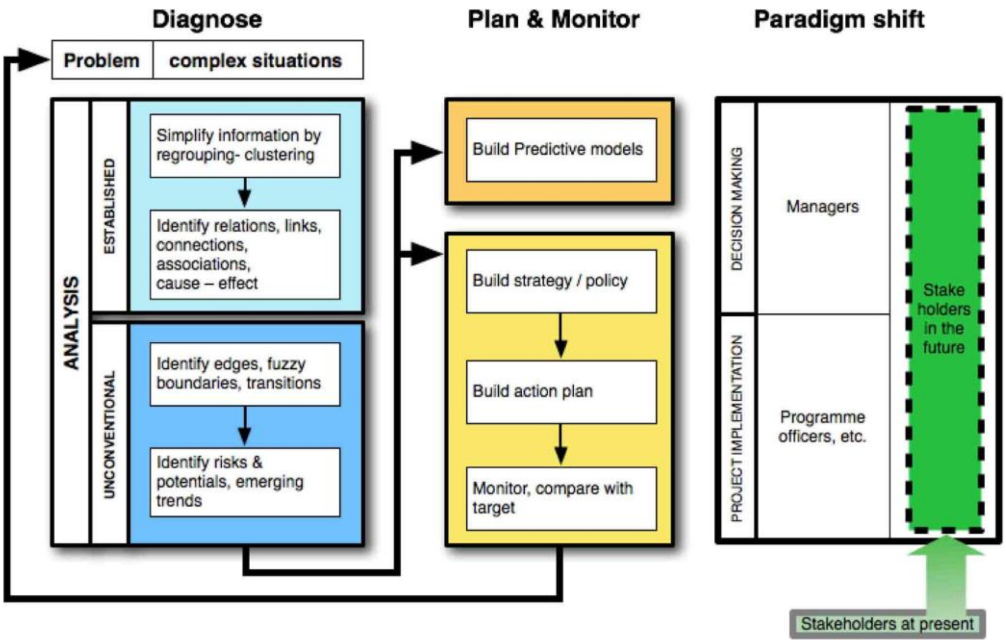
CONCLUSION

Images are very powerful and bring transparency and understanding to all stakeholders. It facilitates a bottom-up and participatory approach, that is a must on paper but not always wished for by the powers that be.

FUTURE

The challenge is thefore to bring the various stakeholders, who are presently outside the process of decision-making, into it (**Figure 9**). This will require a paradigm shift and change of mindset.

Figure 9: The challenge to integrate the stakeholders into the process



[1] Infographics and Mathematics Applied to Geography.

[2] Chappuis A and de Golbéry L, Un atlas regional, outil d'aide a la décision en Inde. Paper read to the 12th International Cartographic Conference, Perth, Australia, 1984

[3] D. R. F. Taylor, Computer assisted cartography in developing nations, Auto-Carto London volume 2, 1986. http://mapcontext.com/autocarto/proceedings/auto-carto-london-vol-2/pdf/computer-assisted-cartography-in-developing-nations.pdf

[4] Chappuis A and de Golbéry L, Info-Graphics, its applications to Planning in India, proceedings of Auto-Carto VII, Washington D.C., 1985 http://mapcontext.com/autocarto/proceedings/auto-carto-7/pdf/info-graphics-its-applications-to-planning-in-india.pdf

[5] An intermediary reform in 1981 creating 305 taluks was never applied.

[6] See footnote 3