Use of GIS in Education related Decision Making and Strategy Planning

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1. Abstract

Education is a critical determinant of economic and social development and also of household livelihoods and food security status. Public sector educational data is compiled and released almost every year in Pakistan. Lengthy tabulated report with missing geographic visualization is less friendly for the intended audiences. There was a need to improve this information, not only in terms of data quality but also in terms of linkages with technological leverage like GIS and WWW. Geospatial analysis allowed seeing the spatial patterns of various indicators and correlating them with proximity of other features like accessibility and drainage. This study aims to highlight the potential use of GIS to strengthen the representation of available educational data and, in the longer term, improve its quality through geospatial analysis. The intention is to arrive at an effective combinatorial assessment of educational parameters through their distribution in space.

Key words: Geographic Information Systems, Web Mapping, technology implementation, technology adoption, Educational Planning, Education GIS, effectiveness research, Data Sharing.

2. Introduction

In Pakistan, Public sector contribution to education system has a dominant share in geographic outreach, however this is being seconded by rapid expansion of private sector. Public sector educational data is collected and compiled annually for the whole country and a yearly statistical report highlights educational indicators successively aggregated to the province level. Some provinces also release their own data and reports to address their provincial needs by including customized indicators aggregated at district level or sometimes even at union council[i] level.

In all of this reporting, lengthy tabulated reports with missing geographic visualization of trends makes for cumbersome reading, especially for those wanton to macro level decision making and strategy planning. There arises a need to improve the understanding of this information through map-like visualization and wider deliverance over the web.

The intended visualization through *GIS has the potential to make significant contribution to education* (Barstow 1994). Geospatial analyses allows for correlation and assessment of spatial patterns of various indicators in the context of other supportive mapped information. Visual representation of all indicators offers a unique opportunity to examine spatial patterns in combination with population distribution, accessibility and other supportive infrastructure.

3. Objectives:

The paper explores the potential utilization of geospatial techniques in;

- Decision making and strategy planning.
- Adoption of procedures and methodologies towards mapped visualization of educational parameters
- Exploring technological aids for web publishing of mapped data.

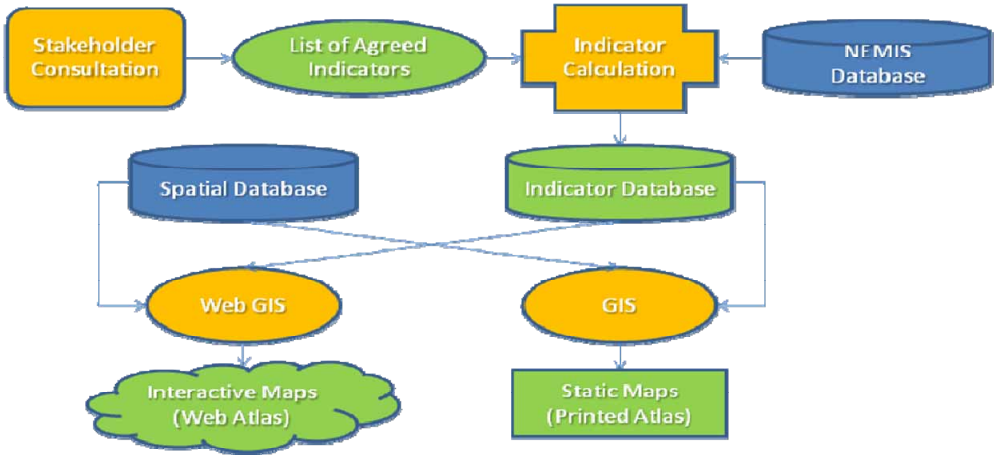
4. Methodology

The Pakistan Education Atlas Project was initiated in April 2010 with a view to enhance the coverage and dissemination of educational statistics and indicators through the use of available technologies like Geographical Information System (GIS) and World Wide Web (WWW). This Project is a collaborative venture between the World Food Programme (WFP) and the Federal Ministry of Education (MoE) through the National Education Management Information System (NEMIS) [ii]at the Academy of Educational Planning and Management (AEPAM).

The Project has three components: (i) development of the printed Pakistan Education Atlas 2010, (ii) development of an on-line version of the Education Atlas 2010 and (iii) capacity building of NEMIS and provincial EMIS staff through training in map analysis and publishing. All three components of the Project have been successfully completed.

To facilitate the sustainability of information use, both NEMIS as well as provincial EMIS staff have been trained by a team of WFP GIS experts. This capacity building supports future endeavors and NEMIS has already started working as the GIS hub at the MoE in providing expert advice and training to other government organizations.

Following diagram explains the methodology adopted to develop Pakistan Education Atlas 2010;



A list of indicators is agreed through a stakeholder consultation involving education managers, Federal and provincial level policy makers and strategy planners in education. Additional contributions came from donor agencies, NGOs and researchers from academics.

There were three factors for the selection of indicators:

a) It should support strategic decisions
b) Ensure upscale the availability of data, and
c) Should be map-able (i.e. it has geographic component).

Following Indicators were agreed;

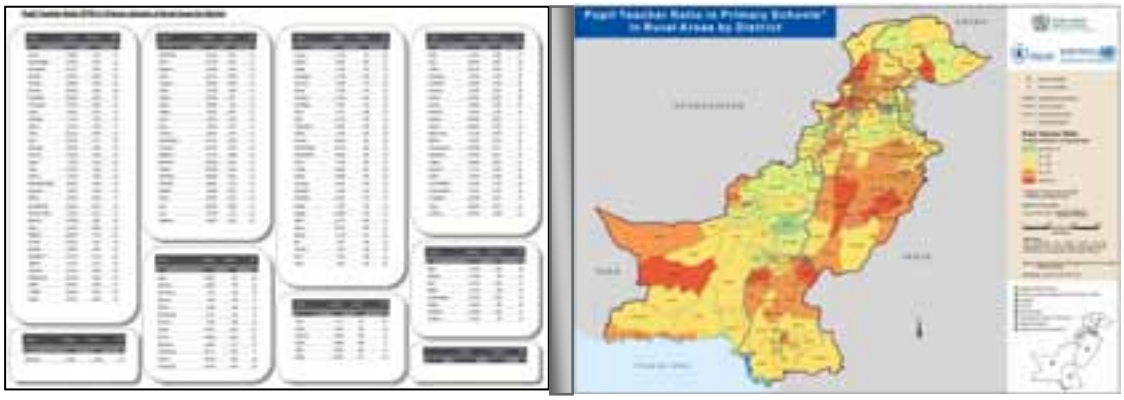
1. Gender Parity Index of Enrollment[iii]
2. Pupil teacher Ratio[iv]
3. Survival Rate to Grade Five[v]
4. Facilities
    a. Availability of Drinking Water
    b. Availability of Student Latrine
    c. Availability of Electricity

Based on geospatial analysis, the Atlas presents spatial patterns of various indicators. The indicators have been desegregated to reflect on rural/urban divide, Stage[vi] i.e. Primary[vii]/Elementary [viii]and High[ix] and Gender and then aggregated and mapped at district level. Population dependent variables such as Net Enrolment Rate (NER) and Gross Enrolment Rate (GER) were not calculated due to the unavailability of representative population data for the school-going age groups. The data on mixed schools (co-educational) was also not included in the analysis owing to disagreement amongst provinces on the definition and registration of mixed schools.

The indicator database is developed by calculating school level data from National Education Management Information System, aggregating at district level. Spatial

datasets (e.g. district boundaries) from WFP's Spatial Database were mapped with indicator database using a common district code. Static maps were developed using ESRI's ArcGIS on a template shown below, for all the indicators disaggregated at the levels mentioned above.

Right hand side page shows the thematic maps shaded in five classes. The cut-off points for the classes are discussed and agreed with the NEMIS Data Analysts. The opposite page gives the absolute values for the corresponding district grouped in their respective provinces. For every map, the national average is provided as a reference; also, the cut-off range having the national average is labeled as a star (*) to highlight the color range of national average. Method of indicator calculation is also expressed on the map to make it explicit.

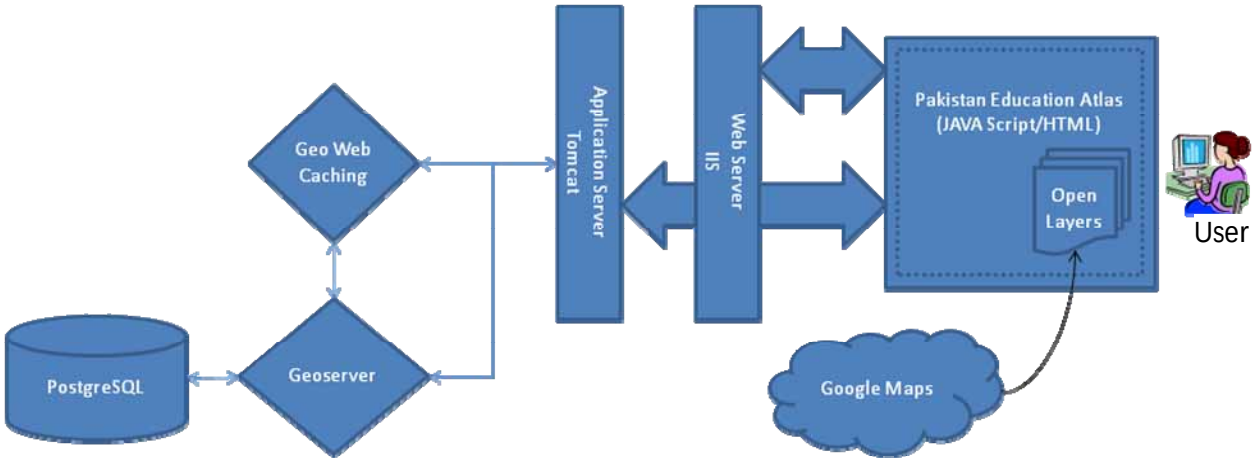


Web-GIS Atlas

GIS is popularly used to publish and share geo-spatial information on the Internet amongst large numbers of people (Maged NK Boulos, 2006). Other than proprietary solutions in the market, there are *Open Source Web GIS software systems have reached a stage of maturity, sophistication, robustness and stability, and usability and user friendliness that rivals commercial competitor*s (Maged NK Boulos, 2006). Web GIS based interactive atlas is developed mainly using open source technology and can be found at http://atlas.edu.pk/. It is a publically available web mapping application offering the standard map navigation and query operations in an interactive fashion. The web-based edition allows the user to switch quickly between layers to observe patterns and make spatial enquiries.

PostgreSQL has been used as spatial database for storing the NEMIS data whereas PostGIS gave additional spatial capabilities to the database. Tomcat is used as a servlet container or application server which executes JAVA code and returns the result. Tomcat is configured to receive requests from Internet Information Server (IIS) based on a URL pattern; for instance, all requests to geoserver are routed through Tomcat for

processing. Google maps are used as a base map. A figure below explains the architectural design of the web application.



5. Results and Discussion

Pakistan Education Atlas is the first such exercise to study a broad array of education-related indicators. Starting from the individual school level, data has been aggregated to the district level, thereby allowing users to access decentralized information for the entire country pertaining to enrolment, teachers and facilities. For every indicator, the national average is provided as a reference. The same information is available in the on-line version of the Atlas which allows for navigation across map levels and determination of distances between locations. With expanding access to the Internet, citizens would be able to secure basic educational statistics across a standardized representation.

Anomalies and Synergies: Spatial analysis lends itself to deliverance of geographic patterns: for example, while looking at Gender Parity Index, *Panjgur* District in Balochistan province stood out in its proximity, as its GPI at primary stage is more than 1 (more girls enrolled as compared to boys) in rural areas while it is 0.15 in urban areas (one girl enrolled against 7 boys). This trend is dissimilar to the pattern in the adjacent districts.

Another significant anomaly is seen when analyzing the Pupil-Teacher ratio against the back drop of survival rate to grade five. Low pupil-teacher ratio means fewer students per teacher and a higher survival rate to grade five. This is not necessarily the case considering District Kohlu in Baluchistan.

The Atlas is an important means to data validation and trend rationalization. Shared information allows the educational data managers to examine inconsistent trends for reasons that are otherwise not too obvious in tabular descriptions.

6. Conclusion

Geographic Information Systems (GIS) constitute an important leverage towards understanding spatial trends in education levels and infrastructure. Sharing information is the best way of validating information and the online version of Atlas makes the information widely accessible. Open source technology is proven to be cost effective and together with Google services provide enhanced data processing and visualization facilities to the common user. The Atlas will serve to stimulate education-related discourse in Pakistan, including ways to overcome discrepancies in indicator definitions or data quality. This is an ongoing process that should lead to continuous improvement across multiple levels of dissemination and visualized analysis.

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End Notes:

[i] A Union Council (UC) is the fifth tier of government in Pakistan, the territory represented by a UC usually comprises a large village and surrounding areas, often including nearby small villages. The term "union council" may be used for localities that are part of cities.

[ii] The National Educational Management Information System (NEMIS) is an integral part of the Academy of Educational Planning and Management (AEPAM). The main purpose of NEMIS is to consolidate and collate education statistics, maintain a comprehensive national education database, set standards for quality improvement of education data, and provide technical support to the provincial and district Education Management Information Systems (EMIS) to generate and maintain data. The EMIS units are responsible for collection, compilation, analysis and dissemination of education statistics/data of their respective provinces/regions. These units usually collect data through their district EMIS cells by conducting the annual school census. The provincial data is transmitted to NEMIS for consolidation at the national level. AEPAM plays a coordination role in addressing crucial issues and problems arising with regard to the compatibility of questionnaires, statistical terminologies, data requirements for the development of core educational indicators, data discrepancies and inconsistencies, data reliability and validity and the timely availability of data.

[iii] **Gender Parity Index (GPI) of Enrolment:** This reflects girls' level of access to education compared to that of boys. In its crude form it is a ratio of girls enrolment to the boys' enrolment though it is also calculated for other educational indicators such as survival rate to grade five or dropout rate etc. A GPI of less than 1 indicates that there are fewer girls than boys in the formal education system. A GPI of more than 1 means that there are proportionately more girls enrolled as compared to the boys. A score of 1 reflects equal enrolment for boys and girls. It is calculated using the following formula;

$$\text{Gender Parity Index} = \frac{\text{Indicator Value for Girls}}{\text{Indicator Value for Boys}} \times 100$$

[iv] **Pupil-Teacher Ratio (PTR):** This is one of the most common indicators used in educational planning. A low number of pupils per teacher suggests that students will have a higher chance of contact with the teachers and hence a better teaching-learning process. This would also tend to indicate a more expensive education. This ratio is also used to measure the level of human resource input (teachers). Many planners also use this ratio for projecting the number of teachers required. It can be calculated by dividing the total number of pupils enrolled in a specific education level by the number of teacher at the same level.

$$\text{PTR} = \frac{\text{Total number of pupils enrolled in a particular education level}}{\text{Total number of teachers in same level}}$$

[v] **Survival Rate to Grade Five:** This is the proportion of a cohort of pupils who reached Grade 5 expressed as a percentage of pupils enrolled in the first grade of a given cycle in a given school year. This indicator is used to show the extent to which the school system can retain pupils, with or without repetition, and reflects the dropout rate. It is also used to measure the impact of dropout on internal efficiency. It is calculated by dividing the total number of pupils belonging to a pupil cohort who reached Grade 5 of primary education by the number of pupils in the original pupil cohort (i.e. those pupils who enrolled together in the first grade of primary education) multiplied by 100. Usually this indicator is typically derived using a reconstructed student cohort flow model. It requires the following data:

Number of students enrolled by grade for two consecutive years
Number of repeaters by grade in the second school year
Number of graduates (successful completers) in the first school year

Number of net transfer students (optional)

[vi] **Enrolment by Stage:** Enrolment by Stage defines the students enrolled in a particular class range irrespective of the official gender or level of the school. Two stages of education are discussed in this atlas i.e. "Primary Stage" (Class 0-5) and "Middle and Secondary Stage" (Class 6-12).
Middle and secondary stage is a super set of Middle Stage (Class 6-8), High Stage (Class 9-10) and Higher Secondary Stage (Class 11-12).

[vii] **Primary Schools:** A primary school is an institution in which children receive the first stage of education that is from class zero (Kachi) to class five. However, some primary schools also provide education till class eight (Middle Stage) or even higher.
[viii] **Elementary or Middle Schools:** In middle schools children receive middle stage of education. Most of the middle schools have primary stage and some also have a High stage.
[ix] **High Schools:** In high schools students receive education at High stage and most of the high schools have middle stage and some have primary stage too. Some of the high schools offer education till class 12 and are known as **Higher Secondary Schools.**

Note: The term "Middle and Secondary Schools" is a super set of Middle, High and Higher Secondary Schools.