APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS IN ARMENIA

OPPORTUNITIES FOR EXPANDED USE IN THE HEALTH SPHERE

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LIST OF ACRONYMS

AUA	American University of Armenia
B&W	Black and White
CDC	Center of Disease Control and Prevention
CTMY	Centre of Technology Management of Yerevan
CGC	"Centre of Geodesy and Cartography" SNCO of the State Agency of Real Estate Cadastre
CJSC	Closed Joint-Stock Company
DEM	Digital Elevation Model
Ecocenter	Center for Ecological Noosphere Studies of NAS
ECRC	Environmental Conservation and Research Center at the AUA
EMA	Emergency Management Administration Under the Government of RA
EIMC	Environmental Impact Monitoring Center
ESRI	Environmental Systems Research Institute
GIS	Geographic Information Systems
GPS	Global Positioning System
MEP	Ministry of Environmental Protection
MCH	Maternal Child Health
MoH	Ministry of Health
NAS	National Academy of Sciences
NPP	Nuclear Power Plant
PIU	Program Implementation Unit
PC	Personal computer
PHC	Primary health care
RA	Republic of Armenia
RH	Reproductive health
REDAM	European Project for Regional Development of Armenia
SNCO	State Non-Commercial Organization
UN	United Nations
USAID	U.S. Agency for International Development
UTM	Universal Transverse Mercator (Map Projection)
WB	World Bank
WHO	World Health Organization
WGS	World Geographic System

EXECUTIVE SUMMARY

Project NOVA, a USAID-funded technical assistance project, is presently engaged in activities to support the efforts of the Republic of Armenia (RA) to improve reproductive and child health services in rural areas. To achieve this, the Project utilizes various new approaches and technologies, one of which is the geographic information systems (GIS).

Although modern GIS technology, including software and powerful personal computers, has been available for at least a decade, most public health agencies world wide have not yet incorporated it into their routine practice. The situation is even worse in Armenia. Reasons surely include the skills and resources necessary for developing GIS applications. To uninitiated public health professionals, these requirements may appear needlessly complex and overwhelming.

Project NOVA uses GIS to map the network of more than 900 health care facilities in the Armenian health care delivery system and to better understand the relationships between the physical location of health care facilities and their performance.

This report is designed to stimulate interest in GIS technology by demonstrating to health officials how they can use it to improve their practice.

The particular issues discussed here are:

- Introduction to GIS and examples of its health related application;
- Current status of GIS in Armenia;
- Presentation of organizations implementing GIS tasks in Armenia;
- Recommendation of possible GIS applications in health sector for more effective analysis, decision making and planning purposes;
- Description of the Project NOVA-developed coding system used for communities and health facilities in Armenia, which supports data sharing and mapping activities and allows for the linking of different datasets into a unified information system. .
- A list of websites with useful GIS-related information.

The information provided here is based on different reports, publications, online resources and discussions with specialists from several organizations. This publication does not necessarily cover all existing GIS resources and organizations involved in health activities in Armenia.

1. INTRODUCTION

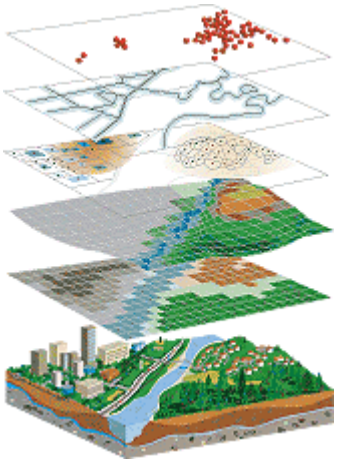
A Geographic Information System (GIS) is defined as an information system that is used to input, store, retrieve, manipulate, analyze and output geographically referenced data in order to support decision making and solve complex problems regarding the planning and management of resources [1].

GIS combines information about where things are with information about what those things are. It means that we can work with both attribute and spatial databases and manipulate spatially referenced data. The essential components of a GIS are as follows:

- Data acquisition,
- Preprocessing,
- Data management,
- Data manipulation and analysis and
- Product generation.

Based on the above components, GIS can be used to investigate questions about location, conditions, trends, routing and patterns of attributes. For example, a paper map – such as a health care facilities map – can show the location of the particular facility and inform us of the route to get there. However, a GIS can do that and much more. It can give us additional information such as the road length and type, or it could calculate the time it would take to travel from a particular village to that facility based on the time of day, quality of the road, the speed limits along that route and the amount of traffic expected at that time. Therefore, GIS differs from Computer Aid Design (CAD) and from statistical analysis system. Spatial analysis is useful also for evaluating suitability and capability, for estimating and predicting, and for interpreting and understanding.

Information is organized by layers in GIS. Each layer presents a specific type of feature or geographic object. Commonly these are points, lines, or polygons. Point layers can represent coordinates for health posts, hospitals or other small places on a map. Lines represent such things as roads, railroads and rivers. Polygons represent political and administrative boundaries, lakes, parks or other large areas. The layers provide a means to separate large amounts of graphic data into smaller groups that tend to be used together. They are linked to each other by the common coordinate system they share with the base map.



GIS layers example

GIS can combine many layers of information, for example:

- Demographic Data: *Births, Deaths, Diseases, Population*
- Infrastructure: *Buildings, Roads, Floor Plans, Nursing Units*
- Internal Data: *Patients, Utilization, Revenues*
- Facilities: *Hospitals, Ambulatories, Health Posts, Drug Stores*
- Administrative Boundaries: *Marz, Service Regions, Planning Areas*
- Environmental: *Topographic, Toxic Sites, Infectious Disease, Air and Water Quality Testing Sites.*

GIS can analyze this kind of data of one layer based on another layer, and display the information needed.

The above characteristics of GIS make it essential for health service and management given that the health service facility, immunization, demographics, health personnel, etc, have different geographically defined information [9].

1.1 GIS IN THE HEALTH SECTOR

In spite of its 30 year history, GIS only recently became used world wide. This may be attributed to the fact that creating a digital spatial database is a long and expensive process so organizations who have undertaken this process have only recently completed it. However, this process takes less time as more digital data becomes available. The development of geo-informational technologies also accelerates the process as does increased access to information via the Internet. The Internet also provides the opportunity for wide spread dissemination.

Most health and human service problems facing the world today exist in a geographic context and any analysis must consider that. Understanding issues ranging from medical epidemiology to healthcare access requires a comprehensive understanding of their geography. GIS is becoming a vital tool for scientists and public health officials investigating the cause and spread of diseases around the world. The globalization of infectious disease makes the use of GIS critical across the healthcare system in every national health ministry.

GIS uses the fact that most data sources collected for health, socio-demographic and environmental data contain some piece of information about the location to which the data refers. This locational information might be in the form of an address, postcode or grid reference or it might refer to a particular health facility, ward, region or marz. By knowing the relationships between the boundaries of these areas and the addresses or grid references within them we can relate data from many different sources to specific parts of our country.

GIS integrates common database operations, such as query and statistical analysis, with the ability to see how data relates in space and time. GIS-produced maps are useful for showing places and the events that occur there, like location of home-births or outbreaks of disease. GIS can analyze and visualize any system that is spatial. For example, GIS can map a patient's heart or brain; show a breakdown of diagnoses on a map of the body; or even indicate which beds on a hospital floor are occupied, for how long, and by whom.

GIS provides a common analytical framework in which public health authorities can understand problems and formulate a response, improving incident management and health planning. Using GIS for health organizations gives detailed and compelling answers to the difficult questions health care providers ask every day: Where is the disease coming from? How will it spread? Where the most often cases of home-births are? Where is the nearest hospital? What is the fastest route for the ambulance? Where should we allocate our funding?

The area of GIS in health rose to prominence recently with the recognition that health surveillance practices and health service allocations need to become more sensitive to the needs of people in local geographic areas. The collection, storage and manipulation of geographic information have undergone a revolution in recent years with the development and widespread availability of GIS software. Many health professionals can benefit from further education in this area, and with their new knowledge, they can influence the progress of health surveillance, environmental health assessment and the geographic allocation of health resources.

Improvements in the following areas contribute to the rapid adoption of GIS in health:

- Health information systems - the increasing availability of geo-coded health data;
- Availability of digital geographic files that contain layers of geographical information;
- GIS technology - inexpensive software is easier to use, contains increased functionality and runs on a wider range of hardware, including PCs; and

- Methods of spatial analysis are becoming available as separate software modules embedded in GIS.

A few real examples of GIS application in particular health sectors in the world are presented below.

1.2 SOME EXAMPLES OF GIS PRACTICE IN HEALTH ISSUES

Interactive Atlas of Reproductive Health

The Interactive Atlas of Reproductive Health is a web-based interactive geographic information system dedicated to reproductive health issues such as infant mortality, fertility, and low birth weight. The atlas provides viewers with access to a unique collection of geographic datasets that describe reproductive health indicators. Access to the reproductive health data is provided by an ESRI ArcIMS™ map server application developed at the CDC (http://apps.nccd.cdc.gov/gisdrh).

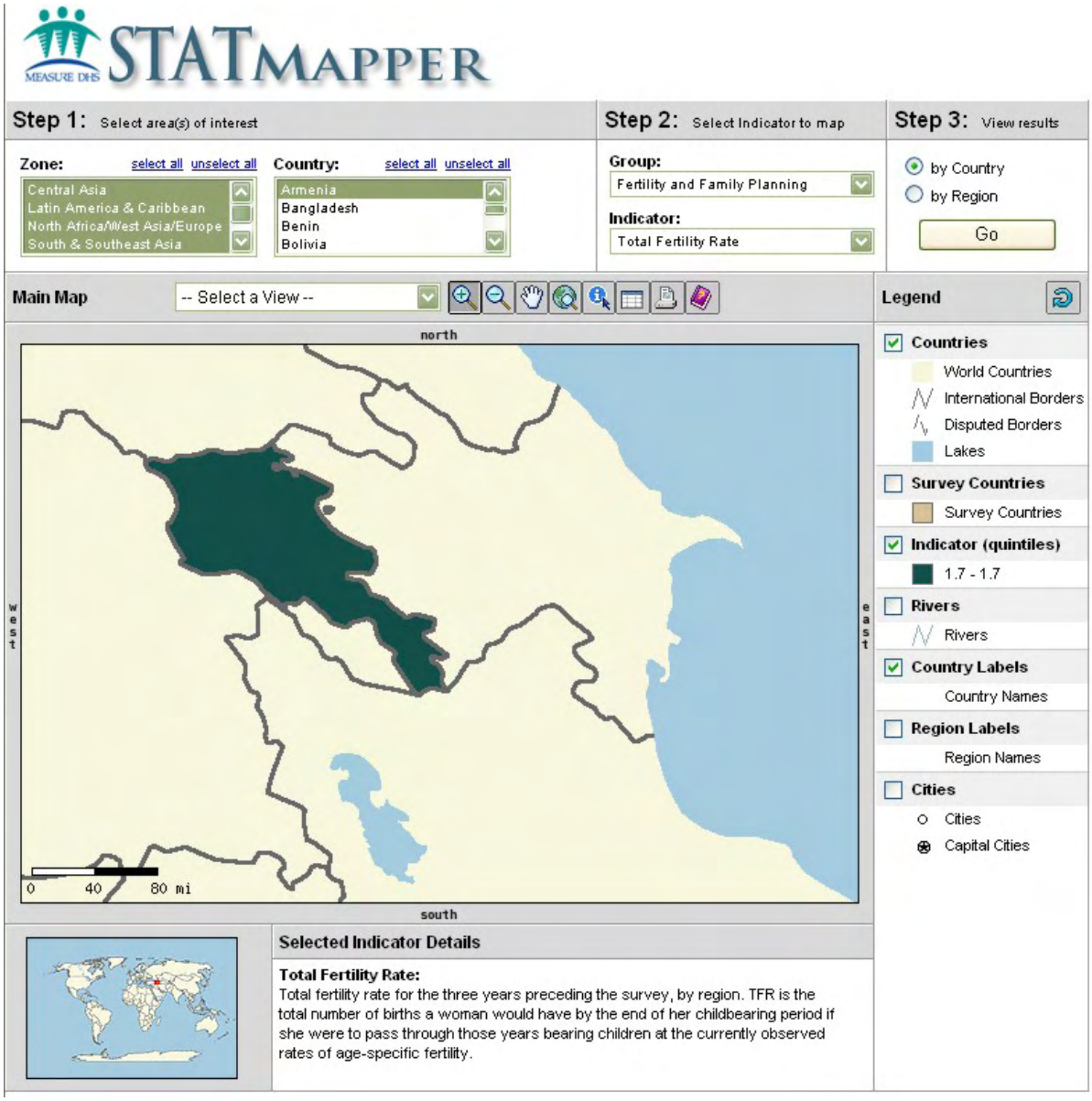
Interactive Atlas of Reproductive Health: Map Results

MEASURE DHS Project

The Demographic and Health Surveys (DHS) project is a global data collection effort funded by USAID and carried out by ORC Macro and in-country implementing organizations. The nationally representative DHS surveys collect data on demographic patterns, fertility, health, and nutrition for policy and program planning. MEASURE DHS disseminates data free of charge.

The new MEASURE DHS website displays international population and health data with just one click of the mouse. Users can create maps in seconds, download tables, display country profiles, and explore data from all parts of the world. With the new STATmapper and other enhanced features, the redesigned MEASURE DHS website makes finding worldwide health and population information faster and simpler than ever (http://statmapper.mapsherpa.com).

STATmapper, an interactive mapping application, allows users to create maps in seconds from a database of Demographic and Health Survey findings from more than 75 countries, including Armenia. Website visitors can use STATmapper to create a map of children's vaccination coverage in Kenya or households with access to electricity in Bangladesh. Visitors can produce maps of provinces within a country or compare multiple countries within and across continents, using major health and population indicators from the world renowned DHS project. A variety of information can be mapped, ranging from fertility rates to infant mortality to household characteristics like running water and possession of durable goods. Additional mapping elements such as road networks and population density will be added in the future.



Map of Total Fertility Rate in Armenia Created by STATmapper

Website users can download data tables to integrate into their own GIS. Users can also save maps as pictures for use in PowerPoint presentations or reports.

The Effect of Settlement Zones and Economic Diversity on Reproductive Behavior in West Africa

USAID's Regional Economic Development Services Office for West and Central Africa provided funding for the West Africa Spatial Analysis Prototype Project [12]. One of the goals of the Project's studies was to measure the relationship between reproductive behavior, settlement

zones and economic diversity in 12 African countries. The purpose of this study was to test the proposition that settlement zone and economic diversity affect reproductive behaviors, such as knowledge of family planning, use of family planning methods and demand for family planning. The settlement zone is measured by the rate of urbanization and the extent to which town and rural areas have become integrated. Economic diversity is measured by the number of different economic sectors operating in each administrative unit.

Comprehensive GIS analysis revealed some interesting results, a few of which are:

- Knowledge of any family planning method and knowledge of a modern method was highest in high growth areas and lowest in very low growth areas. This trend was found both in urban and rural areas.
- In addition, the overall knowledge of contraception was higher in urban areas then in rural areas.
- Results showed also that in areas of high economic diversity, knowledge and use of family planning was higher than in areas where the economy was dependent on a single sector.

The relationship of contraceptive knowledge and use to economic diversity suggested that economic development, especially industrialization in West Africa, likely has demographic implications.

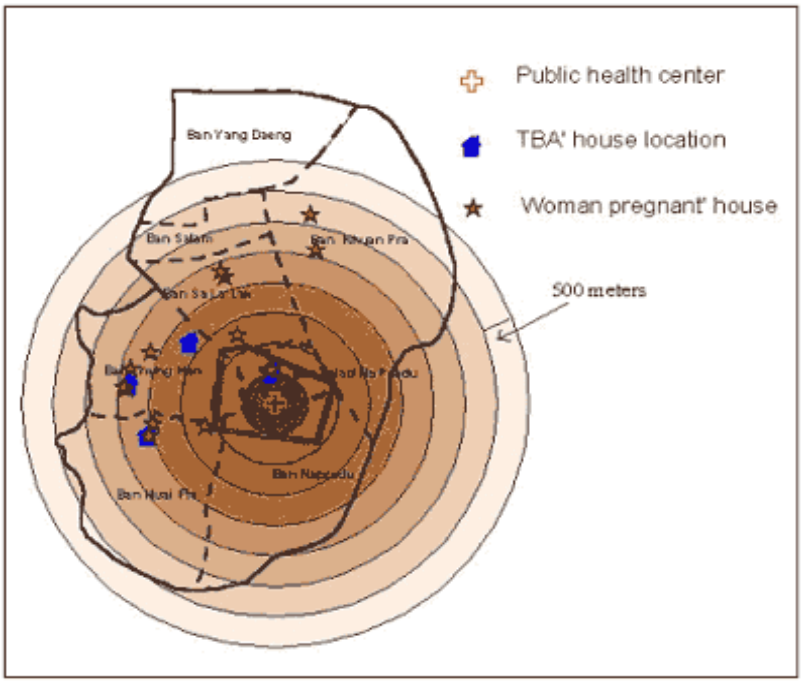
Analyzing and Planning Reproductive Health Services in Pattani Province, Thailand

The Pattani Provincial Public Health Office (PPHO) received financial support from the UN Population Fund AID to launch a pilot project on the application of GIS for analyzing and planning RH services in 2001 [11].

The short-term objective of the Project was to reduce the Infant Mortality Rate and Maternal Mortality Ratio by using GIS as a tool for analyzing and identifying clusters of houses of pregnant women who utilize Traditional Birth Attendants (TBA) services for delivery. The long-term objective was application of GIS technology and gaining the experience to develop RH plans as well as address other health concerns such as STI/HIV protection, family planning, adolescent reproductive health, health education and epidemiology for common and rare disease control.

GIS analysis has been used to develop a health plan to encourage pregnant women to deliver at the government hospitals instead of using TBA services. The GIS database was built and linked to the existing public health database.

The results revealed that most of the pregnant women in all villages practiced modern methods of family planning. Oral contraceptives were the most popular method used. The majority of pregnant women delivered in government hospitals or sub-district health centers. Results also revealed that Muslim



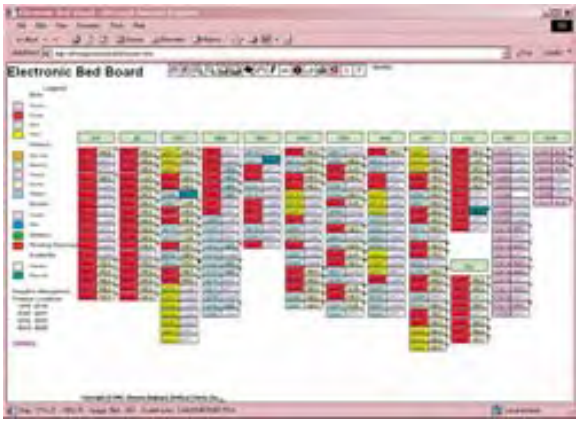
Locations of TBAs, Pregnant Women, and Tentative Service Area of TBAs

pregnant women who used the TBA's services had received lower education and came from the agricultural sector.

Based on the results of the pilot study, it was recommended that the Pattani PPHO should consider raising awareness on RH to these Muslim women and encourage them to use government services.

GIS in Hospitals

Hospital capacity changes continuously. Intensive Care unit occupancies fluctuate dramatically, dependent on staffing and physician availability. Knowing real-time capacities for emergency events is essential.



The screen pictured to the right provides an example of GIS linked to an internal Hospital Information System. With this application, the hospital care location of every patient is linked directly to the clinical events relevant to that patient.

Hospitals using GIS can report the exact status of every bed, allowing informed decisions about availability in emergencies. GIS also allows hospital management to see the physical location of each patient within the healthcare environment and to more efficiently allocate resources and speed up admission procedures.

Other Examples of GIS Application

The US Centers of Disease Control and Prevention, the world's premier disease-tracking organization, has used GIS for at least a decade to study how disease spreads from place to place and to study how toxic substances affect people's health.

The US Dartmouth Medical School uses GIS technology to show how the amount and type of health care services Americans receive depend greatly on where they live – on both the capacity of the health care system and on the methods practiced by local doctors. Differences in how often hospitals are used, variations in how care of the terminally ill is delivered, and patterns of elective surgery raise important questions about the consequences and value of health care.

John Snow Inc. (JSI) was contracted for the initial phase of a geo-mapping project for Colorado Community Health Network in 2002. JSI created a relational database consisting of current safety net dental and physical health provider locations, patient population demographics, and potential dental and physical health marketplaces. The project allows for the integration of future data sets reflecting marketplace changes over time.

Health planners use GIS to assess how well patients are served by doctors and staff at any individual site, and determine the distance patients had to travel to receive services. Knowing which services different populations typically need, and how far away the services are, health planners can use GIS to anticipate demand for any particular service. Health planners also use GIS to evaluate marketing programs, make decisions, and determine how best to allocate health services. The maps they create may help them see, for example, where there is room for a new facility.

Building contractors use GIS to help health care companies decide where to locate new clinics and decide the appropriate size for those facilities in order to serve everyone well.

2. GIS IN ARMENIA

Armenia is in the beginning stage of developing geo-informational systems, with only the most common and small-scale maps digitally available. Only a minor part of available information is maintained in standard electronic tables and GIS-supported databases.

Public information is limited to items published in the press and Internet. Permission from Officials at appropriate levels is required for access to the archival information of various ministries, agencies, and institutions. In some cases the use of archive materials requires a fee.

The legislative framework of the Republic creates another obstacle for GIS development in Armenia. RA laws "On Geodesy and Cartography" and "On State and Service Secret" regulate the use of the topological, geodesy and cartographical data. According to these laws, all maps with a scale larger than 1:50,000 are considered "confidential", and with a scale larger than 1:100,000 are considered "for official use". In accordance with the Government Decrees "On the Procedure of Getting a Permission for Use of Topo-Geodesy Data and Materials Containing State and Official Secret" the State Committee of the Real Estate Cadastre has sole right to issue permission. The permit is needed for the use of any data, including non-confidential topological-geodesy and aero-spatial information. The provision of topological-geodesy, aero-spatial and other cartographical information is implemented by the Committee on paid basis. All these data are free and non-confidential in many other countries.

Despite these obstacles, Armenia is taking steps to improve access to such information. The Government of Armenia adopted the "Concepts for Development and Management of GIS for Republic of Armenia" on January 20, 2005. The document defines the responsibilities of GIS development in Armenia, including the standards, base maps, layers, and scales, as well as the timeline of the designed works. According to the adopted work plan, the digital base maps will be developed during 2005-2007, and finalization of the overall Geographic Information System of Armenia is anticipated by 2014.

However, community governments, the basic providers of information, do not have the opportunity to use GIS. Only the municipalities of Yerevan and Gyumri cities have their own special GIS departments. A project for Yerevan city GIS is under development now in the Centre of Technology Management of Yerevan Municipality. With the support of USAID, within the framework of the project for community government development, eight specialists from Seismic Protection National Service, "Stability and Development" NGO and city government, were trained in Moscow and Dubna and consequently established the Gyumri GIS Center. It is currently developing a project for elaborating Gyumri city GIS.

Yerevan State University provides some GIS courses in the Departments of Geography and Biology. American University of Armenia also conducts a few GIS trainings. But mostly GIS is not used in the universities of the country, due to a shortage of funds and specialists, as well as a lack of understanding of the importance of the issue.

The list below summarizes a few institutions that use GIS and have resources which can be useful for health-related GIS analysis in Armenia

- Centre of Geodesy and Cartography of the State Agency of Real Estate Cadastre
- Environmental Impact Monitoring Center of Ministry of Environmental Protection
- Center for Ecological Noosphere Studies of National Academy of Sciences
- Emergency Management Administration Under the Government of RA
- Environmental Conservation and Research Center at the American University of Armenia
- USAID Project NOVA

- TACIS / European Project for Regional Development of Armenia
- MedInfo Computing Center
- GeoRisk Scientific Research Company
- GeoCom Ltd
- BroncoWay.

A brief overview of each organization and their activities are presented in Appendix A.

2.1 HEALTH RELATED APPLICATIONS OF GIS IN ARMENIA

Applications of GIS technologies in the health sector of Armenia are very rare. A few organizations having related experience are presented bellow.

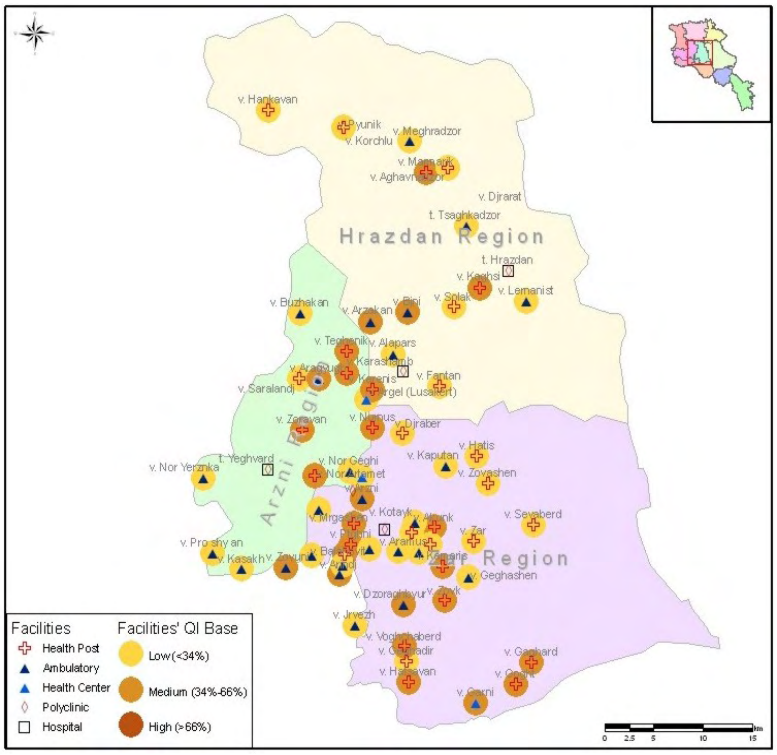
National Health Information Analytic Statistical Center is the structural unit of the National Institute of Health and was established according to the Government Decision No1747 dated on 21.11.2005. Functions of the Center include:

- Development and implementation of the "National Program on Enhancing the Health Information System";
- Development of Regional Information System models and infrastructure;
- Harmonization of the Health Information Statistical System with the international regulations, classifications, norms and rules;
- Collection and analysis of important health indicators; information provision to the health system and other institutions;
- Evaluation and monitoring of the population's health status, monitoring of services and resources, special research in common health and health care problems;
- Participation in the process of health system reform, development of policies and strategies, participation in organization of preventive measures and development of modern public health models.
- Provide consultation and methodical assistance to health facilities;

National Health Information Analytic Center collects and analyzes the State Medical Statistics and medical-sanitary information from health facilities. It has a detailed information on morbidity in Armenia (according to International Classification of Diseases X) stored in DOS-based databases. Currently they are using EpiInfo for analysis and specifically EpiMap for mapping purposes. Some specialists of the Center have experience in using GIS in health-related research and recognize the capability and effectiveness of GIS for such tasks. They have mentioned also the importance of using GIS for evaluation and monitoring purposes. Unfortunately, the lack of resources and trained specialists is an obstacle for practical application of geo-information systems in the Ministry of Health and in the National Health Information Analytic Center in particular.

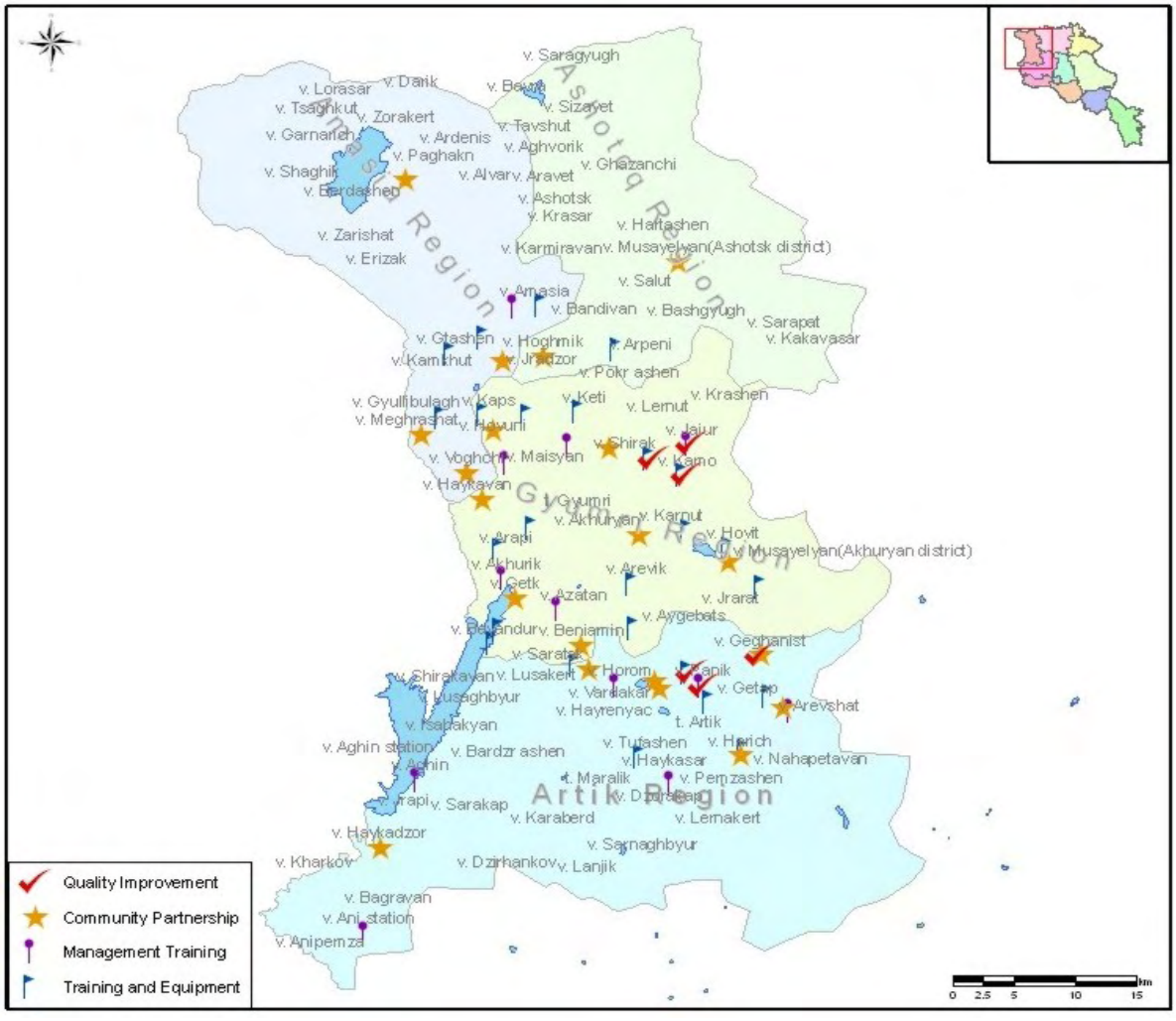
Project NOVA is working with the MoH to improve the quality of reproductive health and maternal and child health care services through improving RH/MCH knowledge and clinical skills for rural PHC providers; and providing basic PHC medical equipment and supplies; developing the capacity of regional health managers to improve the management and supervision of rural facilities; accelerating the momentum of reform in the health delivery system to be more responsive to the reproductive and child health needs of the population; and increasing consumer demand for high-quality RH/MCH services through community education and mobilization activities.

Since neither the Ministry of Health nor any other health agency has a proper coding system for health facilities. Project NOVA developed a special coding system, which can be shared with other interested parties. The proposed coding system provides an opportunity to combine/link different datasets into one unified information system, to share and exchange data with other organizations using the same coding system, as well as to promote GIS mapping activities. A brief description of the applied coding system is presented in Appendix B.



Map of Health Care Facilities Quality of Index in Kotayk

Project NOVA uses GIS to map the network of more than 900 health care facilities in the Armenian health care delivery system and to better understand the relationships between the physical location of health care facilities and their performance.



Map of Project NOVA Interventions in Shirak

Using ESRI ArcGIS software, the following maps were developed and are available on the project website (http://www.nova.am/eng/gis.php):

- Satellite picture and map of South Caucasus
- Activity areas of the Project
- Marzes and communities of Armenia
- Communities by population size
- Health Care Facilities by type
- Primary Health Care Administrative Network
- Health Post/Center Quality Index in Lori, Shirak and Tavush marzes
- Project NOVA interventions by types

These maps are geo-referenced and linked to the Project database system and provide extensive of information collected during different activities of the Project. Some of the mentioned maps were converted into HTML using HTML Image Mapper software and presented as interactive online maps on the Project's website.

The **MedInfo Computing Center,** established in 2002, developed various health information systems, including GIS. Some of the projects implemented by the Center's specialists in Armenia are:

- Infection Diseases Surveillance System ("IDS") software created for MoH by the support of WHO. The system provides aggregated Infection Diseases data collection, data exchange between different administrative levels, data analysis in text (table), graphical and GIS mapping, evaluation and managerial possibilities.
- Immunization Information Standard System. The system provides aggregated immunization data collection, data exchange between different administrative levels, data analysis in text (table), graphical analysis, GIS mapping, evaluation and managerial possibilities.
- Poverty Data Presentation System with GIS Mapping and Graphics Data Processing developed in the scope of World Bank supported Poverty Reduction Strategy Project. The system provides aggregated Poverty data analysis and presentation in graphical and GIS mapping formats.

Geographic information system is included in majority of health information systems created by Medinfo. GIS is used as a visual presentation tool and for showing spatial distribution of studied objects.

A few other organizations implementing various GIS tasks are presented in Appendix A, including a list of maps and GIS layers available.

CONCLUSIONS AND RECOMMENDATIONS

Armenia is at the beginning stage of GIS application in different spheres. In health service and management, health databases are used as feature attribute data without any spatial information. GIS could be considered to use maps, which are correlated to various health information systems.

The following deficiencies and obstacles to proper development of geographic information systems in Armenia were revealed during composition of this report:

- Spatial information is limited and mostly not available for the public. Special permission is required to access the information kept in the archives and libraries of various ministries, administrations and institutions.
- There is no information about data availability. In some cases, data are stored in the archives of an organization about which the staff of the organization are unaware.
- The poor quality and high cost of the Internet in Armenia does not allow the retrieval of information from the web.
- Most of the existing spatial datasets have no Meta information and their reliability is uncertain. Layers are usually digitized from paper maps and have no properly filled attribute information.
- No specified GIS standards exist among Armenian GIS users and each organization has its own criteria. For example, some develop digital maps using international projection system WGS84, while others use Pulkovo 42, which comes from the Soviet system.
- Usually no collaboration takes place between companies and they are not willing to share information.
- Most of the modern GIS software is very expensive.
- Lack of qualified specialists and advanced equipment.
- There are very few GIS courses in the post-graduate education and they are not offered on the regular basis.

Several other barriers and deficiencies certainly effect the development of GIS in Armenia as well.

One may consider three options in using GIS for health management in Armenia.

Desktop GIS by which, maps and attribute data are used by implementing appropriate software. This system can be used individually or by a group by installing the GIS on their computer.

Workstation GIS, by which maps and attribute data are stored in a server computer and users are able to use a software map and data processing from their computer via a local network.

An enterprise GIS can be established to coordinate the system more efficiently by using Web-based GIS. This sort of GIS uses the World Wide Web as a platform to access the map and related attribute data. This is a new well-developed GIS tool and can be used as a powerful enterprise GIS.

Some benefits of web-based CMS applications are as follows:

- Allows non-technical users to easily update the web
- Ensures that users do not access secure areas
- Monitors updates prior to publishing
- Remains up-to-date for the web content

- Allows users to customize viewing contents
- Presents the web in the local language

However, preparing thematic maps and related attribute data is the main problem in establishing an enterprise GIS. This is a more difficult task in developing countries, including Armenia, and becomes more problematic when the enterprise GIS is for health service and management [10]. Maps and spatial data sources, traditionally, are not used in this section. The limited map resources available in other governmental organizations can be used as basically thematic maps for MoH. Some other maps should have been prepared working in the field using GPS devices.

In conclusion, the development and integration of a GIS in Armenia's health sector is an important step for proper and effective health care management and planning. For its contribution several activities are necessary to implement, particularly:

- Increasing awareness of health officials on GIS capabilities and applications in health issues;
- Providing at least one copy of the ArcGIS basic package and GPS device to the MoH for training purposes and future GIS activities.
- Taking into consideration the high prices of modern GIS software it is worth looking for open source / free GIS software as well, like GRASS, HTML Image Mapper, Map Server, OpenEV, etc.
- Conducting training for the health officers in the concepts of mapping, GIS, and the use of GPS in health surveys. Conducting more advanced GIS training for IT specialists working in the MoH.
- Studying GIS international experience and its suitability in the Armenian context

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APPENDIX A: ORGANIZATIONS IMPLEMENTING SOME GIS TASKS

GOVERNMENTAL ORGANIZATIONS

Center of Geodesy and Cartography of the State Agency of Real Estate Cadastre (CGC)

Address: 35/2 Komitas str., 375051, Yerevan, Armenia
Phone: (374-10) 255829
http://www.armgeokart.am

The organization was set up in 1973 by the Central Board of Geodesy and Cartography of the Council of Ministry of the USSR. It was transferred from the Ministry of Urban Structure to the State of the Committee Coordination of the Real Estate Cadastre of the Government of the RA as a “Center of Geodesy and Cartography” SNCO in September 2000, by the resolution of the Government.

The subject and goals of the CGC are implementing activities in the system of geodesy and cartography of the RA, particularly creating state and national plan and high – altitude geodesic nets, topographical and thematic maps of the state significance, refreshing normative, technical documents, as well as activities related to treatment of standards and creation of geological – inquiry system, tools and equipments.

RA conception of GIS was processed by the CGC, and adopted by the resolution N197 of the Government of the RA on January 20, 2005. Now the Center is carrying out the project on creating GIS for the governor bodies of the Republic.

The Center is working currently on the development of digital base map of Armenia of the scale 1:10,000. The anticipated date of completion of the work is 2006. The layers are created using Pulkovo 42 projection and MicroStation software.

The CGC does some generalization and exception of strategic and secret objects for sale or publication proposes.

Qualified and experienced 184 specialists are employed at the organization. The CGC is equipped with contemporary accurate geodetic tools, satellite survey stations, GPS receivers, tachymeters, theodilites, Digital level NA 3003-2, Laser range-finder Disto-2, plotter, A0 format scanner, Scanner Leica DSW 600.

The following software packages are usually used: MicroStation, AutoCAD, PCL, Geomatica, Corel Draw, Arpac, Geographics, Socket Set Orima, and ArcGIS 8.

Table 1: Maps available at "Centre of Geodesy and Cartography" SNCO

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Digital Base Map of Armenia (all topological layers)	Vector (MicroStation)	1:10,000	Part of Armenia
Topological Maps of Armenia	Paper	1:10,000 - 1:1000000	Armenia
Map of Yerevan	Paper, Vector	1:2000 1:5000	Yerevan
Settlements of Armenia	Paper	1:2000 1:5000	Armenia
Cadastral Digital Maps	Vector	1:500- 1:10,000	229 communities

Environmental Impact Monitoring Center of Ministry of Environmental Protection (EIMC)

Address: 29 Komitas str., 375012, Yerevan, Armenia
Phone: (374-10) 261602
Website: http://www.eimc.am

EIMC implements water, air and soil quality monitoring in Armenia.

In frame of technical support during the USAID project on Water Management in South Caucasus implemented by Development Alternatives Inc EIMC was supplied with GPS receivers, and GIS software. Several training courses were conducted for technicians of EIMC.

The EIMC currently has a few GIS trained specialists. They use ArcView 8.3 (single user license) and OCAD 7.0. The Center maintains 2 Garmin eTrex Summit GPS receivers.

EIMC presents maps of air pollution, water quality in Yerevan city in their bulletins.

Table 2: Maps available at Environmental Impact Monitoring Center

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Map of Armenia	Vector (OCAD)	1:1000000	Armenia
Locations of Water Quality Monitoring Points	Shape	1:500,000	Armenia
Map of Yerevan	Vector (OCAD)	1:25,000	Yerevan
Air Pollution in Yerevan	Vector (OCAD)		Yerevan
Yerevan from Space	Raster (JPG)	1m x 1m	Yerevan

Center for Ecological Noosphere Studies of National Academy of Sciences (Ecocenter)

Address: 68 Abovian str., 375025, Yerevan, Armenia
Phone: (374-10) 569331
E-mail: ecocentr@sci.am
http://www.sci.am/view.php?lang=1&Class=0&SubKey=1&docID=3&instid=14

The Center for Ecological-Noosphere Studies was founded by special governmental decree in 1989 as a principal research organization carrying out fundamental and applied studies in the field of ecology and environmental protection. The Ecocenter unifies a number of laboratories and individual researchers sophisticated in the field of ecological studies. Ecocenter supplied with modern laboratory equipment including Atomic Adsorption Spectrometer Analyst 800, HACH Spectrophotometer DR/2400 and some mobile devices.

Multidisciplinary investigations carried out at the Ecocenter are oriented at the complex assessment of the territory ecological state and elaboration of scientific-methodical fundamentals of ecological expertise, optimization of nature management processes.

The Ecocenter carries out interdisciplinary investigations in the field of human ecology. In particular, joint programs in co-operation with the National Institute of Health, the Armenian Institute of General Hygiene and Occupational Diseases have been elaborated.

In cooperation with WS Atkins Environment Firm (UK) Ecocenter participates in Armenian Nuclear Regulatory Authority's project "Mapping and GIS of radioactive pollution in case of emergency on NPP site".

In cooperation with NATO within South Caucasus Rivers Monitoring Project Ecocenter implements water quality studies from 13 observation points in Armenia. As a result they have developed MS Access database linked with spatial layers.

About 7 GIS specialists work in the Center. They use ArcView 3.2a, ArcInfo 6.5, ArcGIS 9, Spatial Analyst and 3D Analyst Extensions for ArcView 2.0, ERDAS 8.4, and Image Analyst. Some of the developed maps mentioned in the Table 3.

Currently the Center maintains HP DesignJet 500 Plotter (A1 format), A3 format scanner, Magelan Gold GPS receiver.

Table 3: Maps available at Center for Ecological Noosphere Studies of National Academy of Sciences

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Layers of topological map of Armenia	Vector	1:500,000 1:200,000	Armenia
Layers of topological map of Armenia	Vector	1:100,000	70% of the total area of Armenia
Layers of topological map of some marzes of Armenia	Vector	1:50,000	Some marzes
Yerevan	Vector	1:10,000 1:25,000	Yerevan
Elevation	DEM	1:10,000 (with 10m interval)	Yerevan
Land cover	Raster	8m x 8m	Area of Armenian Nuclear Power Plant
Land cover	Raster		Northern marzes of Armenia

Emergency Management Administration under the Government of RA (EMA)

Address: 25 Pushkin str., 375010, Yerevan, Armenia
Phones: (374-10) 539749, 530797
http://www.ema.am

The EMA RA works out and pursues the RA Government policy in the sphere of population and economic objects protection in emergency situations and martial law. The EMA tasks include:

- Implementation of joint state policy in the spheres of civil defense and population protection in the emergency situations.
- Organization and implementation of rescue, accidental rescue, urgent accidental-reconstruction and fire extinguishing works.
- Coordination and monitoring of the activities of state governing bodies, local authorities, organizations on the questions of civil defense and population protection in the emergency situations.
- Implementation of information reception, summarization and decision processing works to solve the problems connected with civil defense and population protection in emergency situations.
- Organization and implementation of emergency situation prevention and consequences elimination activities as well as the study of phenomena causing emergency situations within its competency.

The EMA has 2 GIS specialists, ArcView 3.2, ArcView 8.3, 3D Analyst and Spatial Analyst Extensions software and A3 format scanner.

In GIS tasks EMA collaborates with GeoCom Ltd (see the “Private Companies” section).

INTERNATIONAL PROJECTS / ORGANIZATIONS

Project NOVA

Address: 7 Aygedzor str., Yerevan, Armenia
Phone: (374-10) 274125
http://www.nova.am

In October 2004, USAID awarded Emerging Markets Group together with IntraHealth International and Save the Children a contract for a 5-year program to improve reproductive health and maternal and child health care in rural areas throughout Armenia. Project NOVA scales up the approaches and strategies to the national level, and places greater emphasis on sustainability and capacity building of national institutions.

Project NOVA is using ArcGIS 9.1 software to map the network of health care facilities in Armenia and to present the relationships between physical location of health care facilities and their performance.

Table 4: Maps available at Project NOVA

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Marzes	Vector	1:500,000	Armenia
Communities		1:200,000	
Regions		1: 500,000	
Health Facilities of Armenia		1:200,000	
Rivers		1: 500,000	
Lakes		1:500,000	

Environmental Conservation and Research Center of the American University of Armenia (ECRC)

Address: 40 Marshal Baghramian ave., 375019, Yerevan, Armenia
Phone: (374-10) 512692
http://www.aua.am/aua/research/ecrc

Established in 1992, the Environmental Conservation and Research Center conducts research into conservation, ecology, environmental contamination, and sustainable development in the Republic of Armenia, and serves the community through education outreach programs and collaboration with local scientists and organizations.

In 1998, ECRC used its GIS resources to produce the State of the Environment Report for Armenia in cooperation with the Ministry of Environmental Protection. The report was prepared for the United Nations Environmental Program as part of their Global Resource Information Database.

Current GIS based projects developed at ECRC include:

- mapping of metal contamination in the air, water, and soil in industrial and mining regions as well as the capital of Yerevan
- assessing the environmental and health risks of trace element contamination
- creating an information system for the Khosrov State reserve
- mapping surface water resources and conditions throughout Armenia

- mapping Sevan National Park.

ECRC has been involved with research projects in collaboration with the University of California at Santa Cruz, the Institute of Geosciences in Armenia, and Johns Hopkins University in order to assess the environmental impact and public health threats of toxic metals contamination in Armenia's air, soil, and water. These projects were externally funded and have provided the only current and accurate information about metals in the Armenian environment.

Recent efforts have included Primary Health Care component (including needs assessments and trainings) of the Humanitarian Assistance Program to Nagorno Kharabakh in collaboration with AUA Center for Health Services Research and Development and Fund for Armenian Relief.

Another health related project implemented by ECRC was the estimation of hazards from lead contamination in Yerevan. 1131 soil samples were measured using an x-ray fluorescence spectrum analyzer. Results were calibrated against 3 international soil standards and a blank was measured to determine the detection limit.

ECRC has used its GIS capabilities in a variety of projects including described above and in preparation of the State of the Environment Reports for Armenia in 1998 and 2000. These reports were prepared in cooperation with the Ministry of Nature Protection and incorporate extensive use of thematic maps prepared by ECRC.

1 GIS specialist is currently working in the ECRC. They use ArcView 3.2, ArcView 8.1 software packages and HP DesignJet 750C Plus Plotter (A0 format), Digitizing table (1.8mx1.2m), GPS receiver.

Most of the maps in ECRC during 1998-2000 were created without geo-referencing (Appendix A, Table 5). They have not meta-data and there is no information on the scales and base sources.

Table 5: Maps available at Environmental Conservation and Research Center at the AUA.

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Regional	Vector		South Caucasus
Administrative Divisions			Armenia
Physical Map			
State Reserves and National Park			
State Reservations			
Natural Habitats			
Number of Endemic, Rare and Endangered Plant Species			
Distribution of Some Threatened Reptile and Mammal Species			
Wetlands			
Forests			
Soil types			
Geological			
Land use			
Mineral resources			
Key water bodies and rivers			
Average annual precipitation			
Hydrological			
Water quality			
Water shortage areas			
Lake Sevan Basin			Lake Sevan Basin
Sevan National Park			

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Concentration of copper in rivers			Areas of Kapan copper deposit
Yerevan		1:15,000	Yerevan
Concentration of zinc in rivers			
pH levels in rivers			
Concentration of copper in vegetation			
Concentration of zinc in soil			

TACIS / European Project for Regional Development of Armenia (REDAM)

Address: 14/1 Ghazar Parpetsi str., 375020, Yerevan, Armenia
Phone: (374-10) 532076, 530538
E-mail: info@eu-red.am
http://www.eu-red.am

REDAM is an initiative of the European Union's TACIS Program for Armenia which seeks to support the socio-economic development of the Marzes. To achieve this objective, REDAM strengthens the service delivery capabilities of the Marzpetarans and the local government, foster partnerships among all development actors within the Marzes, and mobilizes citizens to maximize their participation in the development of their communities. During its initial phase (2004-05), REDAM has concentrated its activities in two Marzes: Ararat and Vayotz Dzor.

REDAM helps the Marzpetaran and local governments of each Marz to create a computerized and highly integrated regional information management system which will facilitate all administrative functions related to the delivery of public services. This system will also enable smooth information delivery to citizens via Community Information Centers which will be established in the municipalities of each Marz.

The following GIS activities are undertaken:

- GIS has mainly been used as a supporting tool in the socio-economic analysis - for spatial analysis of data in two marzes of Armenia - Ararat and Vayotz Dzor.
- An interesting work has been accomplished using Model Builder in Spatial Analyst extension - to assess lands suitable for growing of apple trees, pear trees, grapes, tomatoes, walnut trees and peach trees in the above - mentioned marzes. As a result, a land suitability map has been produced for each product.

REDAM has 1 GIS specialist. During their GIS activities they have used ArcGIS 8.2, ArcView 3.2 with Spatial Analyst Extension, ENVI 4, ERDAS Imagine 8.7 software packages and HP DesignJet 500 plotter (42").

Table 6: Maps available at TACIS / European Project for Regional Development of Armenia

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Community boundaries	Vector	1:10,000	Ararat and Vayotz Dzor marzes
Roads		1:100,000	
Contures (20 m interval)		1:100,000	

PRIVATE COMPANIES

GeoRisk Scientific Research Company

Address: 24a Marshal Baghramian Ave, 375019 Yerevan, Armenia
Tel: (374-10) 526517
E-mail: georisk@sci.am
http://www.georisk.am

GeoRisk Scientific Research CJSC is a company registered in Armenia in 1998 and specialized in providing professional consultancy and research in the fields of remote sensing, geology, assessment of natural hazards and their environmental impacts. GeoRisk has performed studies supported by the NSF, NATO, INTAS, PICS and ISTC international grants, as well as by Eurasia Foundation. The Company has performed researches in the territories of Armenia, Nagorno-Karabakh, Iran, Cyprus, Sri Lanka, Turkey, Lithuania, Greece, France and Italy. GeoRisk largely applies GIS technologies in its works and have gained experience in GIS.

Currently the staff of the Company is about 30 specialists who work on MapInfo Professional, IDRISI Kilimanjaro, ArcView 8.1, AutoCAD software packages. GeoRisk maintains several GPS receivers and a large format plotter.

Table 7: Maps available at GeoRisk Scientific Research Company

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Land cover	Landsat 7 ETM+	15m x 15m (color and B&W)	Armenia
Land cover	Landsat 5 TM	30m x 30m (color)	
Land cover	Spot	10m x 10m (color)	
Land cover	Quickbird	60 cm x 60 cm (B&W)	Yerevan
Air photos	Raster (TIFF)	B&W	Armenia
Topo / contours	Vector	1:50,000	
Topo / contours		1:10,000	Yerevan
Landslide		1:50,000	Armenia
Forestry			
Settlements with population		1:50,000	
Water supply distribution network		1:10,000	
Dams		1:50,000	
Springs		1:50,000	
Rivers		1:50,000	
Groundwater aquifers			Sevan & Yerevan
Lake profile			Sevan
Soils	Raster	1:50,000	Armenia
Elevation	DEM	1:500,000	Armenia

GeoCom Ltd

Address: 10 Pushkin str., 375036, Yerevan, Armenia
Phone: (374-10) 564504
http://www.geocom.am

GeoCom, ltd is committed to providing up-to-date GIS solutions to state and local authorities, as well as for private businesses in Armenia.

GeoCom, ltd is involved in a few of projects one of which is creating a 3D model of Armenia using 1:200,000 scale topographic maps.

The GeoCom Ltd. currently maintains ArcView 3.2, ArcView 8.3, 3D Analyst and Spatial Analyst Extensions, A3 format scanner, GPS receiver and about 6 GIS specialists.

Table 8: Maps available at GeoCom Ltd and Emergency Management Administration

Title/Layer	File Type / Paper	Scale / Resolution	Footprint
Road and Railway Network of Armenia	Vector	1:200,000	Armenia
		1:50,000	
Objects (restaurants, road signs, etc) located near the road network of Armenia		1:200,000	
Populated places with English names and Census data		1:200,000	
Settlement boundaries of Armenia, including marz boundaries		1:200,000	
Settlements of Armenia		1:50,000	
Boundary of Armenia		1:100,000	
		1:50,000	
River network of Armenia		1:200,000	
		1:50,000	
Boundaries of main river basins		1:200,000	
Reservoirs		1:200,000	
Volcanoes		1:200,000	
Mudflow gorges		1:200,000	
Landslides		1:200,000	
Digital Elevation Model of territory of Armenia	DEM	1:200,000	
Community Boundaries of Ararat and Vayotz Dzor Marzes	Vector	1:50,000	Ararat and Vayotz Dzor
Soil Map of Vayotz Dzor and Ararat	Vector	1:100,000	
Digital Elevation Model of Ararat and Vayotz Dzor Regions	DEM	1:100,000	
Digital Elevation Model of Akhuryan River Basin	DEM	1:25,000	Akhuryan River Basin
Digital Elevation Model of Yerevan	DEM	1:10,000	Yerevan

MedInfo Computing Center

Address: 80 Hanrapetutian str., Yerevan, Armenia
Phone: (374-10) 528336

The center was established in 2002. General activities of Medinfo Computing Center cover design, developing and implementation of Information systems with graphic and GIS mapping systems in the different organization and companies. Besides of common computing and design works the Center implements also design, development and application of Medical and Biostatistical Information Systems. Medinfo Computing Canter has developed such systems not only in Armenia, but also in many other countries, including Denmark, Portugal, some Asian countries, etc.

Geographic information system is included in majority of health information systems created by Medinfo. GIS is used as a visual presentation tool and for showing spatial distribution of studied objects. For those purposes specialists of MedInfo use ArcView and EpiInfo software packages. Medinfo has licensed version of ArcView 9.0, a few GPS devices, GIS specialists as well as programmers who are using C++ and Pascal programming languages to create user friendly and independent computer programs for final users. Usually they provide also training courses for those programs.

Broncoway LLC

Address: 2 Arshakunyats str., Yerevan, Armenia
Phone: (374-10) 527480
http://www.broncoway.am

Broncoway LLC is an IT company, committed to serving businesses worldwide in need of IT outsourcing and offshore development. It has operations in Armenia and representatives and partners' network in the US and EU.

At the core of Broncoway lies the concept of unique co-sourcing (outsourcing) model for product development in the following areas: software development (in the areas of Client/Server, Desktop, Networking, VoIP, Finance and Banking, Security, Mobile, Embedded and Custom Applications), hardware and IC design.

BRONCOGIS, the portfolio company of Broncoway, offers services in Geographical Information Systems and Remote Sensing in the fields of Environment, Conservation, Water Resources Management, Tourism and Business. Capitalizing on the experience and technological capabilities of Broncoway, BRONCOGIS delivers high-quality, complete cycle GIS services from client needs assessment, system design, analysis to end-user training. Their GIS team works with both industries standard GIS applications adhering to the internationally adopted GIS practices and methods.

APPENDIX B: PROJECT NOVA'S CODING SYSTEM FOR THE COMMUNITIES AND HEALTH FACILITIES IN THE RA

Having a unique identifier for each community and health facility is essential for effective information system. The coding system of communities and health facilities is necessary for proper database development, data sharing processes, and data analyses.

Project NOVA' research demonstrated that there is no unified coding system used by the Ministry of Health of RA or by other health agencies. Therefore, Project NOVA developed a coding system. The proposed coding system provides an opportunity to combine/link different datasets into one unified information system, to share and exchange data with other organizations using the same coding system, as well as to promote GIS mapping activities.

The comprehensive list of communities presented in the RA Population Census official results (http://docs.armstat.am/census/pdfs/11.pdf) was used for the development of the coding system. The marzes and communities in the list are presented in the alphabetical order according to the Armenian alphabet, which determines the official spelling of the name, consequently determining the identifiers (IDs).

Coding of the Communities

Community IDs (codes) are constructed according to the following scheme:

Digit Meaning	Marz ID		Sequential Number of the Marz Community of that Specific Type			Type ID
Number of Digits	1 or 2		3			1
Code	x	x	x	x	x	x

Where the marz IDs are:

ID	Marzes
0	Yerevan
1	Aragatsotn
2	Ararat
3	Armavir
4	Gegharkunik
5	Lori
6	Kotayk
7	Shirak
8	Syunik
9	Vayotz Dzor
10	Tavush

and community type IDs are:

ID	Type
0	Capital
1	Marz Center
2	Other city / town
3	Village
4	Community

For example the Code of the city of Vanadzor will be: 5 001 1:

Code Meaning	Marz		Sequential Number of the Marz Community of that Specific Type			Type
Value	Lori		1			Marz Center
Code		5	0	0	1	1

Coding of the Health Facilities

Health facility codes are composed on the basis of community codes, according to the following scheme:

Digit Meaning	Community ID						Type ID	Sequential Number of that Type of Facility in the Community	
Number of Digits	5 or 6						1	2	
Code	x	x	x	x	x	x	x	x	x

Where facility types are:

Type ID	Abbreviation	Type Full Name
0	MHD	Marz Health Department
1	FAP	Feldsher-Akusher Post / Health Post
2	MA	Medical Ambulatory
3	HC	Health Center
4	PC	Polyclinic
5	HSP	Hospital
6	Other	Other
7	MC	Medical Center
8	WCC	Women Consultation Center
9	N/A	Not Available

For example the ID of Vanadzor #5 Polyclinic will be: 50011 4 05:

Code Meaning	Community						Type	Sequential Number of that Type of Facility in the Community	
Value	Vanadzor						PC	5	
Code		5	0	0	1	1	4	0	5

It is obvious that even a quick look at the facility identifier makes possible to understand the type of facility, its location, what the status of that community is, etc. Additionally, the logical structure of the identifiers is useful for different data filtering and analyses processes. For example by the following math expression we can get all facilities in the Lori marz:

$$50000000 < FacilityID < 60000000$$

A complete list of all health facilities and communities of the RA is available for sharing at Project NOVA.

APPENDIX C: GIS RELATED WEBSITES

Title	Address
Project NOVA GIS Page	http://www.nova.am/eng/gis.php
Maps of Armenia and Kharabakh	http://www.armsite.com/maps http://www.aua.am/extens/N_maps/gcontent.html
Website of ESRI	http://www.esri.com
GIS Day	http://www.gisday.com
Google maps	http://maps.google.com
MSN Virtual Earth	http://local.live.com
Geo Community	http://www.geocomm.com
Geospatial Information & Technology Association	http://www.gita.org
National Center for Geographic Information and Analysis	http://www.ncgia.org
US Geological Survey	http://www.usgs.gov
National Council for Geographic Education	http://www.ncge.org
Center for International Earth Science Information Network	http://www.ciesin.org
UCSC GIS Technology Lab	http://gis.ucsc.edu
Earth Resources and Observation and Science	http://edc.usgs.gov
University Consortium for Geographic Information Science	http://www.ucgis.org
The Geospatial Resource Portal	http://www.gisdevelopment.net
The FreeGIS Project	http://freegis.org
Open Geospatial Consortium, Inc.	http://www.opengeospatial.org
Geo Strategies Limited	http://www.geo-strategies.com
Land Info World Wide Mapping	http://www.landinfo.com
GIS WWW Server	http://www.geo.ed.ac.uk/home/gishome.html
GIS Software Documentation	http://www.gsd.harvard.edu/gis/manual/gis_docs
Stanford University Website for GIS Health Data	http://library.stanford.edu/depts/gis/medical.html
“OpenEV” GIS viewer software	http://openev.sourceforge.net/
University of Minnesota Mapserver	http://mapserver.gis.umn.edu
GRASS	http://grass.baylor.edu//index.html
Open Source Software Image Map	http://www.ossim.org
GeoTools	http://www.geotools.org
GeoServer	http://geoserver.sourceforge.net
CDC “Interactive Atlas of Reproductive Health”	http://www.cdc.gov/Reproductivehealth/GIS Atlas /index.htm
DHS STATmapper	http://statmapper.mapsherpa.com/
DATA+	http://www.dataplus.ru
ГИС-Ассоциация	http://www.gisa.ru