CODATA Germany

# Lecture Notes in Information Sciences

Horst Kremers (Ed.)

# CEGeoIC 2013

## International Conference on Geo- and Environmental Information and Communication

## Bogota, Feb. 6-8, 2013

# Proceedings

ISBN 978-3-00-040771-0

# Index

# An Assessment of Climate Change in Colombia: Trends in the 20th Century and Scenarios for the 21st Century

José Daniel Pabón-Caicedo

Research Group "Weather, Climate, and Society"
Department of Geography, National University of Colombia
Oficina 317, Edificio 212 (Aulas de Ciencias Humanas)
BogotáD.C, COLOMBIA
jdpabonc@unal.edu.co

**Abstract:** Using climatological time series of different regions of Colombian territory, a reassessment of the long term trends observed in air temperature, precipitation and extreme events during the second half of the 20th Century was made; additionally, supported by A2 and B2 IPCC climate change scenarios, regional scenarios were elaborated to provide the possible conditions will be observed over Colombia during the 21st Century. It was identified the trends for the last 50 years: a decreasing of annual number of frost days and an increasing of the maximum temperatures frequency; changes (reduction and increasing) in both annual precipitation and rainfall extreme events frequency. The future scenarios show a gradual increase of air temperature in the range of 2-3°C for 2011-2040 and 3-4°C for 2071-2100 periods compared with the averages observed in the reference period 1961-1990; over Magdalena and Cauca valleys the warming could be greater than the rest of the regions. At the end of 21st Century the annual precipitation could be reduced in 30% over the interandean area, and in the Caribbean region, meanwhile in the Pacific region, the eastern foothills of Eastern Cordillera, and in a zone of Bolivar and Sucre departments the precipitation could be increase in 30% of the annual amounts observed during 1961-1990.

**Key words**: climate change in Colombia; climate change scenarios for Colombia; Colombian climate.

## 1 Introduction

For Colombia, the issue of climate change is a matter of high concern for three reasons: First, with its greenhouse gases emissions originated from domestic anthropogenic processes, although with a minimal contribution in the world context (according to [1], the national emission constitutes 0.37% of the world total), the country participates as a cause of global warming. Second, the country will experience the effects of the regional expression of the global phenomenon, with impacts on the biophysical environment, ecosystems and the socioeconomic system of their regions [2]. Finally, the country will be also affected by the measures taken into the Frame Convention of the United Nations on Climate Change (see [3]). In these three ways there are negative and positive aspects, and it is necessary to improve the knowledge to reduce the negative impacts and taking advantage of the potential benefits that new climatic conditions may provide.

In the last two decades several studies on climate change in Colombia have been developed to identify the recent and current trends, and to present the possible climate conditions for 21st Century (see a summary in [4]). As a contribution for improving the knowledge on this issue for Colombia, it was carried out a study with updated information, whose results are reported in this paper.

## 2 Materials and Methods

This work was developed in two parts: identification of the second half of the 20th Century long term trends, and building of the climate change scenarios for 21st Century.

Daily observational data of air temperature and precipitation recorded in climatological stations located in different regions of Colombia for 1960-2005 period was used to estimate the long term trends. After the quality control checking, it was remaining for the analysis data of precipitation for 46 stations and 55 for air temperature. These data were analyzed with the RClimdex tool applying the statistical procedures proposed

by [5] and the experiences and recommendations issued by [6, 7, 8, 9 y 10] for extreme event analysis. Here are presented the trends in both annual precipitation and number of the events with daily precipitation greater than 25 millimeters. (This threshold was taken because it is an intensity related to rainy storm and other phenomena (flashfloods, landslides), which frequently produce disasters in different regions of the country).

Table 1. Trends of indices related to air temperature in different climatological stations in Colombian territory

| No | CLIMATOLOGICAL STATION | LONGD | LATD | ALTD | # FREEZING DAYS | # DAYS WITH T>25°C | # DAYS WITH T>20°C | # DAYS WITH T>5°C (lenght of growing period) | Max of Tmx in the month (en °C/year) | Max of Tmin in a month (en °C/year) | Min of the Tmx in the month (en °C/year) | Min of the Tmin in the month (en °C/year) | Amplitude air temperature daily cycle (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | EL CARAÑO | -76,65 | 5,70 | 53 | NA | 0,05 | 0,09 | 0,04 | 0,05 | -0,03 | -0,01 | -0,07 | 0,00 |
| 2 | EL SALADO | -75,58 | 8,92 | 40 | NA | -0,01 | 0,97 | 0,01 | -0,07 | 0,02 | -0,12 | 0,13 | -0,22 |
| 3 | TURIPANÁ | -75,82 | 8,85 | 20 | NA | 0,06 | -1,53 | SD | SD | SD | SD | SD | SD |
| 4 | LORICA | -75,82 | 9,27 | 30 | NA | -0,53 | -0,37 | 0,00 | -0,04 | 0,06 | 0,01 | -0,03 | -0,02 |
| 5 | GALERAZAMBA | -75,27 | 10,78 | 7 | NA | -0,24 | 0,21 | -0,01 | -0,01 | 0,07 | 0,07 | 0,23 | 0,01 |
| 6 | APTO RAFAEL NUNEZ | -75,52 | 10,45 | 2 | NA | 0,01 | -0,35 | 0,01 | 0,19 | 0,00 | 0,06 | -0,03 | 0,03 |
| 7 | APTO SIMON BOLIVAR | -74,23 | 11,13 | 4 | NA | 0,33 | -0,01 | 0,01 | -0,01 | 0,00 | 0,01 | 0,01 | 0,02 |
| 8 | MATITAS | -73,05 | 11,25 | 20 | NA | 0,35 | 0,75 | SD | SD | SD | SD | SD | SD |
| 9 | MANAURE | -72,45 | 11,77 | 1 | NA | -1,23 | 12,33 | SD | SD | SD | SD | SD | SD |
| 10 | ESCUELA AGRARIA CARRAIPIA | -72,37 | 11,22 | 118 | NA | -1,00 | 6,00 | 3,00 | 0,50 | 0,00 | -0,20 | 0,20 | 0,08 |
| 11 | APTO. CAMILO DAZA | -72,52 | 7,93 | 250 | NA | 0,03 | 0,94 | 0,01 | 0,04 | 0,02 | 0,03 | 0,02 | 0,01 |
| 12 | APTO SESQUICENTENARIO | -81,72 | 12,58 | 1 | NA | 0,10 | 0,22 | 0,27 | 0,10 | -0,02 | 0,00 | 0,07 | 0,05 |
| 13 | APTO BENITO SALAS | -75,30 | 2,97 | 439 | NA | 0,06 | 0,25 | 0,02 | 0,03 | -0,04 | 0,03 | 0,01 | 0,00 |
| 14 | APTO SANTIAGO VILLA | -74,80 | 4,28 | 286 | NA | 0,00 | 0,16 | 0,03 | 0,01 | 0,01 | -0,09 | 0,04 | -0,03 |
| 15 | TIBAITATA | -74,22 | 4,70 | 2543 | -0,25 | 0,01 | SD | -0,01 | 0,10 | 0,02 | 0,07 | 0,06 | 0,03 |
| 16 | EL DORADO DIDACT ICA | -74,15 | 4,70 | 2546 | -0,18 | 0,00 | 0,00 | 0,00 | 0,17 | 0,05 | 0,01 | 0,10 | 0,08 |
| 17 | GRANJA SAN JORGE | -74,20 | 4,52 | 2900 | 0,00 | NA | NA | 0,04 | 0,03 | -0,02 | -0,08 | 0,00 | -0,10 |
| 18 | LA SELVA | -75,42 | 6,13 | 2090 | NA | 0,31 | SD | -0,07 | 0,01 | 0,03 | -0,01 | 0,16 | -0,06 |
| 19 | APTO. YARIGUIES | -73,80 | 7,02 | 126 | NA | 0,03 | -0,16 | -0,01 | -0,01 | 0,04 | 0,04 | 0,02 | -0,01 |
| 20 | EL CENTRO | -73,77 | 6,87 | 162 | NA | -0,05 | 0,23 | 0,12 | 0,03 | -0,11 | 0,06 | 0,11 | 0,00 |
| 21 | APTO. EL OTU | -74,72 | 7,02 | 630 | NA | 0,83 | -4,29 | 0,00 | 0,12 | -0,02 | 0,05 | -0,11 | 0,17 |
| 22 | UIS | -73,10 | 7,13 | 1018 | NA | 1,39 | 4,45 | 0,09 | -0,13 | -0,12 | 0,26 | 0,10 | -0,04 |
| 23 | ISLA DEL SANTUARIO | -73,73 | 5,47 | 2580 | 0,00 | -1,40 | 0,00 | 0,03 | -0,03 | 0,02 | 0,05 | -0,04 | -0,14 |
| 24 | EL CUCHARO | -73,22 | 6,52 | 975 | NA | 0,85 | -0,51 | -0,31 | -0,08 | -0,02 | 0,20 | 0,09 | 0,08 |
| 25 | SURBATA BONZA | -73,07 | 5,82 | 2485 | 0,08 | 3,31 | NA | NA | 1,04 | -0,03 | -0,20 | -0,04 | 0,35 |
| 26 | APTO. BARACOA | -74,82 | 9,27 | 18 | NA | 0,50 | 0,13 | NA | -0,50 | -0,27 | -0,10 | 0,00 | -0,54 |
| 27 | AYAPEL | -75,13 | 8,32 | 22 | NA | 0,02 | -0,35 | NA | 0,18 | 0,01 | 0,20 | -0,11 | 0,04 |
| 28 | APTO.GUILLERMO L. VALENCIA | -76,58 | 2,43 | 1730 | NA | 2,30 | SD | -0,03 | 0,10 | -0,01 | 0,02 | 0,05 | -0,01 |
| 29 | PALMIRA ICA | -76,32 | 3,52 | 975 | NA | 0,09 | 0,80 | 0,02 | 0,06 | -0,02 | -0,01 | 0,06 | -0,05 |
| 30 | APTO .FARFAN | -76,22 | 4,10 | 955 | NA | 0,48 | -1,09 | -0,06 | 0,14 | -0,06 | 0,25 | 0,01 | 0,15 |
| 31 | APTO. EL EDEN | -75,77 | 4,47 | 1204 | NA | 1,07 | SD | 0,03 | -0,04 | -0,01 | -0,01 | 0,05 | -0,06 |
| 32 | APTO. MATECAÑA | -75,73 | 4,82 | 1342 | NA | 1,38 | 0,05 | 0,22 | -0,02 | 0,02 | 0,06 | 0,13 | -0,04 |
| 33 | BELLAVISTA | -75,82 | 5,28 | 2000 | NA | 1,08 | SD | -0,13 | 0,36 | -0,12 | 0,13 | -0,07 | 0,14 |
| 34 | CAMELIA LA | -75,87 | 5,05 | 1670 | NA | -18,50 | SD | 2,00 | -0,61 | -0,59 | -0,07 | -0,87 | 0,11 |
| 35 | APTO. OLAYA HERRERA | -75,58 | 6,22 | 1490 | NA | -0,07 | 0,14 | -0,09 | -0,06 | 0,06 | 0,02 | 0,15 | -0,06 |
| 36 | TULIO OSPINA | -75,55 | 6,32 | 1438 | NA | 1,45 | 0,01 | 0,29 | 0,02 | 0,05 | 0,04 | 0,01 | -0,04 |
| 37 | EL RINCON | -73,17 | 10,27 | 350 | NA | -0,07 | -8,57 | 0,04 | 0,10 | -0,07 | -0,12 | -0,02 | 0,05 |
| 38 | MOTILONIA CODAZZI | -73,25 | 10,00 | 180 | NA | 0,07 | 0,55 | 0,09 | 0,21 | 0,02 | -0,15 | 0,03 | -0,40 |
| 39 | APTO. CORTISSOZ | -74,78 | 10,88 | 14 | NA | 0,17 | -0,12 | -0,08 | 0,08 | 0,02 | -0,05 | -0,03 | 0,16 |
| 40 | LA MACARENA | -73,80 | 2,18 | 350 | NA | 0,67 | 6,59 | -1,67 | 0,10 | 0,17 | 0,12 | 0,27 | -0,31 |
| 41 | CARIMAGUA | -71,37 | 4,58 | 200 | NA | 0,38 | 0,11 | 0,11 | -0,04 | -0,02 | 0,22 | 0,03 | 0,02 |
| 42 | LAS GAVIOTAS | -70,93 | 4,55 | 171 | NA | 0,09 | -0,75 | -0,10 | 0,00 | -0,08 | 0,04 | -0,09 | 0,04 |
| 43 | APTO.VANGUARDIA | -73,62 | 4,17 | 423 | NA | 0,14 | 0,76 | -0,07 | 0,06 | -0,01 | 0,05 | 0,02 | 0,04 |
| 44 | NUEVO COLON | -73,45 | 5,35 | 2438 | NA | 3,78 | 0,03 | 0,01 | -0,32 | 0,02 | 0,19 | -0,01 | 0,02 |
| 45 | HACIENDA LAS MARGARITAS | -72,17 | 4,35 | 150 | NA | 0,21 | 1,41 | -1,00 | 0,04 | 0,10 | 0,07 | 0,22 | -0,19 |
| 46 | BERLIN | -72,87 | 7,18 | 3214 | -0,35 | 0,12 | NA | 0,14 | -0,29 | 0,04 | 0,06 | -0,06 | 0,17 |
| 47 | VILLAGARZON | -76,60 | 1,05 | 440 | NA | 6,43 | 6,81 | -0,43 | 0,76 | 0,02 | 0,24 | 0,10 | 0,04 |
| 48 | APTO. VASQUEZ COBO | -69,95 | -4,15 | 84 | NA | 0,01 | 1,07 | -0,02 | 0,00 | 0,00 | 0,03 | 0,02 | -0,02 |
| 49 | FONDA LA CITEC | -77,05 | 2,15 | 580 | NA | -0,74 | -3,60 | 0,78 | 0,08 | 0,08 | 0,00 | -0,02 | 0,08 |
| 50 | BOLIVAR | -77,00 | 1,83 | 1510 | NA | -1,41 | 0,36 | 0,00 | 0,06 | 0,10 | 0,04 | 0,08 | -0,19 |
| 51 | MERCADERES | -77,17 | 1,82 | 1174 | NA | -0,52 | -0,17 | 0,00 | -0,03 | -0,05 | -0,06 | 0,09 | -0,01 |
| 52 | OBONUCO | -77,30 | 1,18 | 2710 | 0,00 | 0,12 | NA | 0,01 | 0,06 | 0,01 | 0,00 | -0,03 | 0,03 |
| 53 | APTO. ANTONIO NARIÑO | -77,28 | 1,40 | 1796 | NA | 1,50 | -0,02 | 0,06 | 0,12 | -0,11 | 0,04 | 0,04 | 0,04 |
| 54 | APTO. SAN LUIS | -77,68 | 0,85 | 2961 | 0,04 | -0,08 | NA | -0,01 | 0,31 | 0,00 | 0,08 | -0,02 | 0,06 |
| 55 | PANAMERICANA | -77,40 | 6,22 | 4 | NA | 0,50 | 1,14 | 0,00 | 0,25 | -0,14 | 0,20 | -0,06 | 0,11 |

Estimated with P value <0.06. Statistical significance

SD - No data NA - Not applicable

The future climate conditions for 21st Century in different regions over Colombian territory were estimated building climate change scenarios on the basis of regional climate modeling with PRECIS (Providing Regional Climates for Impacts Studies) developed by Hadley Centre of United Kingdom (details about

PRECIS are described in [11]). Initially, the climate of the reference period (1961-1990) was simulated with PRECIS at 25x25 kilometers for the spatial resolution using ERA40 data set [12] as boundary conditions. The results were validated comparing the time series of monthly values of simulated temperature and precipitation with the corresponding time series of observed data in 680 stations distributed in the country. For the future climate, PRECIS ran with data produced by the global model HadCM3 [11] for scenarios A2 and B2 [14]. A full description of methodology for building these regional climate change scenarios may be found in [4, 13]. For each scenario and period was made a map.

## 3 Results and Discussion

The Table 1 synthesizes the results obtained for air temperature. This table shows the trends in the indices with exception of the mean air temperature. (About the mean air temperature trends in previous work [2] it was established a rate 0,1-0,2°C/decade). It is clear that for the analyzed period is occurring a decreasing trend of the number of frost days in the mountainous regions (above the 2500 meters altitude) where this phenomenon actually occur in a given period of the year (usually December-February period). Also it can be confirmed an increasing trend in the number of days with air temperature greater than 25°C. Other indices, such as absolute maximum and absolute minimum temperature and the daily amplitude, do not present a main trend, in some regions are increasing in others are decreasing or there is not a clear trend.

The trends in precipitation occurred during the second half of 20$^{th}$ Century are summarized in the Figure 1 which presents the long term trends of both the annual precipitation and the events of daily precipitation greater than 25 millimeters. Regarding the trends in annual precipitation it may be verified that there is not a homogenous behavior: in some regions precipitation is increasing, in others, is reducing. This heterogeneity could be explained with the climate diversity over Colombian territory induced by the complex orography. According to this spatial distribution of trends, precipitation is increasing over eastern Colombia, in a broad sector of the Orinoquia and Amazonia, in small areas of the Coffee Grower zone, in the Middle Magdalena river basin, in Central sector of Pacific coastal region, such as in sector of Caribbean region and in Providencia Island. The annual precipitation has been reduced in the southwestern sector of Colombian territory, in a broad zone of Coffee Grower Region, in the Upper Basins of Cauca and Patia rivers, and over the high plains of Cundinamarca and Boyaca.

In spite, the distribution of the trends of the number of events with precipitation greater than 25 millimeters (Figure 1, right side) is mainly similar to the distribution of annual precipitation trends, the area where the number of events have been increased is greater than the zones where those are diminishing. The frequency of these events is rising in Providencia Island, Central sector of Caribbean coast, Middle Basin of Magdalena River, in the Upper Basin of the Cauca river, in the Amazonian and Orinoquia piedmonts, and in the central sector of Pacific coast. A reduction in frequency is observed in several sectors of Caribbean region, in Coffee Grower region, over the mountains of Antioquia and Nariño, in the southern sector of Colombian Pacific coast, such as over the northern sector (Chocó).

The estimated changes in mean annual air temperature and annual precipitation in scenarios A2 and B2 for the 2011-2040 and 2070.2100 are presented in Figure 2 and 3. These changes were calculated as the difference between multiannual values of the future period (2011-2040 or 2070-2100) minus the multiannual values of the reference period (1961-1990).

The Figure 2 shows that the changes in mean air temperature for 2011-2040 period could achieve 3°C in almost the whole Colombian territory, but there are some zones, specially Magdalena and Cauca valleys, with a major warming. For the 2070-2100 period the area with changes between 3- 4°C cover a big part of the country and there are some sectors with changes greater than 4°C located mainly in the Magdalena and Cauca valleys and in the central sector of Caribbean coast. The major warming over Magdalena and Cauca valleys has to be analyzed in more detail, but it could be initially explained as a product of the strengthening of the föhn effect which usually is observed in this region due to the interaction of the trade winds with the south-north oriented cordilleras and valleys.

The possible changes in annual precipitation for the future periods are displayed in Figure 3. The spatial distribution of these changes for the 2011-2040 period reveals that a reduction is like to occur over pacific sector and south-central sector of Chocó, in the Cauca river basin, and a broad zone of Caribbean region; very marked reduction (more than 50% of the annuals amounts shaded in red) is like to be observed in the coastal sector of pacific region, over the Caribbean coast, and in the La Guajira Peninsula. The areas of a possible rising of precipitation (blue areas) cover the eastern plains, Amazonian region, a sector at the East of the Sierra Nevada de Santa Marta, Middle basin of the Magdalena river, and the northern sector of Chocó. Very marked increasing of precipitation could occur over the zone of the Eastern Plans piedmont.

For the 2070-2100 period the spatial distribution of these changes has marked difference of the described in the previous paragraph. The area with reduction of precipitation covers the south mountainous region, the whole Magdalena and Cauca rivers basins, the northeastern sector, and Caribbean region; the major reduction is located over the mountain of Nariño, covers the Upper Magdalena and Cauca rivers basins, the high lands of Cundinamarca and Boyacá, northeastern sector, and La Guajira. In contrast, the annual precipitation

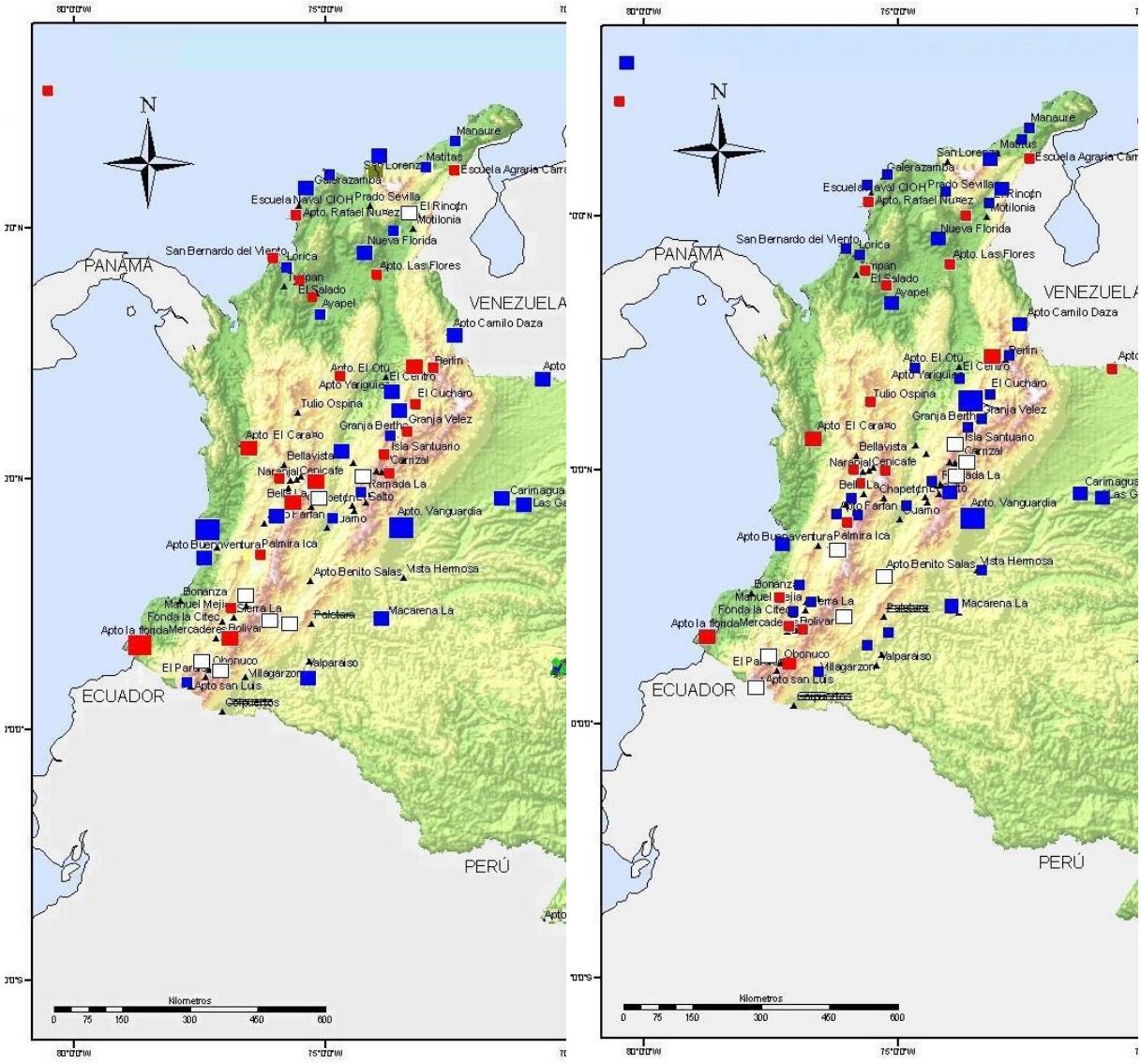


Figure 1. Spatial distribution over Colombian territory of both the annual precipitation trends (left) and the frequency of events with daily precipitation greater than 25 millimeters (right).

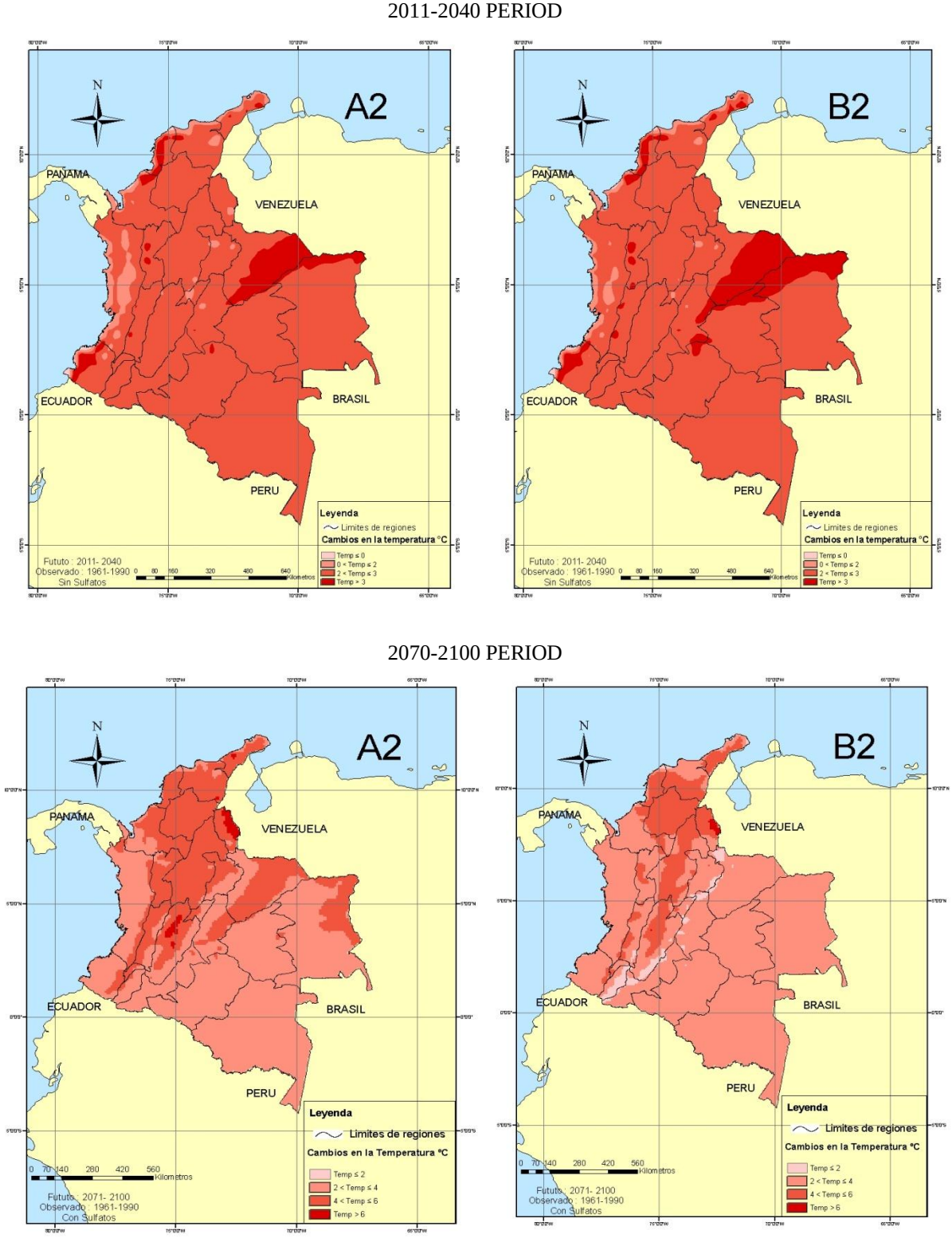
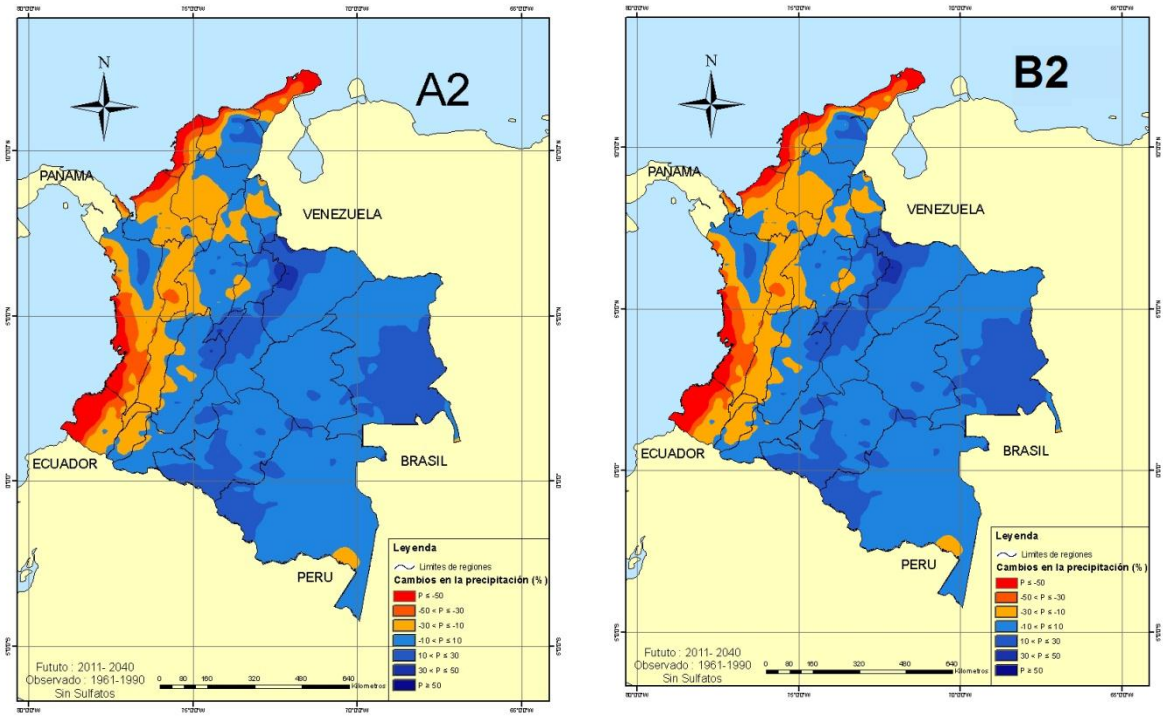



**Figure 2**. Changes obtained by comparison of the future mean air temperature in two scenarios with the mean air temperature observed in the reference period 1961-1990. It is shown the changes obtained for period 2011-2040 (top panel) and 2070-2100 (bottom) in scenarios A2 (left) and B2 (right) issued by [14].

amounts could rise in whole Pacific region, over the Eastern Plains and Amazonian regions, and in a sector over the Middle Magdalena river basin. The increasing of annual precipitation amounts over the eastern piedmonts supports the hypothesis about the reinforcement of the föhn effect in this regions: in a warmed atmosphere, the evaporation process increases the water vapor that is transported by the trade winds to the cordilleras where it will produces more precipitation at the inward side and a warming in the leeward side.

2011-2040 PERIOD




2070-2100 PERIOD

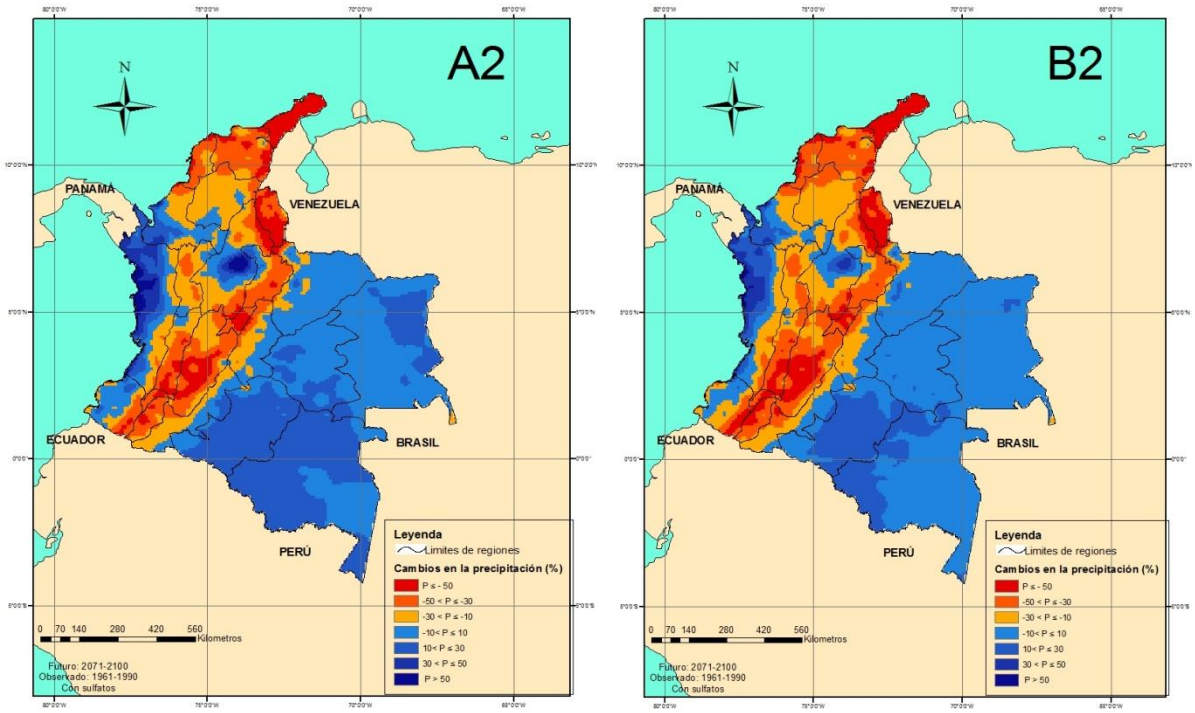



**Figure 3**. Changes obtained by comparison of the future annual precipitation in two scenarios with the annual precipitation observed in the reference period 1961-1990. It is shown the changes obtained for period 2011-2040 (top panel) and 2070-2100 (bottom) in scenarios A2 (left) and B2 (right) issued by [14].

## Conclusions

This analysis allows to identify that during the second half of the 20th Century a decreasing of annual number of frost days and an increasing trend in the number of days with air temperature greater than 25°C have been observed; no clear trends were found in the maximum temperatures frequency nor in the amplitude of the daily cycle of air temperature.

The results also indicated changes (reduction and increasing) in both annual precipitation and rainfall extreme events frequency over different regions of Colombian territory during the second half of the 20th Century. The annual precipitation has been reduced in Pacific region, over the Andean sector of Nariño, Cauca, Valle departments, in sectors of the Coffee Grower region, in the high lands of Cundinamarca and Boyacá, over the mountains of Santander, and in areas of the Caribbean region. According to the analysis of trends, annual precipitation has been rose in Amazonian and Eastern Plains regions, in the eastern slopes of the eastern Cordillera, over the Pacific region, and in the Middle Magdalena river basin, mainly.

The frequency of events with daily precipitation greater than 25 millimeters has been increasing over the whole Eastern half of Colombian territory (Orinoquia and Amazonia), and in sector of Upper Cauca river basin, high lands of Cundinamarca and Boyacá departments, in sector of the Middle Magdalena river basin, and in areas of the Caribbean region. This frequency is diminishing in sectors of Nariño, areas of the Coffee Grower departments, in Chocó, Antioquia and in some sectors of the Caribbean region.

Regarding the possible climatic conditions during the 21st Century, the elaborated scenarios show a gradual increase of air temperature in the range of 2-3°C for 2011-2040 and 3-4°C for 2071-2100 periods, however over Magdalena and Cauca valleys the warming could be greater than the rest of the regions; at the end of

21st Century the annual precipitation could be reduced in 30% over the inter-Andean area, and in the Caribbean region, meanwhile in the Pacific region, the eastern foothills of Eastern Cordillera, and in a zone of the Middle Magdalena river basin (Sucre, Bolivar, eastern Antioquia, and western Santander) the precipitation could be increase in 30% of the annual amounts observed during 1961-1990.

## Acknowledgements

The results presented in this paper was produced in the frame of the research line on climate change studies which has been developed by the research group "Weather, climate, and society" of the Department of Geography, Human Sciences Faculty, National University of Colombia at Bogotá D.C, with the support of different institutions and agencies such as National University of Colombia (Research Division at Bogota, the Research Division of the Human Sciences Faculty), the Institute of Hydrology, Meteorology, an Environmental Studies (IDEAM), the Corporación Autónoma Regional de Cundinamarca (CAR), and the Corporación Autónoma Regional del Tolima (Cortolima).

Acknowledgements to Yenny Viviana Sanchez Alcalá, and to Guillermo Armenta, who supported the spacialization of the information and the modeling for the scenarios building, respectively.

## References

[1] MAVDT-IDEAM-PNUD, 2010: Segunda Comunicación de Colombia ante la Convención Marco de Cambio Climático. Instituto de Hidrología, Meteorología y Estudios Ambientales. Bogotá D.C. 443 p.

[2] Pabón J.D., 2003: El cambio climático global y su manifestación en Colombia. *Cuadernos de Geografía*, v XII (1-2), pp. 111-119

[3] Rodríguez-Becerra M., Mance H., 2009: Cambio climático: lo que está en juego. Fondo Nacional Ambiental. Bogotá D.C., 73 p.

[4] Pabón J.D., 2012: Cambio climático en Colombia: Tendencias en la segunda mitad del siglo XX y escenarios posibles para el siglo XXI. Rev. Acad. Colomb. Cienc. 36 (139), pp.127-144

[5] Zhang X., Yang F., 2004: RClimdex (1.0) User Manual. Climate Research Branch of Meteorological Service of Canada 23 p.

[6] WMO, 2009: Guidelines on Analysis of Extremes in a Changing in Support of Informed Decisions for Adaptation. Climate data and monitoring. WCDMP No. 72. Geneva – Switzerland, 52 p.

[7] New M., Hewitson B, Stephenson D.B, Tsiga A., Kruger A., Manhique A, Gomez B., Coelho C.A.S., Masisi D.N-, Kululanga E., Mbambalala E., Adesina F., Saleh H., Kanyanga J., Adosi J., Bulane L., Fortunata L, Mdoka M.L., Lajoie R., 2005: Evidence of trends in daily climate extremes over Southern and West Africa, Journal of Geophysical Research. 111 (D14) doi:10.1029/2005JD006289

[8] Vincent L.A., Peterson T.C., Barros V.R., Rusticucci M., Marino M.B., Carrasco G., Ramirez E., Alves L.M., Marengo J., Ambrizzi T., Berlato M.A., Grimm A.M., Molion L., Moncunill D.F., Rebello E., Anunciaciao Y.M.T., Quintana J., Santos J.L., Baez J., Coronel G., García J., Trebejo I., Bidegain M., Haylock M.R., Karoly D., 2005: Observed Trends in Indices of Daily Temperature Extremes in South America 1960-2000. J. of Climate, 18, pp. 5011-5023.

[9] Haylock et al., 2006: Trends in Total and Extreme South American Rainfall in 1960–2000 and Links with Sea Surface Temperature. *J. of Climate*, 19, pp. 1490-1512.

[10] Alexander L.V., Hope P., Collins D., Trewin B., Lynch A., Nicholls N., 2007: Trends in Australia´s climate means and extremes: a global context. *Aust. Met. Mag*., 56, pp.1-18.

[11] Jones R.G., Noguer M., Hassell D.C., Hudson D., Wilson S.S., Jenkins G.J., Mitchell J.F.B., 2004: Generating high resolution climate change scenarios using PRECIS, Met Office Hadley Centre, Exeter, UK, 40pp.

[12] Uppala S.M., Kållberg P.W., Simmons A.J., Andrae U., da Costa Bechtold V., Fiorino M., Gibson J.K., Haseler J., Hernandez A., Kelly G.A., Li X., Onogi K., Saarinen S., Sokka N., Allan R.P., Andersson E., Arpe K., Balmaseda M.A., Beljaars A.C.M., van de Berg L., Bidlot J., Bormann N., Caires S., Chevallier F., Dethof A., Dragosavac M., Fisher M., Fuentes M., Hagemann S., Hólm E., Hoskins B.J., Isaksen L., Janssen P.A.E.M., Jenne R., McNally A.P., Mahfouf J.-F., Morcrette J.-J., Rayner N.A., Saunders R.W., Simon P., Sterl A., Trenberth K.E., Untch A., Vasiljevic D., Viterbo P., Woollen J. 2005: The ERA-40 re-analysis. Quart. J. R. Meteorol. Soc., 131, 2961-3012.

[13] Pabón J.D., 2011: El cambio climático en la región de la Corporación Autónoma Regional de Cundinamarca. Universidad Nacional de Colombia – Corporación Autónoma Regional de Cundinamarca. Bogotá D.C., 128 páginas.

[14] IPCC, 2000: Special Report on Emissions Scenarios. Edited by N. Nakicenovic and R. Swart. /. Cambridge University Press. Cambridge, United Kingdom and New York, NJ, USA.

# The National Arctic Atlas to Meet the Challenges of Sustainable Development in the Arctic Region of Russia

Nikolay S. Kasimov[1], Vladimir S. Tikunov[1]
[1]Faculty of Geography, M.V. Lomonosov Moscow State University,
Vorob'ievy Gory, Moscow 119991 Russia
tikunov@geogr.msu.su

**Abstract.** This brief report presents background information on the **National Arctic Atlas** (**NAA**) of Russia. The report summarizes main features of the **NAA** and the benefits it provide or the users of this publication. The report also presents main principles and requirements applied in the compilation of the **NAA** that is viewed as a part of the information-reference system for the Russian Arctic region. The report contains description of socio-scientific outcomes associated with the **NAA** publication. The **NAA**'s contribution to sustainable development of the Arctic regions of Russia is also discussed.

**Keywords:** National Arctic Atlas, the principles of creation, the areas of application, the **NAA** structure.

## 1. Introduction

The Arctic region plays a special role in the contemporary stage of human civilization and requires responsible and balanced approaches to decision making towards achieving sustainable development. In the 21st century, the Arctic became a major theme of different level socio-scientific discussions. For example, the Arctic was the major focus of the International Arctic Forum "The Arctic - Territory of the Dialogue" that was organizes by the Russian Geographical Society (Moscow, September, 2010). The main themes of the Forum were:

- Strategy for sustainable development in the Arctic region;
- Increased interaction among states in addressing socio-economic development;
- Assessment of the impact of climate change on the Arctic environment;
- Discussion of measures to preserve fragile ecosystems in the region and of Arctic natural resources exploration.

The publication of the **NAA,** that uses the most recent and objective research data and information, will meet the challenges of sustainable development in the Arctic region of Russia in the context of the national interest, international dialogue, environmental conservation, and development of the Arctic natural resources.

## 2. The National Arctic Atlas

The **NAA** will represent a set of spatial-temporal information related to geographical, ecological, economic, historical, ethnographic, cultural, and social characteristics of the Arctic, i.e., a cartographic model of the territory intended for use in a wide range of scientific, administrative, economic, defense, educational, and social applications.

The main goal of the **NAA** is to assess and reflect the importance of the Arctic region for Russia and the world in general. The **NAA** will contain general maps of the Arctic and thematic maps related to regional and local issues in the Russian Arctic. This publication will be the most comprehensive to date compendium of information about the region. The **NAA** will reflect, in the most optimal form, the level of knowledge of the Arctic, of its environmental problems, of the state of rare and endangered species, as well as of ethnic groups and their cultures.

The population of Arctic indigenous peoples barely exceeds 300 thousand. Many of them retained their traditional lifestyles of land and sea animal hunters, nomadic reindeer herders, and anglers. The population of the tundra and forest-tundra zones of the Arctic is approximately 3,5 million people in total. This number may be assumed to represent the total number of people living in the Arctic. Approximately three-quarters live in Russia, which is less than 2% of Russia's population. These people, however, contribute

11% to the national income of Russia and 22% to the Russian export income. About 30 Russian cities with the populations of over 10 thousand people are located north of the Arctic Circle.

Russia differs from many circumpolar countries because its Arctic territories are the most populated and much more involved in economic life. Therefore, the **NAA** will focus on problems of nature management, specifically, on human-nature interaction, on economic activities, and on their consequences. The **NAA** will describe potentially hazardous sites in the Arctic, which will be of interest to the companies engaged in economic activities in the region.

Cross-border and interdisciplinary nature of the **NAA** will help to obtain new knowledge, to understand linkages that are not visible from a science or business viewpoint, and to form concepts of industrial revival of the region while preserving its wildlife and nature.

There will be several versions of the **NAA;** their brief description is presented below.

*The Information and Reference Publication* will have the most current and detailed information on the Arctic region of Russia. This publication will address the main goals of the **NAA**, i.e., to overcome a gap between information flow and decision-making and to create informational and analytical basis for addressing various problems associated with development of the region. While promoting the general idea of conservation, the **NAA** will focus on interactions between improving quality of life and maintaining healthy environment through environmentally safe methods of economic development and technologies that protect the environment.

*The Educational Edition* may serve as a manual for all levels of education. It can be used in schools, colleges, public and government organizations, professional schools, and continuous education courses. The edition will have a high-quality scientific content presented in a nontechnical and user-friendly language making it accessible to a wide audience of readers. The edition will stress traditional forms of careful regard for nature of the indigenous peoples of the Arctic. The maps may be used as a reference material for the Arctic and will describe its landscape and ethnic-cultural diversity.

*The Gift Edition* may satisfy individuals with the most discriminating taste, for example, members of the diplomatic community. The dissemination of the **NAA** will help to promote the image of the Arctic as the world's and Russia's national treasure.

The **NAA** will be based on such fundamental cartographic products as the National Atlas of Russia (2004 - 2008), the Ecological Atlas of Russia (2002), the Atlas of Snow and Ice Resources (1997), the Atlas of Nature and Resources of the Earth (1998), the Atlas of the Arctic (1985), and the Atlas of the Oceans - Arctic Ocean (1980).

The **NAA** will focus on the main features of the Arctic region of Russia that influence formation of public policy in this region. Specifically:

a) extreme climatic conditions, including a permanent ice cover and drifting ice in the Arctic seas;
b) focal nature of industrial and economic development and low population density;
c) remoteness from major industrial centers, high resource consumption, and dependence of economic activities and livelihoods of the population on the supply of fuel, food, and essential commodities from other regions of Russia;
d) low stability of ecological systems that are important for biological balance and climate of the Earth and their sensitivity to even minor anthropogenic influences.

The **NAA** will provide the foundation for scientific substantiation of strategic planning of socio-economic development in the Russian Arctic region.

## 3. Scientific Principles and Requirements.

In order to secure the high quality of the **NAA**, its material will be based on the latest scientific achievements and practices of cartographic research expressed in a series of requirements applied to the **NAA**'s compilation.

The **NAA** is regarded as a collection of information and knowledge gained to date in the course of long-term and comprehensive studies of the Arctic region as a means of research and development strategy.

The **NAA** will be developed using the most recent scientific and methodological advances of modern science (geography, biology, ecology, history, etc.). It will maintain continuity with the best national and international cartographic products.

The **NAA** will be a part of the Russian Arctic reference system. It will be created and maintained within constantly updated cartographic and geographic systems.

The **NAA** will have a highly multidisciplinary content. It will be complete thematically but will have specific geographic details, inner unity (complementarity, coherence, and comparability of maps), the most current scientific background, and a layout that will make the **NAA** accessible to a broad audience of its readers.

The **NAA** will reflect environmental characteristics, resource potential, and the current level and trends of socio-economic development in the Arctic region. A great deal of attention will focus on a comparative presentation of a number of regional indicators.

The **NAA** themes will encompass the main problems of modern development in the Arctic (e.g., sustainable development of the region, conservation of its resource potential, environmental problems, problems of social infrastructure development, preservation of ethnic and cultural potential, etc.).

The **NAA** maps will cover a wide spectrum of topics. Their large number will require balanced presentation of the themes, careful selection of proper scales and levels of generalization, and consideration for many other characteristics.

The themes will be presented dynamically and with historical background. This will help to deeper understand the nature of processes and to forecast their specific development features.

There are four major interconnected levels of cartographic presentation in the **NAA**, specifically: overall Arctic, Russian, regional, and local.

The content of the **NAA** maps will be developed using modern scientific approaches (integrated, systemic, inventory-resource, regional, assessment-forecast, geo-engineering, ecological-geographic, historical, and comparative-geographic).

Mapped objects and phenomena, their statûs, and relations between them will be assessed and presented at three levels of generalization: analytical (display of "homogeneous" objects using the same system of indexes), integrated (display of several interconnected phenomena or of their elements using an individual system of indexes in each case), synthetic (display of identified integral objects with holistic characteristics).

## 4. The Outcomes of the NAA Publication.

The **NAA** will target primarily three groups of users: decision-makers, teachers and students, and experts in various fields of science, economy, culture, and health.

For decision makers, the **NAA** will serve as a cross-border database suited for the development of regional policies that incorporate conservation principles. It will be not just a system of providing information to different social groups, but rather a tool for interaction and influence of territorial management processes towards their optimization.

**Scientific Outcome.**

The compilation of the **NAA** presents some scientific-research challenges. The concept of the **NAA** is not just to describe the existing conditions in the Arctic. Its goal is to reflect the dynamic character of the region, because only through understanding the dynamic relations between phenomena one can understand the role of the region in the world.

**Social Importance.**

The **NAA** will contain visual presentations of diverse opportunities and prospects in the Arctic. Along with promoting the idea of environmental preservation, the **NAA** will analyze dependencies between quality and diversity of life and quality and diversity of its natural environment. The **NAA** will offer environmentally safe methods of economic development along with environmentally safe technologies for its implementation. The **NAA** will combine the high quality of its scientific content and a clear language to serve a broad circle of readers. It will be a multi-channel bridge between specialists from different fields – the users of the **NAA**.

**Cartographic Presentation.**

This polychromatic and lavishly illustrated publication may become a handbook for thousands of people - from scientists, educators, and representatives of business and industry fields, to the students of secondary and higher educational institutions. At the same time, the publication, made in English, may have a significant impact on the business climate and facilitate rapprochement between different political entities, economies, arts, and cultures.

The **NAA** will serve as a foundation for scientific substantiation of the strategic planning of sustainable socio-economic development of the Russian Arctic region.

## 5. Structure and Thematic Content of the NAA.

The overall structure of the **NAA** will consist of the following sections:

*Introductory section*

Section I. Natural-resource potential of the Arctic
Section II. The history of Arctic exploration
Section III. Ethno-cultural and socio-demographic potential
Section IV. Economic potential of the Arctic Region
Section V. Ecology and conservation
Section VI. Adverse and natural hazards

The main thematic content of the sections is presented below.

### 5.1 Introductory Section

The Arctic from space.
The Arctic region on the world map. Physical map. Political-administrative map. 1:40000000 scale.
General geographic maps of the Arctic region. 1:5000000 scale.
Western European Arctic (Spitsbergen, Franz Josef Land)
Eastern European Arctic (Novaya Zemlya, Northern Part of East European Plain, Isle
Vaigach, Yugor Peninsula, Polar Urals, Subpolar Urals)
West and Central Siberian Arctic (Severnaya Zemlya, Northern Taymyr)
East Siberian Arctic (New Siberian Islands)
Far Eastern Arctic (Wrangel Island, Chukotka)
Alaska
Canadian Arctic Archipelago (Labrador Peninsula, Canadian Arctic)
Greenland

### 5.2 Natural-Resource Potential of the Arctic

#### 5.2.1. Arctic Ocean

The shelf width.

Hypsometry of basins. Three-dimensional map of marine basins and adjacent ridges; natural depth and natural elevation zoning. Morphometric profiles, depths.

Coastal types. Shore-forming parent material. Thermoabrasive reworking of shores (rate of cliff retreat, m/yr). Sites formed by unconsolidated fragmental material, direction of displacement of fragmental material. Beaches. Degree of hazard from landslides, rockslides, and rockfalls.

Bottom sediments.

Distribution of Atlantic and Pacific waters. Surface currents. Surface temperatures (summer, winter). Salinity of surface layer (summer, winter). Density of water. Hydrochemical characteristics.

Winds. Direction of winds of destructive force. Hazardous zones for shipping during storm winds. Tides and surges. Boundaries of catastrophic surges. Wave disturbance.

Ice regime. Sea ice, drifting ice, shore ice, "Great Chukchi polynya" in the Chukchi Sea.
Navigation and pilot charts.
Hydrological fronts.
Continental discharge into the Arctic Ocean.

#### 5.2.2. Continental Lithosphere

Hypsometry. Hypsometric profiles.
Orographic network.
Morphometric maps (density and depth of relief differentiation, steepness of slopes).
Thickness of the Earth’s crust.
Tectonic map.
Neotectonic map.

Main faults - crumple zones, zones of increased fracturing, crushing, and schistosity of rocks. Age of the last intense movements of active faults.

Geological map. Geological profiles.

Mineral resources and reserves. Dates of discoveries of major deposits.

Quaternary sediments. The uppermost bedrock formations. Thickness of the quaternary sediments. Lithological composition of geological-genetic complexes.

Coastal cliffs (outcrops).

Marine transgression in the Pleistocene.

Geomorphological map.

Hydrogeological map. Depth to the uppermost aquifer. Groundwater resources. Thermal springs.

Permafrost map (contours of 100-m thick permafrost, the depth of seasonal freezing and thawing in typical natural conditions, permafrost temperature).

Underground ice.

Microrelief forms. Permafrost mounds, solifluction stages, patches-medallions, melkozem bare spots, salt efflorescence.

**5.2.3. Ionosphere and Geomagnetism**

Planetary influence. Geomagnetism.

Frequency of occurrence of polar auroras.

**5.2.4. Climate**

Network of meteorological stations.

Daylight. Total annual dose of ultraviolet radiation. Solar energy.

Average monthly air temperatures (January, July, April, and October). Number of days with temperatures below -30°C. Absolute minimum air temperature. Maximum air temperature. Average annual air temperature.

Atmospheric circulation. Wind speed and direction. Wind rose. Wind energy.

Precipitation (January, July, April, and October). Annual precipitation. Number of foggy days per year. Number of days with sleet.

Snowpack. Average number of days with snow cover. Date of formation of stable snowpack. Dates of vanishing of steady snow cover. Isolines of average snow depth over winter. Multiannual mean values and variability of maximum winter snow water equivalent. Avalanches.

Dates of last in spring and first in autumn air and ground frost.

Dates when average daily temperature rises to 0°C, 5°C, and 10°C and number of days with these temperatures.

Number of days per year with average daily temperature above 20°C and maximum daily temperature above 30°C.

Level of climate comfort for habitation (bioclimatic maps).

Global climate change. Climate change in the Arctic. Reduction in ice area.

**5.2.5. Glaciers**

Glaciological map.

Types of glaciers and ice-formation zones. Morphology of glaciers (Figures). The total glaciation area (Table). Island of Jan Mayen, Spitsbergen, Franz Josef Land, Novaya Zemlya, Severnaya Zemlya, Polar Urals, glaciological profile across the Ural mountain range (along 67°40'N), the central part of the Byrranga glacial knot, Ushakov Island, De Long Islands, Brooks Range, Greenland, Canada's eastern Arctic Archipelago.

Paleo-glaciological maps. The last Arctic icecap.

**5.2.6. Continental Waters**

Hydrographic network. River and lake basins, degree of wetland formation.

Landscape- hydrological regions.

Average and maximum river discharge (l/s $km^2$).

Interannual distribution of discharge. Graphs of average daily water consumption by the landscape-hydrological regions.

Hydrochemical map. Solid discharge (in t/$km^2$), river turbidity.

Hydropower resources.

Water management. Per capita water consumption. Charts of water use and its distribution by users. Maps of water availability for the population by the river basins.

**5.2.7. Soil Cover**

Lithologic-geochemical maps of landscapes (products of parent material weathering and their composition).

Parent material. Stratigraphic-genetic complexes of the uppermost parent material. Degree of peatland formation (% of land area). Maps of soil depth.

Landscape-geochemical zoning.

Soils. Structure of soil cover (based on V.M. Friedland).

Profiles of typical soil complexes and their geochemical characteristics.

Mechanical composition of soils.

Chemical composition of soils.

Humus content in soils (in %). Excessive accumulation of salts in soils and waters. Excessive accumulation of iodine and boron in soils, waters, and plants.

**5.2.8. Biota**

Vegetation. Geographical ranges of plants. Northern limits of plant growth. Northern boundary of forests. Upper limits of forests. Geobotanical profiles.

Distribution of major mammal species. Populations of polar bears. Habitats of rare and endangered animals. Mammoth burial grounds. The last population of mammoths on the Wrangel Island.

Birds. Migratory routes of birds. Habitats of rare and endangered species of birds.

Freshwater fish.

Entomofauna

Phenological maps.

Oceanic biota. Sites of plankton and benthos accumulation; sites of aggregation of fish and marine animals; biological productivity of waters.

Main commercial fish species. Salmon spawning areas. Finback whales, killer whales, bowhead and gray whales, seals, ribbon seal; rookeries of walruses and ringed, spotted, and bearded seals. Colonies of birds.

Productivity and biomass of ecological communities.

Reduction in the biosphere's capacity and depth towards the North Pole.

**5.2.9. Landscapes**

Landscape map.

Natural-landscape zones and physical geographic regions (cold deserts, cold semideserts, tundra, cryosteppes, oceanic grasslands, brushwood, forest-tundra).

Landscapes-analogues of the world.

Affinity of high-latitude and alpine environments.

**5.3. The History of the Arctic Exploration**

**5.3.1. Ancient Arctic**

Arktida. Hyperborea. The search for Thule. Land "bridge" between Asia and America (Beringia) (approx. 25 thousand years ago).

Archeological findings (archaeological discoveries, artefacts found during the excavation, rock art, etc.).

**5.3.2. Medieval Arctic**

World map of Ptolemy's Geography (1540); A. Florian's Map of the world (northern hemisphere) (1555); Map of the northern polar region of the Mercator Atlas (1569).

Journeys and marine expeditions of the 15th-18th centuries.

B. Barents's navigation map(1598).

G. Shpitsberg's map of the Earth's surface.

Military expeditions of Russian explorers and American settlers
Map-sketch of Siberia (from S. Remezov's internal drawing book of Siberia) (1667).

**5.3.3. Arctic in the 18th-19th centuries**

Map of the Northern Hemisphere by B. Metzger (1711)
M.V. Lomonosov's polar map (1763).
Territory occupied by indigenous peoples in the late 18th century.
Map of Russian marine journeys in the Arctic Sea (1820).
Russian studies of Novaya Zemlya.
First Russia's explorations of the New Siberian Islands.

Introduction of the "*Charter on Governance of National Minorities*" (1822). Rights and responsibilities of indigenous peoples of Siberia according to the Charter. Peaceful nature of relationships of indigenous peoples of the north with the Russian population. First contacts between American traders and the Eskimos and Indians of the North. Towns and settlements in the Arctic during this period. Their population and topography.

Growth of European population during the second half of the 19th century. Beginning of mineral resources exploitation. Development of whaling. Exiled population.

Number of indigenous peoples in the Arctic in 1897. Migration and environmental conditions.

Map of administrative-territorial division of northern Russia in the 18th century (according to the Atlas of the Russian Empire of 1745).

The Arctic on the maps in the 19th century.

**5.3.4. The Arctic in the 20th Century**

The Arctic on the maps in the early 20th century.
North polar map from the A.F. Marx's Atlas (1910)
Expeditions of the early 20th century.

The most important maritime land and sea expeditions along the Northern Sea Route (from 1917 to 1940.)

International Polar Year 1932. Voyage of O. Schmidt's expedition on the icebreaker "Sibiryakov." The drift of Chelyuskin ice camp (1934). The drift of the station "North Pole" (1937-1938) and the mission to rescue the members of the drift (1938).

Industrial development. Exploration of new fields. Gulag. Development of transportation network.

Establishment of collective farms in reindeer herding and marine fisheries. Cultural evolution. Creation of written language of the indigenous people of the Far North (1931 - based on the Latin, since 1936 – based on the Russian alphabet). Emergence of schools and other educational institutions. Antireligious campaign and fight against shamanism.

Glavsevmorput. Voyage of the German ship "Comet." Glavsevmorput in the Great Patriotic War of the 1941-1945. The defense of Murmansk. Voyage of the German cruiser "Admiral Scheer." Military operations of Nazis on Taymyr. Peoples of the Far North in the Great Patriotic War.

Growth of industrial construction in the areas of deposits and of transportation infrastructure in the 1940s-1950s.

Oceanographic expeditions in the northern Greenland Sea.
Map of the Arctic Atlas of the World (1954).
The Soviet Arctic in the 1960s-1980s.
Voyage of the submarine "Arctic" to the North Pole (August 1977).
Exploration of the Arctic air space.

Expansion of industrial growth. Construction of new mines, hydroelectric power stations, the Bilibino nuclear power plant. Logging. Fur animals hunting. Construction of military facilities and strengthening the border of the USSR during the Cold War. Status of indigenous peoples. Trends towards the loss of national identity and decline in population. Deterioration of ecological conditions of the tundra as a result of industrial activities. Signs of the crisis of the Soviet economy in 1980.

Russia's Arctic in the 1990s. Changes in the economy and social life in the 1990s. Transition of state enterprises and mines to the sphere of interests of private and stock capital.

### 5.4. Ethno-Cultural and Socio-Demographic Potential

#### 5.4.1. Ethnic and Cultural Diversity in the Arctic

Ethnic composition of the population. Current population. Territory occupied by ethnic groups. History of ethnic studies. Ethnogenesis. Ancient origin of many indigenous peoples. Anthropologic types of northern peoples.

Indigenous peoples.

Traditional economy. Main economic-cultural types - nomadic herders and settled sea animals hunters. Complexity of traditional economy. Fishery. Fur animals hunting. Sea animals hunting. Weapons (spear, bola, and firearms). Nature of nomadic herding. Herds management. Principles of nomadism. Means of transportation - sleds, skis, and sled dogs. Crafts (woodworking, fur and hide tanning, pottery, weaving bags, and bone and walrus tusk carving). Dwellings and their internal structure. Traditional winter and summer clothing. Food. Family life. Patriarchal community. Nomads camps.

Religious beliefs. Shamanism. Animism. Belief in spirits. Cosmogonic myths and historical legends. Influence of Christianity. Wedding, birth, and funeral rituals. Cult items. Musical instruments. Ritual dances. Legends and folklore. Cultural ties and interactions.

Russian population. Paths and time of settlement. Geography of origin of individual groups of the Russian population. The Cossacks and their role in the exploration of the North (17th-19th cc). Resettlement of former prisoners of the camps and their descendants. Cultural interaction. Mixed marriages. Assimilation of indigenous peoples. Russians in the folklore of indigenous peoples in the North.

#### 5.4.2. Demographic Characteristics of Population

Administrative-territorial division of the Arctic (1897, 1926, 1934, and 2000). Modern administrative-territorial division. Governing authorities and international organizations.

Population density

Rural population density. Population density of urban settlements.

Migration outflow.

Natural growth of population.

Age structure of population

Gender ratio.

Types of settlements. Settlement patterns and regional layouts. Forms of resettlement. Current and long-term resettlement. Green zones around settlements.

Emergence of cities. Growth scheme. Proportion of urban population to total population

Provision for population with housing and its quality. Housing cost.

External migration ties of population. Seasonal pressure of population inflow.

Employment in industry. Employment in agriculture.

Number of people with higher and vocational secondary education, percentage of persons with higher education. Provision for primary, secondary, and tertiary education. Number of school-age children not attending schools.

Human development index.

Electoral geography. Voting results.

#### 5.4.3. Population Health

Health indicators. Fertility. Mortality. Life expectancy at birth. Infant mortality. Morbidity. Mortality from cancer and heart failure, respiratory diseases.

Caloric intake.

Health care expenditures. Availability of medical care.

#### 5.4.4. Education, Science, Culture, and Sports

Scientific institutions and universities.

Museums. Folklore groups and national associations. Media. TV. Radio. Magazines and newspapers.

Libraries, number of visitors.

Sports facilities. Clubs. Teams. Stadiums. Efforts of local governments towards development of sports and physical culture in the region.

**5.4.5. Recreation and Tourism**

Tourism and recreation. Territories least affected by pollution and most favorable for recreation.
Natural and cognitive trails. Recommended routes. Future tourist routes.
Natural attractions location (exotic landscapes, waterfalls, famous rocks, corries, kars, and glaciers).
Duration of favorable period for summer recreation and tourism.
Potential capacity of tourist resources of administrative regions.
Assessment of territory passability.

**5.5. Economic Potential of the Arctic Region**

**5.5.1. General Economic Characteristics**

GNP per capita.
Level of income per capita.
General economic map.
Economic regions.

**5.5.2. Industry**

Industrial development (1913, 1940, 1964, 1989, 2000, and 2005).

Energy resources, their reserves, and depletion. Energy consumption. Intensity of energy use. Power plants. Balance of energy production and consumption. Comparative graphs of dynamics of industrial production and energy production.

Mining. Ore mineral deposits. Non-metallic mineral deposits. Stage of development of deposits on Jan.1, 2007: in exploration, pilot production, increasing production, and falling production. Map of exhausted mineral deposits. Forecast for undeveloped deposits. Mining enterprises: mining and transportation. Factories of raw materials processing. Share of mineral production in the total mineral production in Russia. Prospects for oil and gas reservoirs.

Fishing industry. Fishing fleet condition. Fishing and processing enterprises. Harvest of sea animals. Factory ships and fish processing factories. Whaling. International conventions for protection of marine fish and animal resources. Battle against illegal fish catch and harvest of sea animals.

Investment climate. Extent and risk factors for investment.

Share of foreign and Russian investment. Their distribution by businesses, deposits, and specialization. Investment in mining, fishing, construction, and other industries.

Tax collection.

Capital investment in new construction. Expenditures for construction and operation of residential buildings.

**5.5.3 Agriculture, Forestry, and Game Hunting Industries**

Agroclimatological zoning. Agroclimatological analogues in the world.

Level of economic development of the territory. Land-use patterns. Distribution of land by land users.

Agricultural areas. Energy availability and agricultural mechanization.
Potatoes, potato planting time.
Natural forage land. Location and productivity. Vertical limits of pastures.

Reindeer herding (boundaries of intensive and free-range reindeer management, its upper vertical limits). Number of livestock per capita. Number of reindeer per employee.

Pig husbandry.
Meat production. Leather production.
Hunting and fishing industry. Fur harvesting. Fishing centers. Spawning areas in rivers.
Marine hunting.

**5.5.4 Infrastructure and Communication**

Transportation system in the Arctic region. The region's transit potential.
Marine transport. Shipping routes. Northern Sea Route. Seaports.
Air transportation. Airlines. Airports.
Land transport and inland waterways of the Russian Polar region.

Traffic flows. Import and export of products by the administrative districts.

Infrastructure development to meet the challenges of the Eurasian transit.

Information infrastructure. Telecommunication availability. Computer availability.

### 5.6. Ecology and Environmental Protection

#### 5.6.1. Contamination of the Environment

Atmospheric pollution. Monitoring stations for air pollution. Zones of persistent long-term air pollution. Air pollution with dust and solid particles. Technogenic impact modules. Yields of gaseous and liquid pollutants.

Water pollution. Most polluted river stretches. Charts of wastewater discharged from stationary sources. Concentration of P and N in rivers, lakes, and groundwater. Concentration of suspended particles, heavy metals, and bacteria in water. Oxygen content in water and its biological uptake and concentration of bacteria and heavy metals. Petroleum hydrocarbon pollution, oxygen content in water during fish-kill period in February-April.

Volume of solid waste of major settlements. Major landfills. Production, import, and consumption of toxic and radioactive waste.

Radiation levels.

Total volume of waste and waste production rates by economic sector (industrial, agricultural, and municipal waste).

#### 5.6.2. Destruction of Natural Areas

Land disturbed by mining. Disturbed land to total area ratio (ha per 1000 $km^2$). Military training ranges.

Depletion of biological resources. Assessment of anthropogenic disturbance of vegetation. Geographic regions with the most acute environmental problems.

#### 5.6.3. Environmental Protection

Expenditures on disposal and recycling.

Expenditures on air clean-up (installation of filters). Expenditures on water clean-up. Water usage prices.

Settlements with water protection and treatment facilities.

Operational and under construction treatment facilities.

Activities for forest protection and enrichment.

Water protection zones.

Rare and endangered plants, listed in the “Red Book of Russia.” Protected animals. Animals and birds banned for hunting and trapping. Animals and birds hunted under licenses and permits.

Fish species banned for fishing. Areas of limited fishing periods and levels. Fishery inspection locations. Fish farms and hatcheries. Fish kills in rivers, lakes, and estuarine bays caused by freezing water and influx of bog water.

Regulations for grazing, regulations for hunting, fishing, and gathering berries.

#### 5.6.4. Environmental Issues and Environmental Protection Activities

Areas recommended for environment protection: ban on economic activities; activities for fire protection, erosion, landslides, and mudslide control.

Areas of banned construction of industrial facilities with hazardous emissions.

Environmental protection agencies, expenditures on environmental protection and biodiversity conservation.

#### 5.6.5. Protected Entities

Secure facilities (guarded and protected) objects. Special floristic locations. Areas where hunting dates and number of harvested game birds are limited. Protection of birds in breeding areas.

Protected berrying swamps.

Legally-protected land and water areas (existing and proposed). Reserves, national parks, natural monuments, wildlife sanctuaries, protected landscapes, plant communities, and protected historical and

natural complexes and areas. Protected landscapes. Geographical regions of ethnic territories. Archaeological sites. Underused and unused areas.

Proposed protected land and water areas (nature reserve "Bear Island", national park "Central Chukotka," reserves "Kandalaksha" and "Taymyr").

### 5.7. Adverse and Hazardous Natural Events

Seismic map.

Earthquakes. Epicenters of catastrophic earthquakes and their dates. Zones of possible earthquakes, dead volcanoes.

Map of hazardous geomorphologic processes (territories significantly affected by landslides, earth-flows, rock-falls, large-hillocky peat-bogs, solifluction, repeated wedge-ice, rock-glaciers, and frost-scars). Hazardous events impact factor of the territories. Categories of regional hazard.

Number of days with strong winds (over 15 m/s). Isolines of average annual reoccurrence of hurricanes and snowstorms.

Blizzards and snow drifts (their thickness on the roads and trails - in meters and in point-scores).

Flooding. Years of major high-water events and floods. Locations of floods in river valleys and lake basins due to ice jams, hanging ice dams, and wind surges.

Icing (point-score, dates of duration per year, area, maximal thickness in meters).

Avalanche hazardous areas (potential volume and height of avalanche falls).

Mud flows and estimates of maximal mudflow discharge and volume in $m^3$/sec and mln $m^3$/sec, respectively.

Increase in costs of urban development due to protection from natural hazardous events and to damage they cause.

Fire danger of tundra, of thickets of cedar pine, and of near-tundra sparse forests. Areas of possible development of tundra, forest, and peatland fires.

Landscape and geographical distribution of midges.

Diseases of natural nidality. Biogeochemical endemics.

Number of victims of natural disasters by the administrative districts for 2000-2007.

Proportion of population affected by natural disasters in 2000-2007 (by the administrative districts).

Geography of natural risk. Zoning of the regional natural disaster risk.

Level of control over impacts of natural disasters.

## Acknowledgements.

The research was supported by the Russian Geographical Society (projects № 33/08/2011 and № 38/08/2011).

- empty page inserted -

# Modeling of Hut Type Solar Still And Desalination of Sea Water in the Bay of Paracas

Pedro Córdova[1], Teresa Barrios[1], Ada Barturén[2], Segundo Vásquez[2]

[1]Facultad de Ingeniería Química, Ambiental y Sanitaria,
Universidad Nacional San Luis Gonzaga de ICA,
Panamericana Sur, km 305, Ciudad Universitaria, ICA - PERU.
pcordovam@yahoo.es
obarriosm17@yahoo.es

[2]Facultad de Ingeniería Química e Industrias Alimentarias,
Universidad Nacional Pedro Ruíz Gallo – Lambayeque,
Av. Juan XXIII 391 – Lambayeque - PERU.
abarturen@unprg.edu.pe
svasquezll@unprg.edu.pe

**Abstract**
Mathematical models of the solar still were used to predict the values in the recovery of sea water solar still located in the Bay of PARACAS. Considering the following operating data, air temperature, temperature of glass on the outside and the internal temperature in the internal environment of the distiller, water temperature in the distiller, the outside temperature in the distiller temperature the wall on the inside of the distiller, wind speed and solar radiation.Results show us that the main physical functioning parameters are air temperature at 26.8 °C, wind speed 0.4 m/s and solar radiation of 154.1 Ws, water flow in the asymmetric hut type solar still is 0.78 kg/s obtaining a recovery of 72 % obtaining clean water suitable for human consumption without mineral and biological contaminants less 400 ppm in salt water, with a cost of US$ 0.5 m³/day.

**Keywords:** Mathematical models, solar still, desalination of sea water.

## 1 Introduction

Nowadays many different regions of the planet have serious problems related to water scarcity, especially in recent years, due to factors such as population growth, industrial development and climate change.

One of the applications of solar thermal energy to desalination processes is conventional distillation plants coupled to a solar thermal system, which is known as direct solar distillation. In order to improve the living conditions of rural area inhabitants, it is necessary to provide drinking water in these areas, to avoid the exodus to the urban areas. The need to provide safe drinking water in rural areas has been the basis for the development of solar stills using the sun as a safe source, inexhaustible and sustainable.

This paper aims to promote the use of alternative energy through the environmental assessment of the lack of drinking water in rural areas and the comparison of the obtained value with the implementation cost of a solar still. To achieve this objective, a laboratory scale solar collector was constructed, to determine the cost of a liter of distilled water at different times of the year; this equipment can be built, operated and maintained by members of rural communities. For the environmental economic valuation of the lack of potable water, the methodology of a rural community from the District of PARACAS was used. It considers water as a public good.

## 2 Bibliography

### 2.1 Solar Distillation

There is an important need for cleaning the drinking water [1] in many developing countries. Often, the brackish water (i.e. water containing dissolved salts) and/or harmful bacteria. Therefore, it cannot be used for drinking. In addition, there are many coastal locations where seawater is abundant but potable water is not available. Pure water is also useful for fountains and hospitals or schools.

Distillation is one of the many processes that can be used for water purification. This requires an energy input, as heat, solar radiation can be the source of energy. In this process, water is evaporated, thus separating water vapor from dissolved matter, which is condensed as pure water.

### 2.2 Solar Still

The incident solar radiation is transmitted through the glass cover and is absorbed as heat by a black surface in contact with the water to be distilled. The water is thus heated and gives off water vapor. The vapor condenses on the glass cover, which is at a lower temperature, because it is in contact with the ambient air, and runs down into a gutter from where it is fed to storage tank [2], see Fig. 1.

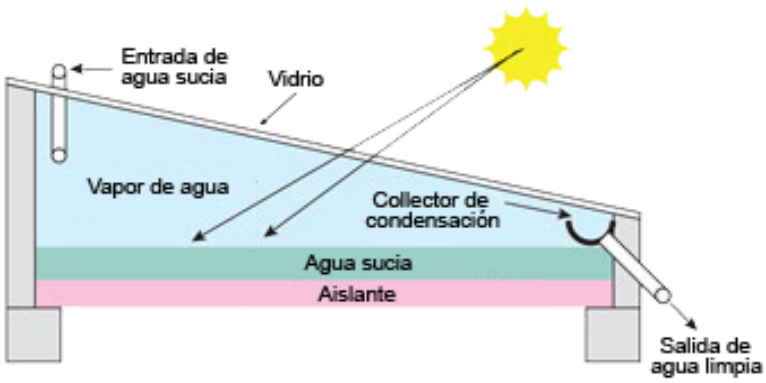



**Fig. 1.** Solar Still.

Solar distillation is a physical process that allows purifying the components of a solution based on differences in volatility, replacing conventional energies by the solar only. When in predominant conditions the solute is almost nonvolatile, distillation is carried out by evaporating the solvent in a distillation area and by condensing the resulting vapor in another part of the distiller.

Although it is not a vapor and liquid flow exchange process as it corresponds to distillation, it is commonly referred to as distillation.

The most important application of distillation is that of purifying brackish water to make them drinkable. This purification method [3] is done differently to conventional methods aimed to keep constant production of water all day and all year round. In solar distillation the obtained quantity depends on the incidence of solar radiation on the earth's surface, whereas the production goes from zero to a maximum at the times of highest incidence, see Fig. 2.

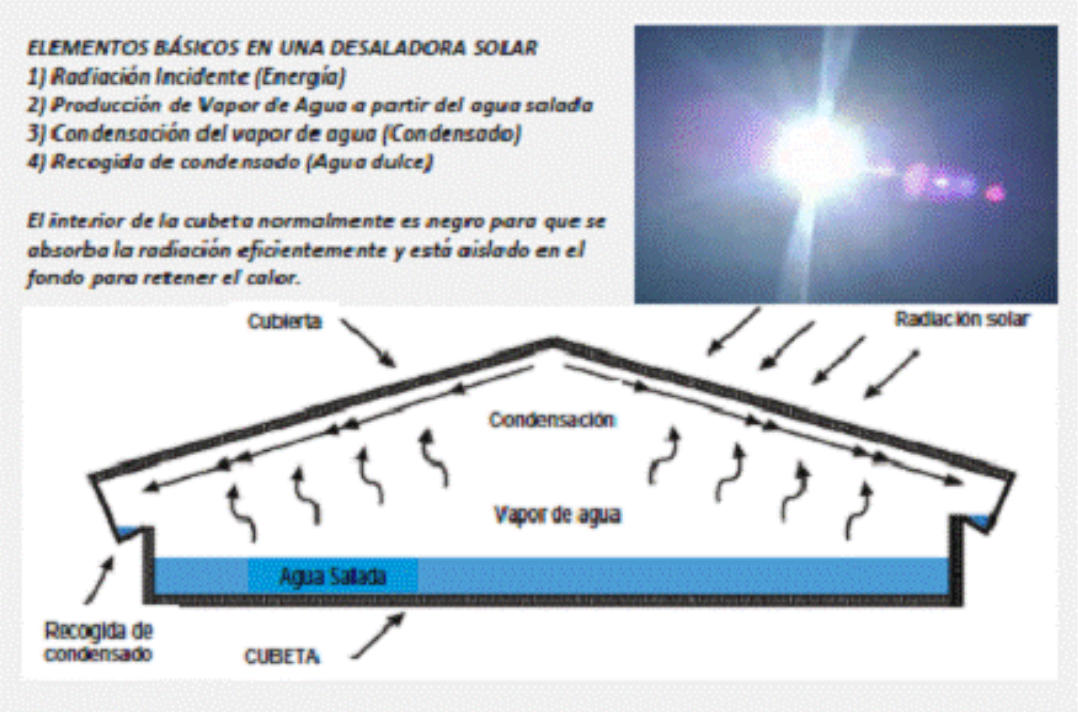



**Fig. 2.** Schematic Diagram of a Solar Desalter.

Although there are different prototypes [4] of solar stills, the differences are in the materials and geometry, but they all involve the same operating principles: recognizing three major areas:

1. Solar collector: is the designed part to catch solar energy.
2. Evaporator: is the area where water evaporation takes place.
3. Condensator: corresponding the part where evaporated water is condensed.

## 3 Methodology for Modeling

### 3.1 Design Equation

For a single stage distiller, the energy balance is given by convective heat of air external side of glass:

$$q_{c,ve-a} = h * \left( T_{ve} - T_a \right). \quad \textbf{(1)}$$

Radiation heat from the glass covers to the water:

$$q_{r,\frac{a}{v}} = \sigma * \left[ \frac{T_{ag}^4 - T_{vi}^4}{\frac{1}{\frac{1}{e_{ag}} - \frac{1}{e_{vi}} - 1}} \right]. \quad (2)$$

Convection heat from water to cover:

$$q_{c,ag-vi} = h_c^{'} * \left( T_{ag} - T_{vi} \right). \quad (3)$$

If the cover is in contact with water and the cover the useful heat, it is exposed to the environment:

$$q_e = 0.00000000915 * h_c * \left( T_{ag} - T_{vi} \right) * h_{fg}. \quad (4)$$

On the other hand, latent heat of water:

$$h_{fg} = \left( 3159057.951\text{-}240 * T_{ag} \right). \quad (5)$$

Convective heat transfer coefficient is given by:

$$h = 5.7 + 3.8 * v. \quad (6)$$

### 3.2 Single Basin type Solar Still

The single basin solar still, also called conventional, is basically a large, shallow container, commonly rectangular shaped and with a black background, where brackish water is placed and is covered with a transparent material to solar radiation, generally glass or a plastic, the cover has an inclination to one or more distilling collector gutters.

In case the exchange is with the sky, the temperature apparent sky, $T_{AS}$, equals the sky temperature and can be calculated through the expression:

$$T_{AS} = \left( e_{AS} T_a^4 \right)^{0.25}. \quad (7)$$

In the second case, there are two parallel plates with infinite dimensions, narrowly placed, with different emittance between them and with different temperature:

$$Q_{r,\frac{a}{v}} = \frac{A * \sigma * \left( T_{ag}{}^{4} - T_{vi}{}^{4} \right)}{\left( \frac{1}{\varepsilon_{ag}} - \frac{1}{\varepsilon_{vi}} - 1 \right)}. \quad (8)$$

The requirement that these surfaces are of infinite dimensions is that the surface emissions are performed in all directions, and there is no analytical solution for the radioactive exchange at the edges of finite plates.

Convection is the way in which fluids transmit heat in a unidirectional due to the movement at the fluid caused by density change. If the fluid is confined in a two parallel surfaces at temperatures $T_{ag}$ and $T_{vi}$ with $T_{ag} > T_{vi}$, the fluid near $T_{ag}$ increases its temperature and simultaneously reduces its density, thus, rising to the surface $A_2$. Once the fluid is in contact with $A_2$, this will give off heat, getting cool and increasing its density, the repetition of this phenomenon becomes the convective movement in which the fluid extracts heat from surface $A_1$ and gives it off on the surface $A_2$.

Single basin solar stills exhibit this phenomenon between the evaporator surface and the condenser, originating internal convection.

$$Q_{c,ag-vi} = h_c^{'} * A * \left( T_{ag} - T_{vi} \right). \quad (9)$$

Coefficient, $h_c$, depends on the relative air humidity inside the distiller and also on the convective flow regime:

$$h_c^{'} = 0.884 * \left[ T_{vi} - T_{ag} + \frac{\left( P_{svi} - P_{sag} \right) * T_{vi}}{\left( 2016 - P_{ag} \right)} \right]^{\frac{1}{3}}. \quad (10)$$

Vapor pressure is calculated through the equation:

$$P_{sag} = e^{\left( \frac{54.12 - 6547.1}{T_{ag} - 4.23 \ln(T_{ag})} \right)}. \quad (11)$$

$$P_{svi} = e^{\left( \frac{54.12 - 6547.1}{T_{vi} - 4.23 \ln(T_{vi})} \right)}. \quad (12)$$

The transport of water vapor inside the distiller is a convective transport phenomenon. In operating conditions, the water travels from the evaporator surface to the condenser by two processes: mechanical air entrainment in its convective motion which is considered insignificant for the purposes of distillation and by diffusion.

If the water is warmer than the cover, then $P_{sag} > P_{svi}$ and when the steam is saturated with respect to the evaporation zone, it is supersaturated with respect to the condensation zone so that it condenses. Through this process heat is transferred to the cover, according to the equation:

$$Q_e = 9.15 * 10^{-7} * h_c * \left( P_{sag} - P_{svi} \right) * h_{fg}. \quad (13)$$

The external convection is one of the main ways of cooling cover distillers.

Heat losses through the air and wind, natural and forced convection, can be calculated by:

$$Q_b = U_b * A * \left(T_{ag} - T_a\right). \quad \textbf{(14)}$$

Convective heat transfer coefficient is given by:

$$U_b = \left[\frac{1}{\frac{1}{h_{cb}} + \frac{x_1}{k_1} + \frac{x_2}{k_2}}\right]. \quad \textbf{(15)}$$

The energy absorption at the base of the distiller becomes the only energy gain of the system to raise the temperature of the water contained in the container.

Another thermal phenomenon occurring in the system is observed in the water contained in the container and corresponds to the thermal inertia effect of the system. It corresponds to the heat gained by the water by $Q_{CW}$ and $\alpha_w \tau_g G$ this term depends on the mass of water and for a fixed area depends on the depth.

$$avG - \left(Q_e + Q_{c,ag-vi} + Q_{r,\frac{a}{v}}\right) = \frac{M_w}{V} Cp_w y \frac{dT_b}{dt}. \quad \textbf{(16)}$$

The heat transferred to the glass cover by convection, evaporation-condensation and that of radiation from the surface of the evaporator is transferred to the atmosphere, due to the convection of air on the outside of the cover, $Q_{c,a-c}$, and to the radioactive emission on wavelengths in the infrared to the atmosphere, $Q_{r,ve-c}$.
The following assumptions are considered to simplify the mathematical model:

1. There are no thermal gradients on the horizontal plan of the crystalline cover and water.
2. The thermal inertia of the crystalline cover and that of the bottom are insignificant.
3. The distiller is sealed so that there is neither leakage of water vapor steam nor air.
4. The temperatures of the inner and outer faces of the glass are equal.

## 4 Material and Methods

It was built an asymmetric single basin type solar still, using, transparent glass to be evaluated under the climatic conditions in the district of PARACAS, PISCO Province, which is characterized by having a hot and dry weather. The basic elements with which this distiller was built were: a pond with an area of 0.25 $m^2$.

In order to concentrate the most heat, the distiller was placed on a black metal surface. A removable cover with an area of 0.29 $m^2$, (hinged at one end, to open the distiller when necessary), was placed and sealed with silicon on the pond, to allow the most radiation emitted by rays of sunlight and avoid potential losses of matter and energy respectively.

The slope of the cover regarding the horizontal was 26.71°, calculated at the time of installation of the equipment through trigonometric ratios. The distiller has a power input on the back. It also has two outputs on one side, an outlet for brine and another for the distilled. To set up the desalination system (see Fig. 3), it was necessary to use: a 15 liters capacity storage tank, to feed the distiller, a pump for transporting water

from the tank to the equipment and a flow regulator for controlling the inflow to the distiller.

The outside of the tank was painted black, in order to improve the absorption of solar radiation and thus to ensure that the feed when entering the system has a high temperature, so that the evaporation process takes place in less time, as a result of preheating. The container lid has a hole for introducing the hose carrying the liquid to the distiller, which has a diameter of 0.64 cm ($^1/_4$ inch).

Once the equipment is constructed, it is put into operation, which will be assessed for the volumetric performance, and regarding water quality produced, obtained from the solar distillation system, which mainly depend on: the intensity of solar energy and environmental temperature at which data will be taken: the brackish water temperature entering the solar still, the temperature of the cover, the environment temperature, conductivity, which will be monitored with temperature and conductivity sensors which has MultiLog. The temperature will be to know (see Fig. 4), at what temperature degree the evaporation, inlet temperature and outlet of feed water start.

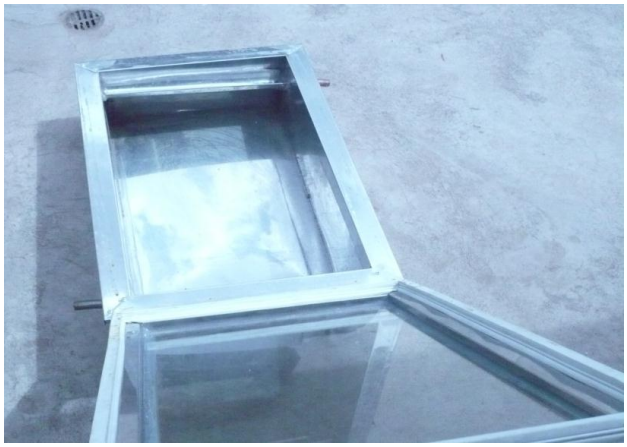


**Fig. 3.** Asymmetric Single Basin Solar Still.

**Fig. 4.** MultiLogPRO.

## 5 Results and Discussion

The physicochemical and biological parameters of the solar distillation system, in the town of PARACAS, were determined in order to know if it is safe for human consumption. The samples of water and the resulting quality will be analyzed in the Regional Address of Health of the city of PISCO. It was found that the required quality water as well as the water supplied to the desalination process is fundamental in its operation.

The following is a seawater classification depending on the quantity of total dissolved solids in the water:

**Table 1. Range of Salinity of the Different Types of Water**

| Name of water | Salinity (ppm of TDS) |
|---|---|
| Ultra pure | 0,04 |
| Pure (boilers) | 0,4 |
| De- ionized | 3.5 |
| Fresh (drinkable) | < 1100 |
| Salty | 1000 – 10000 |

The process of desalination of sea water by solar distillation with a single basin type is a system that allows desalination of sea water which enters into the system through its middle side. When the basin is heated the seawater inside starts to vaporize until it makes contact with the glass in the upper side, showing water drops all around the glass. By gravity these drops fall into a condensed line to be stored in a container, the product obtained is fresh water suitable for human consumption.

The system as it was defined, has an operation distance characterized by four variables (three treatments and the desalination of sea water). Based on this model the following general functional relationship was formulated: $Y = f(X_1, X_2, X_3)$.

This states that seawater desalination (Y) depends on the air temperature ($X_1$), wind speed ($X_2$), and solar radiation ($X_3$). Data are presented in the following table:

**Table 2. Data Taken to Determine the Sea Water Desalination**

| Hour | Air Temperature (At) | Wind Speed, *v* | Solar Radiation, Ws | Condensed Mass |
|---|---|---|---|---|
| 9 | 26.8 | 0.4 | 246.8 | 0.050 |
| 10 | 27.0 | 0.7 | 455.6 | 0.092 |
| 11 | 28.5 | 2.7 | 538.4 | 0.328 |
| 12 | 27.8 | 2.8 | 405.2 | 0.574 |
| 13 | 27.5 | 2.6 | 272 | 0.758 |
| 14 | 27.6 | 1.0 | 154.1 | 0.892 |
| 15 | 27.2 | 1.9 | 142.4 | 0.988 |
| 16 | 27.8 | 1.1 | 142.4 | 1.071 |
| 17 | 28.1 | 0.6 | 151.4 | 1.146 |

**Source:** Report supplied by MultiLogPRO

The choice of treatment levels is made empirically, from a base level or an average level in each treatment, in which the lower level (-1), and upper level (+1) are determined, respectively. The last two levels are located at the same distance from the average level. Thus the levels chosen for this study are given in Table 3.

To determine the efficiency of solar desalination system, the results of the desalination of seawater, are presented in Table 2. The results of this table generate efficiency, Y% (last column) of the experiment, those of which are in detailed in Table 4.

**Table 3. Levels and Treatments**

| Levels and Distance | Notation | Treatments | | |
|---|---|---|---|---|
| | | $X_1$ | $X_2$ | $X_3$ |
| Middle level | 0 | 27.5 °C | 2.6 m/s | 272.0 |
| Lower level | -1 | 26.8 °C | 0.4 m/s | 246.8 |
| Upper level | +1 | 28.1 °C | 0.6 m/s | 151.4 |

**Table 4. Seawater Desalination with the Solar Still**

| N° of experimental combinations | Identification of the combination | Treatments | | | Y, % |
|---|---|---|---|---|---|
| | | $X_1$ °C | $X_2$ m/s | $X_3$ Ws | |
| 1 | I | 26.8 | 0.4 | 246.8 | 1 |
| 2 | $X_1$ | 28.1 | 0.4 | 246.8 | 3 |
| 3 | $X_2$ | 26.8 | 0.6 | 246.8 | 11 |
| 4 | $X_1X_2$ | 28.1 | 0.6 | 246.8 | 19 |
| 5 | $X_3$ | 26.8 | 0.4 | 151.4 | 72 |
| 6 | $X_1X_3$ | 28.1 | 0.4 | 151.45 | 63 |
| 7 | $X_2X_3$ | 26.8 | 0.6 | 151.4 | 65 |
| 8 | $X_1X_2X_3$ | 28.1 | 0.6 | 151.4 | 67 |
| 9 | | 27.5 | 2.6 | 272.0 | 45 |
| 10 | | 27.5 | 2.6 | 130.0 | 57 |
| 11 | | 27.5 | 2.6 | 497.0 | 37 |
| 12 | | 27.5 | 0.8 | 272.0 | 33 |
| 13 | | 27.5 | 4.4 | 272.0 | 35 |
| 14 | | 15.4 | 2.6 | 272.0 | 30 |
| 15 | | 39.7 | 2.6 | 272.0 | 36 |

**Source:** Elaborated by the authors

Therefore, the evaluation of the efficiency of purification of seawater allows the viability of solar systems, being even more effective due to solar radiation (72%), when the temperature is at approximately 26.8 °C, wind speed at 0.4 m/s and 151.4 (Ws) of solar radiation.

At 90% confidence it is checked $X_3$ is very influential, interactions are not influential. At 95% confidence it is checked $X_3$ is influential, the interactions are non influential. At 99% confidence it is checked $X_3$ is slightly influential interactions are non influential.

## 6 Conclusions

1 The results obtained by this study have identified that the main operating parameters are: air temperature ($X_1$), wind speed ($X_2$) and solar radiation ($X_3$), for better seawater desalination : According to the results of the hypothesis test at 90%, 95% and 99% confidence, it is concluded that the main operating parameter that achieves better seawater desalination is solar radiation.

2 The checking of the data for the construction of an asymmetric single basin solar still, these are done on the basis of one month, considering the average one for a day, in the desalination of seawater, using transparent glass as a material to be tested under the weather conditions in the District

of PARACAS. It was determined in the US $ 0.5 $m^3$/day. Therefore, this system is economically viable, making possible the seawater desalination

3 It was verified that the main mineral and organic contaminants are removed from the sea water for human consumption through the solar desalination system, obtaining water with less than 400 ppm with a pH of 7.2 and 100 ppm Na+. The feasibility of the research study of solar distillation of seawater also depends on environmental conditions and location of the place. It can be concluded that the quality of water obtained by this method is suitable for human consumption only with a small post treatment in some cases.

4 The results have established the efficiency of purifying sea water through solar system's viability for desalination of seawater in the Bay of PARACAS. Determining that when combining temperature with wind speed the result is 19% efficiency, the temperature with the solar radiation: 63% efficiency and wind speed with solar radiation is 65%efficiency. By combining the three an efficiency performance of 67% is achieved.

5. The solar still modeling system, $Y = f(X_1, X_2, X_3)$, has permitted a better efficiency in the desalination of seawater. It was determined that solar radiation factor has the most influence on the solar still system with a recovery of 72%. The other two factors: the temperature with a 3% recovery and wind speed with 11%. That is to say the solar still modeling system depends on solar radiation at the seawater desalination at PARACAS Bay.

## Nomenclature

| | |
|---|---|
| $q_{c,ve-a}$ | Air Convective Heat, External Side of Glass, W/m$^2$. |
| $h$ | Convective Heat Transfer Coefficient and Radiation Glass/Ambient, W/m$^2$.°C |
| $T_a$ | Temperature Ambient, °C |
| $T_{ve}$ | Temperature on the Glass External Side, °C |
| $q_{r,\frac{a}{v}}$ | Radiation Heat from the Glass covers to the Water, W/m$^2$. |
| $T_{ag}$ | Water Surface Temperature, °C |
| $T_{vi}$ | Crystalline cover Temperature, °C |
| $q_{c,ag-vi}$ | Convective Heat from Water to the cover, W/m$^2$ |
| $q_e$ | Ambient useful Heat Exposure, W/m² |
| $h_{fg}$ | Water Latent Heat, W/m$^2$.°C |
| $v$ | Wind Speed, m/s |
| $h_c'$ | Convective Coefficient, W/m$^2$.°C |
| $P_{svi}$ | Condensing Zone Vapor Pressure, mmHg |
| $P_{sag}$ | Evaporator Surface Vapor Pressure, mmHg |
| $Q_e$ | Useful Heat, W |
| $Q_b$ | Ambient Convective Heat, W. |
| $U_b$ | Convective Heat Transfer Coefficient, W/m$^2$.°C. |
| $Q_{c,ag-vi}$ | Internal Convection Heat on Air, W. |
| $Q_{r,\frac{a}{v}}$ | Necessary Heat to Evaporate Water on the Container, W. |

## References

1 Moncada, M.E.: Gestión del agua para uso poblacional en el Perú. Lima (2000)

2 Bermúdez, J., Burgués C., Zenón R. y Cobián, F. : Destiladores Solares. Centro de Investigadores de Energía Solar (2007)

3 Albania A.: Tecnologías Sostenibles sobre la Gestión del Agua: La Desalinización. Ingeniería Técnico Electrónica (2007)

4 Alcázar I. D., Delgado J. A., Frisancho M.A. y Herrera M.S.: Evaluación Experimental de un prototipo de destilador solar tipo caseta (2007)

- empty page inserted -

# Mining Urban Mobility to Improve Routing Strategies for e-Vehicle Fleets

Peter Ranacher

University of Salzburg, Department of Geoinformatics – Z_GIS
Schillerstraße 30, 5020 Salzburg, Austria
peter.ranacher@sbg.ac.at

**Abstract.** Electric vehicles (e-vehicles) are widely considered to be the transport of the future – mainly due to their energy efficiency in comparison to petrol-driven means of transport. However, still insufficient batteries require users of e-vehicles to comply with specific mobility patterns. E-vehicles are best used for short distances, they must move as uniformly as possible and a well-designed charge strategy is crucial for extending long-term battery life. The question remains to what degree these e-mobility patterns differ from currently existing movement patterns of human beings in general and urban fleets in particular. Moreover, we lack an understanding of how clever routing strategies can support e-vehicles. This paper introduces a methodology to empirically mine historical floating car data to i) analyze current mobility patterns of urban fleets with respect to the needs of e-vehicles and to ii) tailor routing algorithms for e-vehicle fleets. Thus, we aim to assess the potential of e-mobility for urban fleets and help to overcome some of the e-vehicle's shortcomings route-wise.

**Keywords.** floating car data, electric vehicles, data mining, routing

## 1 Introduction

Electric vehicles (e-vehicles) will play a crucial role in mobility independent of fossil fuel [1]. However, due to limited battery capacity, e-vehicles still face many shortcomings. First, they are best used for short distances. Battery dimensions considerably limit their range compared to traditional petrol-driven cars [2]. Larger-dimensioned batteries are an inefficient solution to this problem as they massively increase the overall energy consumption of the vehicle [3]. Second, to save energy and thus prolong the battery cycle, e-vehicles must move as uniformly as possible and avoid phases of heavy acceleration and deceleration [2], as well as roads with steep gradients. Third, a well-designed charge strategy is crucial for extending long-term battery life [4]. This requires e-vehicles to return to a charging station in regular time intervals. Moreover, compared to fueling a traditional car, charging an e-vehicle takes much longer – from half an hour up to five hours, depending on the charge strategy [5]. Seemingly, these shortcomings prevent e-vehicles from meeting everyday mobility needs and limit their practical use. However, the question remains, whether this conclusion is based on half- knowledge or scientifically valid facts: we lack an understanding to what degree e-vehicles could substitute petrol-driven cars without affecting overall human movement behavior in general and the movement behavior of urban fleets in particular. Moreover, we still miss strategies to optimize routing for e-vehicles.

The remainder of the paper is organized as follows: In section 2 we provide an overview on related work. We introduce research on human movement in general and fleet movement in particular and explain the basic concepts of data mining and movement pattern analysis. Moreover, we describe the need for data preprocessing and introduce graph theory as one model of the underlying space where movement takes place. In section 3 we present the main goals, hypotheses and research questions of our work. In section 4 we describe our data; in section 5 we propose our methodology. We conclude our work in section 6 and give an outlook on our future research activities.

## 2 Related Work

### 2.1 Human Movement and Urban Fleets

From a geographical point of view, the research on human movement has its roots in Hägerstrand's time geography [6]. In the course of their life, human beings leave back a trace in space and time in form of a trajectory. In general, a trajectory describes the movement of an entity through space and time [7]. Mathematically, it is a function that assigns time moments to a sequence of spatial position within some reference system. This rather broad definition of trajectories leaves room to include various moving entities travelling in various environments: one might think of a trajectory as the time-referenced path of an animal in its habitat [8], a ski-jumper in three-dimensional space [9], or a cursor in the virtual space generated by a computer screen [10].

In time geography, Hägerstrand, refers to the trajectory of a human being within its living environment on the Earth surface as a human life path [6]. Even though a life path is the result of millions upon millions of seemingly individual and spontaneous decisions, it does not constitute a purely random walk connecting arbitrary locations. Instead, it follows a more or less strict logic defined by constraints that are imposed externally or developed internally. Hägerstrand identifies three major constraints on human movement [6]. Firstly, human physiology and tools at hand limit human activities. Human maximum walking speed will, for example, limit a person's daily movement radius to no more than several kilometers. With a tool at hand – such as a car – this radius might grow up to several hundreds of kilometers. Secondly, the obligation to participate in social activities with others influences where we go and when we go there. Humans attend social activities and go, for example, to work or to school. These activities must be reachable from a home base. Thirdly, specific rules allow or deny access to spatio-temporal locations. This means, that human beings must not attend certain locations, such as other individuals' private properties. While Hägerstrand's work is purely conceptual, today's availability of ubiquitous positioning devices allows for collecting and analyzing human movement in a truly empirical manner. Gonzales et al. analyze huge volumes of trajectories of mobile phone users and approve Hägerstrand's assumptions. They reveal that human beings move with a high spatial and temporal regularity and attend only a limited number of frequently visited locations [11].

Urban fleets undoubtedly constitute an important part of human movement in urban areas. As for this paper, we define an urban fleet as a fleet of several motorized vehicles, which predominantly roam within the boundaries of a city. Hence, this very broad definition comprises city-based logistic operators – such as parcel delivery services –, public social aid services and municipal utilities, to name but a few. Intuitively the movement of urban fleets does not follow the concept of an individual human being's life path as defined by Hägerstrand. It rather arises as one of the consequences of economic, social and administrative activities in urban areas. Therefore, travels of urban fleet vehicles are highly planned and limited to a certain range [12]. Outliers do not play an important role, in contrast to individual human mobility, where some few long distance travels may occur. That is why urban fleets are particularly suitable for e-mobility. Moreover, it is of considerable interest to urban policy makers to promote that urban fleets rely on "cleaner" transportation alternatives due to their current consequences on inner-city air-quality: urban fleets are one of the main causes of urban air pollution [13].

From this very brief introduction, we see that humans and urban fleets share common characteristics: both are to some degree predictable, return to very few locations, and have a majority of very short travels. This strongly indicates a potential for e-vehicles.

### 2.2 Data Mining and Movement Patterns

In computer science, data mining is known as the process of revealing information that is implicitly conveyed in a set of data [14]. For movement analysis, data mining helps to discover patterns inherently present in the trajectory data, but not visible at first glance. We refer to a movement pattern as a noteworthy relationship in movement data or any spatial or temporal regularity [15]. Literature distinguishes between two groups of movement patterns: patterns of single moving objects and patterns of multiple moving objects [16]. The latter play an important role for analyzing the trajectories of fleet vehicles with respect to e-mobility. An example for a pattern of a single moving object is *constancy*, which describes an invariant movement parameter (such as speed) over a certain time. In [17], trajectories are mined for occurrences of constant speed and non-constant speed (phases of acceleration or deceleration), as well as segments of non-constant direction of travel (course change).

In [15], Dodge et al. present a taxonomy of movement patterns. The taxonomy describes movement patterns with the help of movement parameters. A movement parameter represents one specific characteristic of the moving object, e.g. its location, direction, speed or acceleration [18]. Moreover, the taxonomy structures movement patterns in hierarchically ordered classes. At the top level, Dodge et al. distinguish between generic and behavior patterns. Generic patterns apply to all moving objects no matter of which domain. Behavior patterns are valid for certain classes of moving objects – such as animals or eyes – only. The class of generic patterns is divided into primitive and compound patterns. Primitive patterns are atomic or non-decomposable patterns, whereas compound patterns are a composition of two or more primitive ones. The class of primitive patterns divides into patterns with spatial characteristics, temporal characteristics and spatio-temporal characteristics.

The taxonomy summarizes and structures all types of movement patterns that have so far been detected and described in literature. Hence, it rather loosely couples various approaches of how to formalize a movement pattern. Some of these approaches define patterns solely conceptually [19], whereas others specify them for and verify them in particular domains. These domains are very heterogeneous. They include the paths of football players on a football pitch [20], trajectories of individual motorized traffic in urban areas [21], or the movement of the pupil in the human eye [22].

After having defined a movement pattern type conceptually, researchers apply data mining techniques to discover instances of this pattern in real-world movement data. For the present paper, floating car trajectory data represent the most valuable source of real-world data. Floating cars (FC) are mobile units equipped with positioning devices. These record the trajectory of the mobile unit. With its own movement a floating car reflects to some degree the flow of traffic in the network. In [21], FC-trajectories recorded in the city of Milan, Italy, are mined for three different movement patterns: *co-locations* in space – two or more vehicles visiting the same location (not necessarily at the same time), *moving clusters* – a set of vehicles moving close to each other for a certain time span, and *spatio-temporal sequences* – a list of locations visited by vehicles in an ordered manner. In [23], FC-trajectories collected by taxis in the city of Wuhan, China, are mined for occurrences of constant zero velocity patterns in order to find taxi pick-up and drop off points in a city.

### 2.3 Data Pre-Processing: From Single Points to Trajectories

Conceptually, a trajectory is a continuous path through space and time. From this follows that every time instant $t$ within the lifespan of a trajectory can be assigned a specific position $\boldsymbol{p}$ in a reference space. However, the conceptual model of a trajectory does not match with how movement data are recorded by literally all position fixing methods. Positions in space are sampled in an entirely discrete manner with predefined, mostly constant intervals between each two sampled points. Interpolation connects these discrete space-time tuples to a continuous space-time path [24]. Unfortunately, interpolation is merely "a good guess", of how the actual movement between two or more known data points might look like, no matter if it relies on simple linear regression or sophisticated polynomial functions. Hence, a trajectory does not represent the actual path of a moving object but is affected by uncertainty. This uncertainty grows indirectly proportional to the tem-

poral sampling rate: the lower the sampling rate, the higher the possible error between the actual and interpolated position. In addition to this, the positioning device itself affects the accuracy of the data. As for trajectories collected by Global Positioning System (GPS) devices the positioning error equals to around 13m horizontally and 22m vertically [25]. However, especially on inner city streets errors can grow significantly. Street segments surrounded by high buildings can cause shadowing and multipath effects, which have strong impact on the accuracy and availability of the GPS signal. Therefore we need to apply filtering procedures – such as Kalman filtering – to remove outliers from the raw trajectory data [26].

### 2.4 Graph Theory and Routing

Motorized movement strongly relies on an underlying road network. As for this paper, patterns do not occur independently of a road infrastructure. In order to mathematically model road networks, the present paper falls back on graph theory as proposed by Leonhard Euler. Graph theory defines a network as a set of nodes and edges, where a node is a point element that represents the intersection of at least three edges, and an edge is a line that links two nodes together [25]. Translated into the realm of road networks, nodes represent crossings whereas edges are the street segments between them. Strauss argues that edges and nodes sufficiently model simple networks [27]. He adds, however, that these very basic definitions do not take into account some important features of more complex and more realistic road networks: a street usually consists of lanes in different directions or, in case of a one-way road, of one single lane in one direction. Moreover, some crossings in the road network allow turnings from one edge to another, whereas for others, street signs might prohibit turns. Hence, we need to add topological information to the network to model the directionality of an edge and the possibility or impossibility to turn from one edge to another. For this purpose graph theory introduces two additional topological elements: arcs and traverses. An arc is a directed edge and represents a directed lane of a road. A traverse connects two nodes via a third node and allows to model turnings at a crossing.

Routing is the process of finding the shortest path between two nodes. Traditional routing algorithms aim at optimizing a path from a start node to a target according to a cost function. The cost function assigns each edge of a graph a value that describes how difficult it is to pass the edge [25]. Possible costs are the travel time along the edge, its geometric length or the monetary expenses required to traverse it. Hence, a routing algorithm finds the one optimal path that connects the start node to the target with edges that have – in sum – the least costs. Cost functions either rely on static or changeable information. For the latter, costs are adjusted dynamically according to the current traffic situation [28] or according to empirically derived information about traffic in the network. In [29], typical travel times for road segments at different times a day are derived and routing for fleets is optimized according to these.

## 3 Objectives, Hypotheses and Research Questions

The present paper divides into two parts. The first part analyses FC data to empirically assess the potential of e-vehicles to substitute petrol-driven cars while still meeting the mobility needs of urban fleets; the second part mines FC data in order to optimize routing strategies for e-vehicle fleets.

### 3.1 Simulating the Energy Consumption of E-vehicles

From section 2 follows that urban fleets have a considerable potential to rely on e-mobility, regardless of the e-vehicles' current shortcomings. The main objective of this part of the paper is to identify to what degree an urban fleet's daily tours qualify for e-mobility. This allows for quantifying the potential of e-mobility for urban fleets. We define a set of general travel parameters that affect the performance of e-vehicles routewise. These parameters have two characteristics:

- they can directly be mined from trajectory data (and the traversed road network)
- they influence the energy consumption of an e-vehicle.

From these parameters we derive a route-based model of energy consumption of an e-vehicle. Hence, the most crucial step of the research project is to verify Hypothesis 1. The approval of Hypothesis 1 enables us to answer Research Questions 1a and 1b. These in turn allow for quantifying the amount of an urban fleet's travels that qualify for e-mobility.

**Hypothesis 1:** *A trajectory of a traditional petrol-driven car recorded by a GPS device sufficiently allows for simulating the amount of energy that an e-vehicle would spend when carrying out the same travel.*

**Research Question 1a:** *If car-based travels of an urban fleet vehicle were carried out by an e-vehicle, how much energy would this e-vehicle have spent?*

**Research Question 1b:** *How would this energy consumption have affected the vehicle's state of battery charge?*

### 3.2 Optimized routing for e-vehicles

From [6] and [11] one may conclude that individual human travelling is distinct from a random walk. Hence, also collective human movement must exhibit some reoccurring regularities or patterns. Motorized human movement is clearly an important part of human mobility and, therefore, reflects some of these patterns. We argue that motorized traffic in a road network must be predictable – at least to some degree. Furthermore, we claim that this predictability of human travel affects the spatio-temporal change of traffic flow (cars per time interval) in a road network. We want to prove these assumptions in an empirical analysis of floating car trajectory data. The predictability of urban traffic is important for applications that rely on historic traffic data: only if we can guarantee that the flow of traffic shows similar characteristics within periodic intervals in the past, we can predict traffic flow and travel times for the future. This is, for example, crucial for enhancing routing with empirically mined data.

**Hypothesis 2:** *In urban areas, the movement of a floating car is predominantly influenced by traffic conditions. Hence, travel times, speed and acceleration retrieved from FC data indicate the flow of traffic along a road segment r at a specific time t. A road segment is defined as either an arc or a traverse in the road network (for definitions of both arc end traverse, see section 2.4). The flow of traffic reflects the traffic intensity along the respective segment. Long travel times, slow speed and frequent changes of speed correlate with a high traffic intensity.*

**Hypothesis 3:** *Traffic flow along a road segment is to some degree predictable. The regularity of human movement leads to periodic flow patterns in the road network. These patterns follow a temporal periodicity. We argue that each road segment in the road network has a characteristic flow pattern over time with a certain degree of fuzziness attached to it. The fuzziness describes how clearly the periodicity is visible. The floating car GPS data can reflect these flow patterns.*

**Research Question 2:** *How well do FC data reflect real traffic flows in the road network? To what extent do travel time, speed and acceleration derived from FC trajectories provide information on the amount of traffic along a road segment?*

**Research Question 3:** *How explicitly is the flow of traffic along a road segment governed by daily, weekly, monthly or other patterns? How fuzzy is the pattern found in traffic flow?*

# 4 Data

For empirical data mining we collect and analyze the movement trajectories of around 200 urban fleet vehicles and public transportation vehicles that move in and around the city of Salzburg, Austria, and its hinterland. The vehicles are equipped with GPS positioning devices. These record the position of each vehicle (latitude, longitude and height), a timestamp, vertical and horizontal dilution of precision and the available satellites. The temporal resolution of the measurements equals 1 second. The movements of the fleet vehicles are recorded over the duration of approximately one year, from January 2013 to December 2013. We assume that the data of all vehicles are pre-processed and filtered. This means that all outliers are removed and the recorded positions of each vehicle are connected to individual trajectories by linear interpolation.

# 5 Methodology

## 5.1 Simulating the Energy Consumption of E-vehicles

The first part of the methodology is dedicated to an extended analysis of movement trajectories and e-mobility. We decompose movement into its physical quantities, the so-called movement parameters [18]. We then summarize the most important methods on how to compare movement at these different physical levels. Moreover, we review the main characteristics of an e-vehicle's battery and the impact of different driving routines on the battery. This review allows us to identify those route based-parameters that mostly affect the energy consumption of an e-vehicle. From a preliminary perspective these include:

- the temporal duration of the trajectory
- the spatial length of the trajectory
- the speed curve of the trajectory
- phases of constant movement, acceleration and deceleration
- the gradient of the underlying road network (as a property of the path of the route)

With the help of these parameters we derive a route-based model for the overall energy consumption of a state-of-the art off the-shelf e-vehicle. As not all e-vehicles are similar with respect to battery dimensions and energy consumption this model has to be adapted to classes of e-vehicles or even to specific vehicle models. In a next step, we verify the model to a set of reference trajectories for which the overall energy consumption is known. If the model is reliable and Hypothesis 1 proves true, we continue with empirical data mining. In the data mining task, we apply the model for overall energy consumption of an e-vehicle to the filtered real-world trajectory data described in section 4. We segment the data set into single trips. A trip is herewith defined as a tour of one urban fleet vehicle that

i) starts and ends at the fleet's depot or any other location where charging the vehicle's battery is possible

ii) is followed by a time interval where the moving object remains static sufficiently long enough to completely charge the vehicle's battery.

This means that two tours are aggregated to one single trip if the interval between them does not provide enough time to re-charge the vehicle's battery. For each trip in the data we simulate the energy consumption of an e-vehicle according to the model. A trip qualifies for e-mobility if its simulated energy consumption falls below the energy that the battery could theoretically release within one battery cycle. This allows us to assess which share of all of a fleet's trips qualifies for e-mobility.

Moreover, we assess which impact the single route-based parameters have on e-mobility. This means that we simulate – for example – the energy an e-vehicle would spend if its movement were uniform (without phases of acceleration and deceleration), if its movement were slower, or if the single tours of a vehicle were short-

er. This helps us to understand to what extent changes in mobility behavior or simply better planning could alleviate the advent of urban e-vehicle fleets.

### 5.2 Evaluation of Floating Car Data

In order to use floating car data to optimize routing, we have to first asses how well this data actually indicates traffic flows and traffic intensities in a road network. In literature, trajectories of floating cars are widely used to reason about traffic flows. Ehmke analyzes FC data to predict travel times and to optimise navigation [29]. Hence, he assumes that travel times calculated from floating cars are dependent on traffic conditions rather than influenced by individual driving behaviour. In [30], FC data are mined for identifying flaws in urban planning. The authors argue that longer travel times indicate high traffic volumes and congested roads. Congested roads, in turn, expose flaws of urban planning. This information is a good first indicator for the potential of floating car data. However, we have to evaluate the suitability of our data in a truly empirical manner. This evaluation is based on the following steps:

We choose arcs and traverses in the road network of Salzburg that are likely to be passed by a significant number of floating cars. Then we record the traffic flow (number of vehicles passing by per time interval) in the field. We compare the ground truth data to the floating car trajectories of the urban fleets and verify whether longer travel times, slower speed and a high sinuosity of speed[1] correlate with a higher traffic flow. We repeat this procedure for the trajectories of public transport. Public transport has a fixed time schedule; all delays in that time schedule are caused by external traffic conditions and not influenced by personal driving behavior. In other words, public buses don't move slower because they want to, but because they have to. Hence, public transport should allow best to report on traffic flow, at least in areas where it does not use own bus lanes. We measure the deviation of the movement of public transport compared to other floating car vehicles and, thus, retrieve an indicator for the influence of personal driving behavior on FC data.

### 5.3 Regularity of Traffic Flow

In this part we verify the regularity of the traffic flow along each segment of the road network. Intuitively, a very predictable traffic flow represents one of the main prerequisites for enabling routing based on historical trajectory data. The verification of the regularity of traffic flow includes four steps: map matching, translating flow curves into symbolic representations, periodic pattern mining and modeling "regular" traffic flow.

As we want to measure the regularity of traffic flow along a road segment we first have to relate the floating cars' trajectories to a graph of a road network This process is referred to as map-matching [31]. In our particular case, we map the trajectories of the FC to the road network of the city of Salzburg. This network consists of three topological elements: nodes, arcs and traverses. In order to develop a suitable algorithm for matching trajectories, we adapt an existing map matching algorithm, which relates trajectories to simple nodes [31]. Map matching partitions the trajectories into sub-trajectories and assigns each of them to a road segment of the graph.

In a next step, we determine the flow of traffic along each map-matched sub-trajectory and consequently along each road segment. The flow of traffic is given by the curve of the function $f: v \rightarrow s$, where $v$ is the speed of the vehicle along the road segment $s$. Hence, the curve describes the change of the vehicle's speed when traversing the segment. Similar to the normalized weighted edit distance (NWED) [18], we cluster curves with similar amplitudes (speed) and frequencies (sinuosity of speed) in one class. We translate each class into a symbolic representation. We order all symbolic representations of all trajectories that pass the

[1] Sinuosity describes to what degree a curve deviates from a straight line. In this case it indicates how much the predicted flow of traffic deviates from uniform motion. A flow with a high sinuosity has many phases of accelerating and slowing down.

road segment in a time series. The resulting string of symbols represents all the movements along the road segment.

In a next step, we check the time series for periodicity. However, only road segments passed by sufficiently enough sub-trajectories are further processed, as only those allow making valid predictions of overall traffic flow. We apply an algorithm for mining periodic patterns in time series, amongst others proposed by [32]. The periodicity mining reveals repeating patterns in the symbolic representations with respect to a certain periodicity threshold. According to these we translate the periodically re-occurring intervals into a model of time-bins of similar traffic conditions along the road segment. Subsequently, we calculate the mean travel time $\mu_t$ and mean sinuosity $\mu_{sin}$ of the speed curves for each time-bin from those sub-trajectories that occur along the respective road segment. Both travel times and sinuosity have an uncertainty attached to them. This fuzziness reflects the standard deviation of the travel time $\sigma_t$ and sinuosity $\sigma_{sin}$ respectively. This uncertainty is a measure of how much we can "trust" the mean travel time and mean variability of speed.

### 5.4 Optimized Routing for E-vehicle Fleets

In this section we show one possible application field for the information we empirically mine in section 5.3. We develop a work flow to optimize routing of fleets that operate on e-vehicles. From the characteristics of e-vehicles we can follow that they have very specific demands for routing algorithms. Acceleration and deceleration along the path must be limited as they directly influence battery life. The same holds true for the gradient of the underlying road network. For fleets, predictable travel times are important for maintaining an optimal charge strategy.

We use the empirically mined information from section 5.3 to tailor routing algorithms to the needs of e-vehicles and fleets. A simple shortest-path finding algorithm relies on costs assigned to the edges of a network. The algorithm identifies the one path between a starting and an end point that requires minimal costs to traverse. We replace the simple and static cost function with a dynamically changing function. This function is a weighted average of i) the gradient along the road segment, ii) the mean travel time $\mu_t$, iii) the mean sinuosity of the speed curve $\mu_{sin}$, iv) the uncertainty of the travel time $\sigma_t$ and v) and the uncertainty of the sinuosity of speed $\sigma_{sin}$. We derive these dynamic components of the cost function from the time-bins of our model of regular traffic flow, except for the gradient of the road segment, which is static and retrieved from the map data. Therefore, the cost function changes dynamically according to the periodically changing traffic situation along the road. This cost function influences the routing process: if the average travel time $\mu_t$ is short, the motion is close to uniformity (small degree of sinuosity $\mu_{sin}$) and the standard deviation of travel time $\sigma_t$ and sinuosity of speed $\sigma_{sin}$ are small the road segment offers ideal conditions for e-vehicles. Hence, the value of the cost function during this particular time-bin is low.

We assign each arc and each traverse of the road network with the dynamically changing cost function and use it for calculating optimal paths. The methodology of the routing process itself closely relates to [29], with the only difference that our work calculates a weighted average, whereas [29] optimises routing according to travel time only. Hence, our routing strategy aims at minimizing the deficits of e-vehicles route-wise.

## 6 Conclusion and Outlook

In the present paper we propose a work flow to assess the potential of e-vehicles for urban fleets. This work flow fully relies on floating car data and the data's intrinsic properties. We present a methodology to evaluate the ability of floating car data to reflect traffic flows in a road network and we measure the regularity of these traffic flows. These are important prerequisite to use historical movement data for routing in general and routing of e-vehicle fleets in particular. Only if FC data describe past traffic flows in a network sufficiently we may use this data to predict future traffic conditions. Clearly, the more traffic flow follows a regular pattern and the less fuzzy this pattern is, the better we can predict travel times and speed variability along

each road segment. We propose a work flow to use this historical traffic information to optimize routing for e-vehicles.

In a follow-up work we aim at applying our work flow to the data set described in section 4. At the time of writing this paper, we have already started to record the first trajectories for this analysis. The empirical part of this work will strongly rely on data mining. Data mining is highly dependent on the input data and the temporal as well as spatial scale of investigation. Therefore, the methodology proposed in this paper might have to be revised and significantly adapted to the data.

As we record the movement of floating cars over a considerable period of time (over the duration one year) a subsequent research question may address the long-term results of data mining. How does the information we mine from the floating cars' trajectories change over time? This is particularly interesting when we think of traffic flows in the road network. Is the periodicity of flow static over the course of a year or is it subject to seasonal change? We will address this question in a future work.

## Acknowledgement

This research is funded by the Austrian Science Fund (FWF) through the Doctoral College GIScience at the University of Salzburg (DK W 1237-N23).

## References

1. Rifkin, J.: The third industrial revolution: how lateral power is transforming energy, the economy, and the world. Palgrave Macmillan, New York (2011)
2. Bingham, C., Walsh, C., and Carroll, S.: Impact of driving characteristics on electric vehicle energy consumption and range. Intelligent Transport Systems. Vol. 6(1) (2012) 29-35
3. Campanari, S., Manzolini, G., and Garcia de la Iglesia, F.: Energy analysis of electric vehicles using batteries or fuel cells through well-to-wheel driving cycle simulations. Journal of Power Sources. Vol. 186(2) (2009) 464-477
4. Neubauer, J., Brooker, A., and Wood, E.: Sensitivity of battery electric vehicle economics to drive patterns, vehicle range, and charge strategies. Journal of Power Sources (2012)
5. Fernández, L., San Román, T., Cossent, R., Domingo, C.M., and Frías, P.: Assessment of the impact of plug-in electric vehicles on distribution networks. IEEE Transactions on Power Systems. Vol. 26(1) (2011) 206-213
6. Hägerstrand, T.: What about people in Regional Science? Papers in Regional Science. Vol. 24(1) (1970) 6-21
7. Rinzivillo, S., Pedreschi, D., Nanni, M., Giannotti, F., Andrienko, N., and Andrienko, G.: Visually driven analysis of movement data by progressive clustering. Information visualization. Vol. 7(3-4) (2008) 225
8. Bartumeus, F.: Behavioral intermittence, Lévy patterns, and randomness in animal movement. Oikos. Vol. 118(4) (2009) 488-494
9. Nunner, T., Sidla, O., Paar, G., and Nauschnegg, B.: On-line measurement of ski-jumper trajectory: combining stereo vision and shape description. in *IS&T/SPIE Electronic Imaging*. 2010
10. Oirschot, H. and Houtsma, A.: Cursor trajectory analysis. Haptic Human-Computer Interaction (2001) 127-134
11. Gonzalez, M.C., Hidalgo, C.A., and Barabasi, A.-L.: Understanding individual human mobility patterns. Nature. Vol. 453(7196) (2008) 779-782
12. Schulz, A., Marker, S., and Schindler, V.: Entering the electric mobility market: an analysis of commercial vehicle fleets. in *VDE-Kongress 2010*. 2010
13. Keogh, D.U., Kelly, J., Mengersen, K., Jayaratne, R., Ferreira, L., and Morawska, L.: Derivation of motor vehicle tailpipe particle emission factors suitable for modelling urban fleet emissions and air quality assessments. Environmental Science and Pollution Research. Vol. 17(3) (2010) 724-739
14. Gianotti, F. and Pedreschi, D.: Mobility Data Mining and Privacy: A Vision of Convergence. in *Mobility, data mining, and privacy: Geographic knowledge discovery*, F. Giannotti and D. Pedreschi, Editors. Springer, Berlin (2008), 1 - 11
15. Dodge, S., Weibel, R., and Lautenschütz, A.K.: Towards a taxonomy of movement patterns. Information visualization. Vol. 7(3-4) (2008) 13

16. Jeung, H., Yiu, M.L., and Jensen, C.: Trajectory Pattern Mining. in *Computing with Spatial Trajectories*, Y. Zheng and X. Zhou, Editors. Springer, New York (2011), 143 - 177
17. Rehrl, K., Leitinger, S., Krampe, S., and Stumptner, R.: An Approach to Semantic Processing of GPS Traces. in *Proceedings of the 1st Workshop on Movement Pattern Analysis, MPA*. 2010
18. Dodge, S., Laube, P., and Weibel, R.: Movement similarity assessment using symbolic representation of trajectories. International Journal of Geographical Information Science. Vol. 26(9) (2012) 1563-1588
19. Gudmundsson, J. and van Kreveld, M.: Computing longest duration flocks in trajectory data. in *Proceedings of the 14th annual ACM international symposium on Advances in geographic information systems*2006, ACM: Arlington, Virginia, USA. p. 35-42
20. Laube, P., Imfeld, S., and Weibel, R.: Discovering relative motion patterns in groups of moving point objects. International Journal of Geographical Information Science. Vol. 19(6) (2005) 639-668
21. Giannotti, F., Nanni, M., Pedreschi, D., Pinelli, F., Renso, C., Rinzivillo, S., and Trasarti, R.: Unveiling the complexity of human mobility by querying and mining massive trajectory data. The VLDB Journal—The International Journal on Very Large Data Bases. Vol. 20(5) (2011) 695-719
22. Salvucci, D. and Joseph, G.: Identifying fixations and saccades in eye-tracking protocols. in *Proceedings of the Eye Tracking Research and Applications Symposium*2000, ACM: Palm Beach Gardens, Florida, United States. p. 71-78
23. Yang, Y., Yan, Z., Qingquan, L., and Qingzhou, M.: Mining time-dependent attractive areas and movement patterns from taxi trajectory data. in *Geoinformatics, 2009 17th International Conference on*. 2009
24. Macedo, J., Vangenot, C., Othman, W., Pelekis, N., Frentzos, E., Kuijpers, B., Ntoutsi, S., Spaccapietra, S., and Theodoridis, Y.: Trajectory Data Models. in *Mobility, data mining, and privacy: Geographic knowledge discovery*, F. Giannotti and D. Pedreschi, Editors. Springer, Berlin (2008), 123 - 150
25. Hofmann-Wellenhof, B., Legat, K., and Wieser, M.: Navigation: Principles of positioning and guidance. Springer Verlag, Wien (2003) 427
26. Lee, W.-C. and Krumm, J.: Trajectory Preprocessign. in *Computing with Spatial Trajectories*, Y. Zheng and X. Zhou, Editors. Springer, New York (2011), 3 - 33
27. Strauss, C.: A Note on Hierarchical Routing Algorithms based on Traverse-oriented Road Networks. International Journal. Vol. 4(2009) 239-264
28. Kim, S., Lewis, M.E., and White III, C.C.: Optimal vehicle routing with real-time traffic information. Intelligent Transportation Systems, IEEE Transactions on. Vol. 6(2) (2005) 178-188
29. Ehmke, J.F.: Integration of Information and Optimization Models for Routing in City Logistics. Springer New York (2012) 197
30. Zheng, Y., Liu, Y., Yuan, J., and Xie, X.: Urban computing with taxicabs. in *Proceedings of the 13th international conference on Ubiquitous computing*. 2011
31. White, C.E., Bernstein, D., and Kornhauser, A.L.: Some map matching algorithms for personal navigation assistants. Transportation Research Part C: Emerging Technologies. Vol. 8(1) (2000) 91-108
32. Elfeky, M.G., Aref, W.G., and Elmagarmid, A.K.: Periodicity detection in time series databases. Knowledge and Data Engineering, IEEE Transactions on. Vol. 17(7) (2005) 875-887

# Analysis of the Forest Transition at Usumacinta´s Region in Mexico

Casillas Hernández Claudia[1], Romero Nuñez Manuel[1], Nuñez Hernández Juan Manuel[2]
[1]Facultad de Ingeniería, Universidad Nacional Autónoma de México,
A.P. 70-360, Mexico City, 04510, Mexico
Chayus12@hotmail.com, manurommero@gmail.com

[2]Centro de Investigación en Geografía y Geomática "Ing. Jorge L. Tamayo"
Tlalpan 14240, Mexico City, Mexico
jnunez@centrogeo.org.mx

## Abstract

This article provides a detailed approach in order to complement the research of the forest transition theory. In long-term, changes in the forest cover in a country or region cannot be separated from the general pattern of land use changes. Moreover, this pattern is determined by changes in forest cover over time. Consequently the lack of policies can distort or affect social and economic incentives that can lead to a bias in favor of a definition of one type of land use over the other. From the perspective of Geomatic Engineering, we attempt to show the changes of the forest cover in the south of Mexico in the last 20 years with the help of Geographic Information Systems (GIS), and propose a new solution to the problem of forests and their direct repercussion in the subject of global warming.

Keywords: Forest Transition, forest dynamics, environment, Geomatic. GIS (Geographic information systems), FAO, REDD, Deforestation.

## Introduction

During the last two decades, Mexico has recognized the importance of conserve, manage and restore forest ecosystems and their environmental services. The country has developed public policies to promote sustainable rural development and a good management of forest resources. One of these strategies is the National Strategy REDD which aims to reduce emissions from deforestation and degradation by encouraging a socioeconomic, political and environmental culture of the importance and the consequences of forest resource management. However, in The Usumacinta Region in Mexico (RUM), has been detected an increase in deforestation and degradation related with a mismanagement of the forest resources.

The forest transition theory (FTT) relates a pattern in the change of forest cover over the time. This theory postulates that over time, forest cover decreases when the economy of a country is in development through the exploitation of natural resources, however at some point a transition occurs such that the decline stops and the opposite occur so the forest begins to expand.
Within the various interpretations of the FTT, there is one in particular that try to explain the problem with different variables such as political, ecological and economical factors that involve a transition in forest. This reinterpretation was given by Chomitz, he tried to explain it through an spatial analysis. In this work we will represent the reinterpretation of Chomitz in a GIS considering the social factors (population/ localities) and the processes of forest dynamics.

The main inputs used for the analysis were the cartography of Land use and vegetation of INEGI. Series II, III and IV (for the years 1993, 2002, and 2007) adapted to the definitions given by the FAO (Food and Agriculture Organization of the United Nations) and the population censuses for the years 1990, 2000 and 2010 given also by INEGI.

The particular focus of this study is to associate the interaction of the forest dynamics and the processes that are involved, relating it directly with the weight of localities and the population density, all over time. To identify how forest dynamics interacts with the localities it is necessary to know the statistical and spatial dispersion for each of the forest processes with their communities. Once processes were analyzed and targeted and recalling the need to divide the forests according their disturbance level and the environmental consequences of their conversion, we generated a final spatial model divided in three different types of forest

according to the definition given by Chomitz (2007), allowing to appreciate, in which stage of the forest transition is the region.

The proposed spatial analysis is performed within the field of Geomatics and with the support of the Geographic Information Systems (GIS), since it allows approaching the spatial dimension of the processes of the forest and its environment.

From a social perspective, forests provide wood, fauna and different products. Therefore, understanding forest dynamics, the causes and consequences, is necessary since forests are crucial in sustainability.

For the analysis of forest and forestry, land use is classified into four typifications according to FAO: Forests, Other wooded land, other land and water bodies. These categories are mutually exclusive and they join to the total area of land. On the other hand there are trees outside forests and they join an important category by studying the forest products and services derived, these areas are not assigned but they are part of the classification of other wood.

The definitions of forest in each country do not contain all or, sometimes, specific quantitative parameters for their homogeneity for their study. In fact, all developing countries that are competing for forestry projects or studies under this heading must have a similar concept in order to avoid any confusion or opposition, because to define a concept as forest implies to take into account different disciplines and therefore that each specialty denote singular characters, in order to reach a reasonable and suitable definition. The pressures on forests vary by country and region, and over time. This indicates that there are different factors that can cause the decrease of forest cover over time.

**The Forest Transition Theory (FTT)**

The Forest Transition Theory (FTT) relates a pattern of change of forest cover over time. It tries to explain why and how this transition happens in tropical forest areas mainly. This transition behaves as an inverted curve in shape of "U". Theorists posited that, over time, forest cover declines, but at some point a transition occurs, such that the decline halts and reverses, and forest cover thereafter expands. The first stage occurs when the forest cover is abundant and there are low deforestation rates, the second one happens when the forest cover decreases due to a growth and economic development in the cities creating demand for food and timber and the deforestation rates are high, the last stage occurs when there is a recover of forest as countries reach later stages of development, this transition happens over several years.

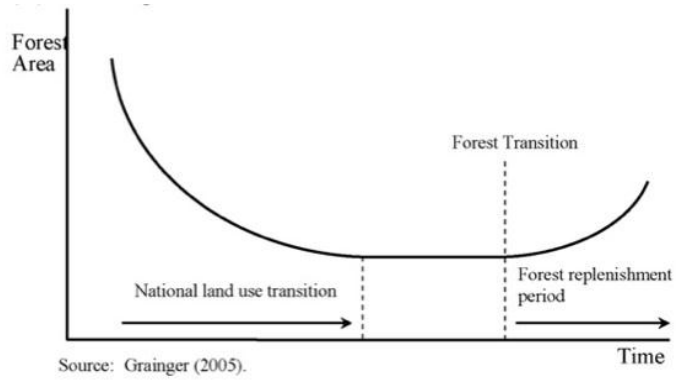



**Image 1. Curve of the Forest Transition according to Grangier**

Within the FTT, we can found various interpretations which try to explain with different variables the problem of forests over time. In particular Chomitz reinterpretation (2007) proposes the study of ecological, political and economic factors involved in the forest transition through the analysis of the spatial configuration of a region.

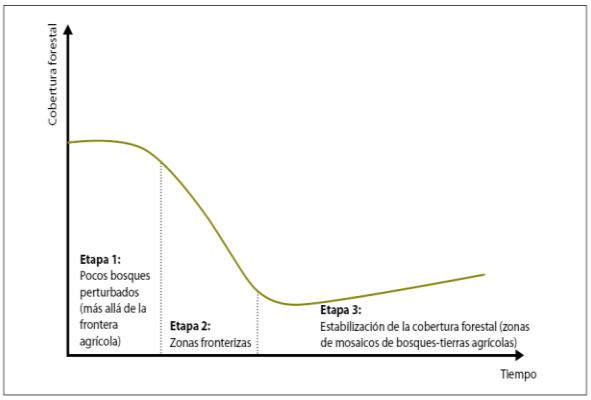



**Image 2. Reinterpretation of the Forest Transition Theory given by Chomitz**

It is necessary to differentiate forests according their deforestation, the extent and depth of poverty and the environmental consequences of its conversion in order to propose solutions and policies to mitigate the problem. Chomitz (2007) divided three general types of forests:

**Forest-agriculture mosaiclands:** Where land ownership is usually better defined, population densities are higher, and markets nearer, and natural forest management often cannot compete (from the landholder's perspective) with agriculture or plantation forestry. The biodiversity is in danger.

**Frontier and disputed areas:** Where pressures for deforestation and degradation are increasing, and land control is often insecure and in conflict.

**Areas beyond the agricultural frontier:** Where there is a lot of forest, few but largely indigenous inhabitants, and some pressure on timber resources.

## Mexico's Usumacinta Region

The Usumacinta's River is located in southeastern Mexico and in northwestern Guatemala. The Usumacinta´s River Basin covers a total surface of more than 7, 000, 000 ha, of which 58% is located in the territory of Guatemala and 42% in Mexico (Ecosur, 1996). The Usumacinta´s River, along with Grijalva's River, form one of the most extensive hydrologic regions in Mexico (11, 5000, 700 ha) and is the seventh largest in the world, with an annual charge of 105, 000, 000 of cubic meters of water (Martínez, 1978).


**Image 3. Uusmacinta's Basin.**

Within this basin, are areas of great importance, as Lancandona's Rainforest, recognized as the center of the highest biodiversity in the tropic, not only in Mexico, but in Septentrional America (De la Maza, 1997).

**Inputs and Methodology**

The main inputs used to generate the analysis were the SHAPES acquired from the cartography of "Land Use and Vegetation" of INEGI (for the years 1993, 2002 and 2007). From these SHAPES, and with the definitions given by FAO to evaluate forest dynamics, a cartographic analysis will be develop, and it will show from a statistical-spatial way, the land use and vegetation of the Usumacinta's Region in Mexico. For this it was necessary to achieve the inputs, however in order to relate the results with the definitions of FAO, the four classifications given above in the article were reclassified and were grouped so that they could be studied without affecting or changing its principal information according with the definitions. The proposed classes were divided as follows: Primary Forest, Secondary Forest, Other Type of Vegetation and Water bodies. With the resulting reclassification and with the help of the software ArcGis, it was generated a visualization or displaying of the three different series of "Land use and Vegetation" (Series II, Series III and Series IV) according to FAO classification, resulting the following images.

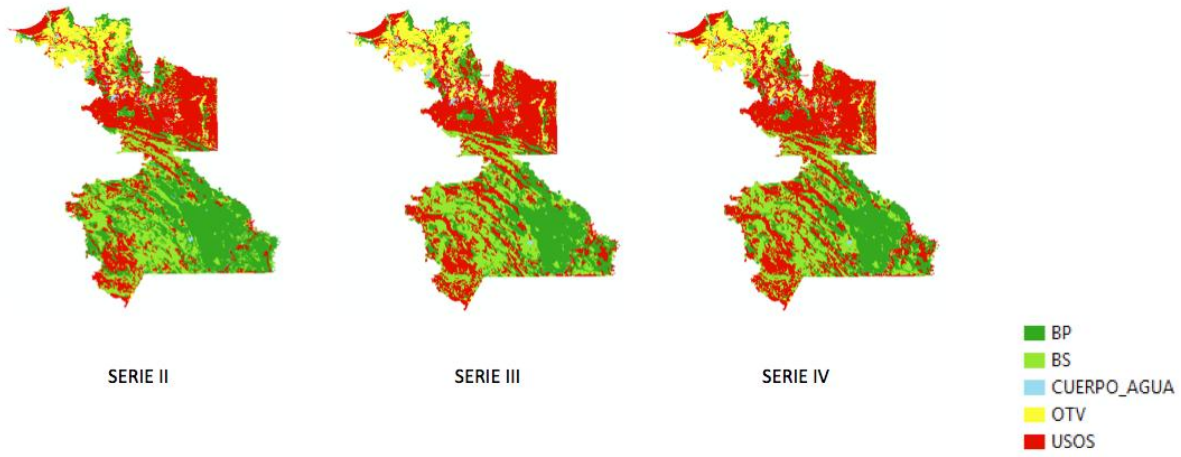



**Image 4. Reclassification of "Land Use and vegetation" according to FAO definitions.**

In the same way, population growth is analyzed, for this analysis it was decided to generate a database for each locality (local population) taking into account the population censuses for the years 1990, 2000 and 2010 from INEGI, in order to achieve a spatial analysis correlating the SHAPES of forest cover shown above. The data of Latitude, Longitude and height, the name of localities, the number of population, and the name of each municipality are some of the fields of the generated database. This database is designed with the intention of doing a spatial interpretation of the region with regard of their localities. From our tabular information and with the geographic coordinates we geospatialize the localities and the result is the following:

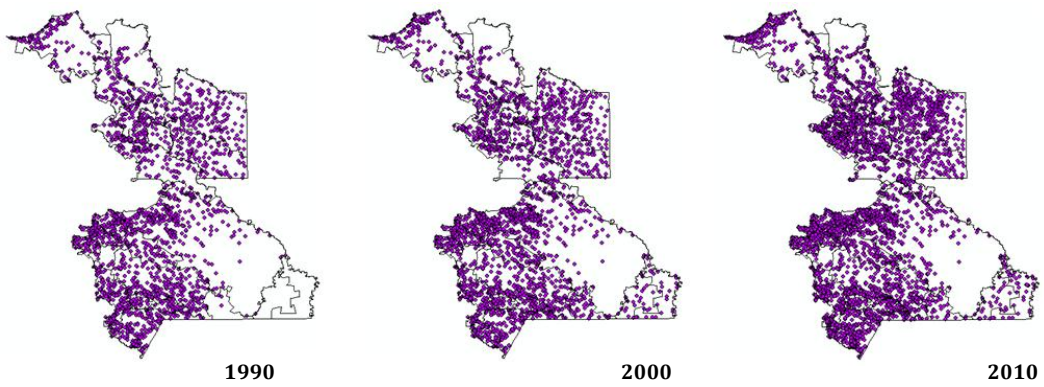



**Image 5. SHAPE of point of the localities according to population censuses (INEGI).**

As a result, we obtained a table in which it is shown the total number of localities per year, the total population and the average of population per locality. We must also take into account the population growth, the geographic dispersion of communities, and how much is the concentration of localities into a particular area. In the region in general we obtained the following.

| RUM | 1990 | 2000 | 2010 |
|---|---|---|---|
| **Número de localidades** | 2 174 | 2 898 | 4 559 |
| **Población Total** | 610 857 | 812 119 | 994 111 |
| **PROMEDIO** | 280 | 280 | 218 |

**Table 1. Numbers of localities and population for Usumacinta's Region in Mexico**

To determine which areas in the region are denser and have higher concentration of localities in one specific area it is necessary to determine a minimum radio of search that could conjuncts the nearest localities one of each other. The used method was "Near Analysis" from ArcGis, it obtains the minimum distance from one locality to other, it was obtain for each series mentioned above, and it shows how far the localities are form each other, inside the assigned radio. Subsequently, another process was used to determine the spatial density of the localities in the study region; the process was the method of Kernel (for the years 1990, 2000, 2010).

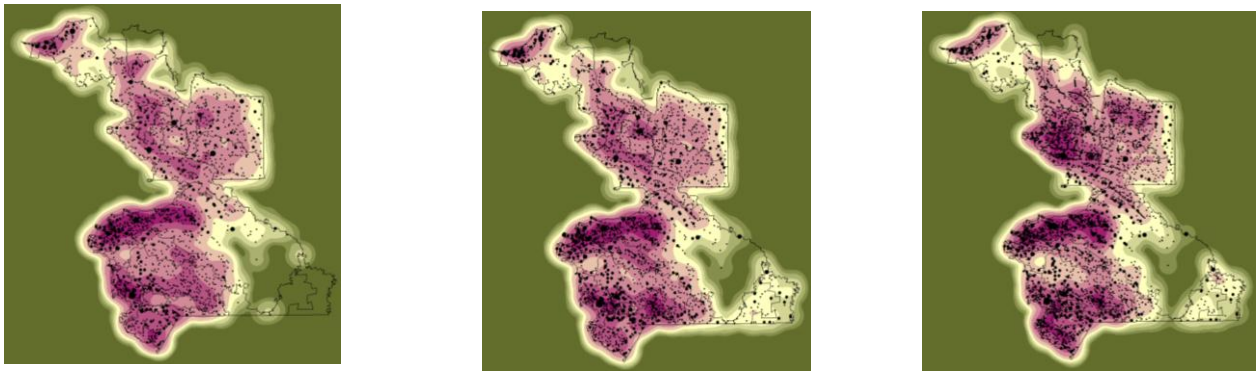


**Image 6. Kernel Method for the years of 1990, 2000 and 2010.**

**Nearest Neighbor Analysis**

It is important to know in a precise and quantitative way how does the spatial disposition un a map of points is and then to compare the observed structure with one of the three types of spatial dispositions of points: Random, Regular and Clustered.

In the Random disposition any localization in the map has the same probability to receive one of the points. In the regular, the points are located so as to cover the entire map in a complete, regular and exhaustive way and the distance that separates one point to another has to be always the same. At last, the clustered disposition is

defined by having most or all the points in few locations in the map, and most of the area is empty (Bosques, Sendra. 1997).

In order to obtain the Nearest Neighbor (R1) we have to do the following calculus.

$$R1 = \frac{Do}{Dm}$$

Where *Do*: is the Observed Distance and *Dm* is the theoretical average distance.

The value of R1 can range between 0 and 2.15, where 0.5 tends to be a cluster disposition, 1 a random disposition and 2.15 a regular disposition.

**Methodology 2**

In the next stage we obtained the necessary tools for the analysis of forest dynamics. To achieve this, first we had to think of a process that could help us identify the different forest dynamics for the three series in the region. Thus, it was decided to work with the method COMBINE from ArcGis which combines several RASTERS and it gives a single value that is assigned to a unique combination of values, giving as final data results several rasters, with different pixel values according to its combination.

Later we transformed the SHAPES of the three series to RASTER and finally we made the COMBINE method. The final result was a RASTER with 73 different pixel values. Each value represents one different combination in which the assigned pixel size was of 250.

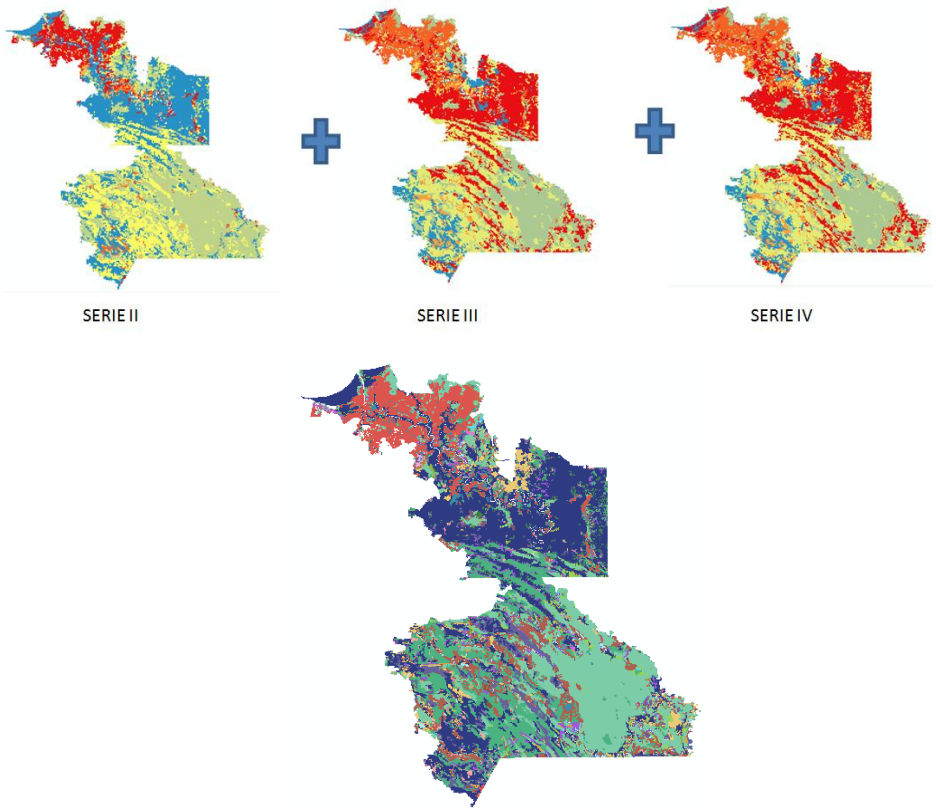



**Image 7. Combine method of the three series of FAO.**

Para analizar por separado cada una de estas clasificaciones se realizó un EXTRACT BY ATTRIBUTES en donde a partir del COMBINE se seleccionaron los atributos que presentaban la misma característica de dinámica forestal, esto se realizó a partir del SQL (QUERY BUILDER) el cual se uso para seleccionar el conjunto deseado de celdas RASTER. Once corroborated, the 73 classes were grouped according to the process of forest dynamics. The 73 classes already mentioned were grouped according to the following characteristics: Continuous primary forest, Continuous secondary forest, Deforestation, forest degradation, afforestation and reforestation.

To analyze separately each of these classifications, we do an EXTRACT BY ATTRIBUTES (ArcGis) in which from the COMBINE method, the attributes with the same characteristic of the forest dynamics were selected, and this was done from SQL (Query Builder) which was used to select the desired set of raster cells.

**Image 8. Corresponding area to Primary forest and Deforestation respectively.**

To work together with the localities (SHAPE point format) and the area obtained by the EXTRACT (raster) we chose to transform all of the RASTER extracted to polygons and get the area of each polygon and to link the information with the purpose of work it individually. From the CLIP (Analysis) tool, attributes (localities) that were superimpose to the polygons of each feature separately were extracted, thus obtaining a product that can only be analyzed statistically and spatially.

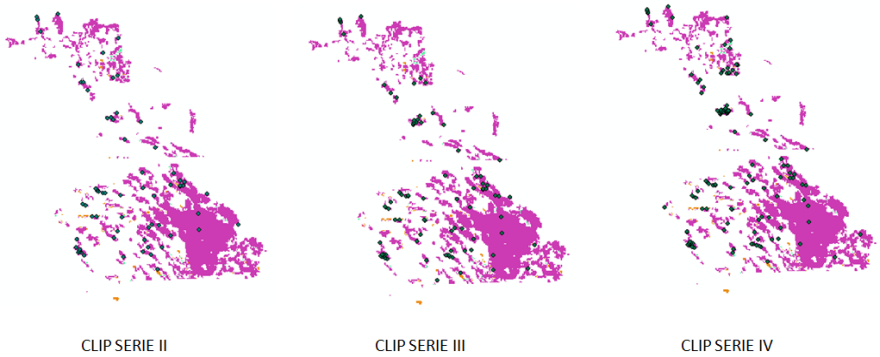



**Image 9. Analysis for Primary Forest.**

Finally the map of forest dynamics was the following:

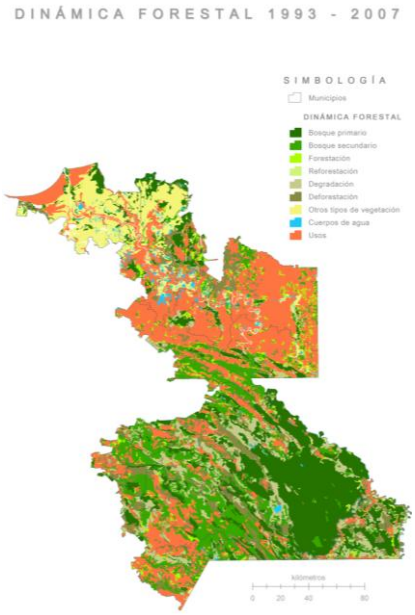



**Image 10. Map of Forest dynamics.**

Once having all necessary elements for the calculus of the statistical method, the calculation was performed with the Nearest Neighbor equation. The variables to determine the theoretical average distance are; n which is the number of localities, and A which is the corresponding area to each SHAPE.

$$Dm = \frac{1}{2 \cdot \sqrt{\frac{n}{A}}}$$

Once we get the theoretical average distance (Dm), we obtain the expected statistical with the following formula:

$$R1 = \frac{Do}{Dm}$$

The observed distance Do is obtained from the ratio of the weighted population PP divided by the total population of each year.

$$Do = \frac{PP}{Pb_x}$$

The following table shows the results of the Nearest Neighbor statistic (R1):

| | Nearest Neighbor | | | CHOMITZ |
|---|---|---|---|---|
| **FOREST DYNAMICS** | **1990** | **2000** | **2010** | |
| **SECUNDARY FOREST** | 0.8 | 0.9 | 1.5 | Forest edge |
| **DEFORESTATION** | 1.3 | 1.5 | 1.6 | forest edge |
| **AFFORESTATION** | 0.7 | 0.7 | 0.8 | Mosaiclands |
| **REFORESTATION** | 0.7 | 0.8 | 1.0 | Mosaiclands |
| **PRIMARY FOREST** | 0.5 | 0.5 | 0.6 | Forest core |
| **DEGRADATION** | 0.5 | 0.6 | 0.7 | Forest core |

**Table 2. Results of the Nearest Neighbor.**

And the generated Transition Matrix was the following:

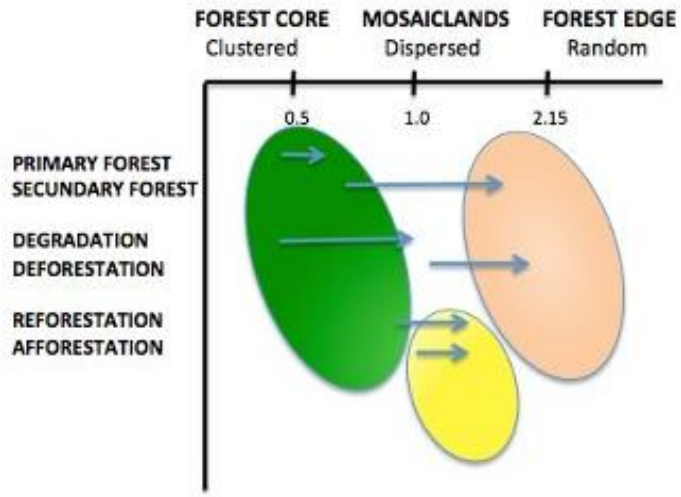



**Image 11.Forest transition matrix.**

## Results

The spatial model generated from the statistical dispersion of localities / population was generated in ArcGIS, in which we did a SHAPE for each stage of the Reinterpretation of the Forest Transition Theory of Chomitz. At the end we obtain the proposed spatial model of the Forest Transition in Usumacinta's Region in Mexico for the last 20 years.

The final spatial model based on the reinterpretation of Chomitz is the following:

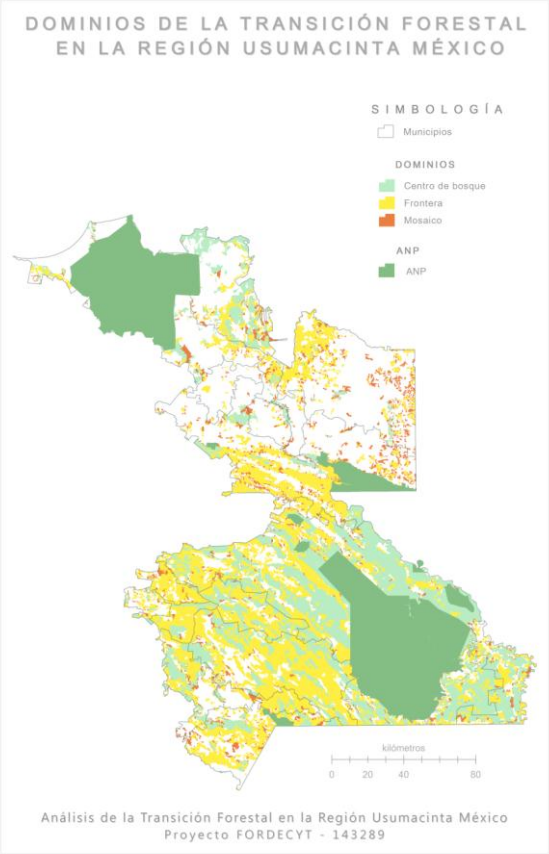



**Image 11.Domains of the forest transition in the Usumacinta's Region in Mexico.**

According to the analysis, the Mexico's Usumacinta Region is located in the First Stage of the forest transition so-called "Forest core", tending to the second stage, which is "forest edge". However, due to the municipal level study we realized that within a relatively small region, it can be found the presence of the three stages, some with higher percentage than others. It is noteworthy to mention that although in many cases the spatial analysis coincides with the described by Chomitz, other further important aspects were not considered that could define more precisely this reinterpretation of the forest transition theory.

By understanding how forest dynamics interacts with the distribution of localities and population density, we may consider appropriate policies in forestry and environmental management. The stages of the FTT try to define zones with certain types of characteristics and behaviors that help to treat the problem with different alternatives, because if you use a single forest policy or strategy for a whole region it will be likely to fail. It is important to consider the inclusion of REDD and its vision of the protection of community rights to their lands and resources.

## References

Angelsen, A., 2007. *Forest Cover Change in Space and Time: Combining the von Thünen and Forest Transition Theories.* World Bank Policy Research Working Paper 4117.

Angelsen, A., et al. 2009. *Reducción de emisiones de la deforestación y la degradación de bosques (REDD)*: Reporte de Evaluación de Opciones, 32-34. Washington, D.C. EEUU. http://www.REDD-OAR.org.

Bosque Sendra, J. 1997. *Sistemas de información geográfica*. Madrid, Ediciones Rialp, 2a edición corregida, 451 p.

Carvacho, Luis. *Geoprocesos utilizando Sistemas de Información Geográfica*. Instituto de Geografía Pontificia Universidad Católica de Chile. 2010 http://www.cepal.org/celade/noticias/paginas/8/35368/pdfs/14PUC-Chile.pdf

Centro de Investigaciones en Geografía Ambiental. 2011. *Fundamentos Para los Lineamientos Metodológicos Para Medir la Tasa de Deforestación y Degradación en México*. Michoacan, México.

CONAFOR, 2011. *Estrategia Nacional Para REDD+(ENAREDD+).* Primer Borrador. México.

Edward B. Barbiera, Joanne C. Burgessa, Alan Grainger. 2010. *The forest transition: Towards a more comprehensive theoretical framework.* Land Use Policy (27), 98–107.

Elizondo, D. Cuellar, N. Kandel, Susan. *Et al.* 2010. *Diseñando un Programa REDD+ que Beneficie a Comunidades Forestales en Mesoamérica. México. 21-36.*

FAO.2010. *Evaluación de los recursos forestales mundiales 2010*. Informe Nacional México, 5-28. Roma, Italia.

INEGI. (2012). *Catálogo de claves de entidades federativas, municipios y localidades.* http://www.inegi.org.mx/geo/contenidos/geoestadistica/catalogoclaves.aspx

INEGI. (2012). *Localidades - archivo histórico – consulta.* http://www.inegi.org.mx/geo/contenidos/geoestadistica/consulta_localidades.aspx

Kenneth, M. Chomitz. 2007. *At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests.* Informe del banco mundial sobre investigaciones relativas a las políticas de desarrollo. EE.UU.

Mather, A.S. 1992. *The Forest Transition*. Blackwell Publishing (4), 367-379.

Mather, A.S., 2007. *Recent Asian forest transitions in relation to forest-transition theory*. International Forestry Review (9), 491–501.

Molles M.C. 1999. *Ecology: concepts and applications*. Dubuque IA WCB McGraw-Hill publisher.

Stephen, G.P. 2007. *Grand theory and context-specificity in the study of forest dynamics: forest transition theory and other directions*. Blackwell Publishing, (59). Florida, EEUU.

- empty page inserted -

# Geographical Substantiation of Forming a Database «The Sub-Alpine Potential for the Sub-Arctic Farming»

Yury N.Golubchikov, Vladimir S. Tikunov, Irina N.Tikunova

Faculty of Geography, M.V. Lomonosov Moscow State University,
Vorob'ievy Gory, Moscow 119991 Russia
tikunov@geogr.msu.su

**Abstract.**
It is well-known that some mountains cultural plants are very important for the polar agriculture. The climatic condition of the northern border of agriculture is comparable with has the climatic conditions of the mountains with sharp continental climate, which is just very suitable for introduction of arctic plants in northern areas. N.I.Vavilov has tried to introduce in the Northern areas of Russia fast-ripening and frost-resisting plants, growing in high altitude areas. Several projects, which were not completed by N.I.Vavilov might be realized at the gardens in the countryside. While introduced this plants can be used for decoration in parks and for planting in forests. In the paper by Kovalevsky there were given the examples of mountain agriculture in different countries [4]. Atlas Information System (AIS) is proposed for inventory and preservation of ancient forms of cultural plants.

**Key words:** cultural plants, upper level of agriculture, polar agriculture, mountaineering, AIS

"A scientist should always be over the globe" – this was an opinion of Russian scientist N. I. Vavilov [9]. He was the first in the scientific world who understood the importance of high mountain plants for improvement of the Northern agriculture. Vavilov has found the correlation of the distribution of the cultivated plants in high-altitude zones of the mountains from the bottom to the upper territories with their distribution in the latitudinal zones of lowlands, from the South to the North.

If the humid tropics and subtropics are characterized by the unprecedented variety of wood species, there are optimal conditions for the development of high biodiversity, especially the diversity of the first year herbs (annual grasses), which includes the most important cultivated plants. While climbing up in the mountains, one can observe the same curious shift from lowland varieties of cultivated plants to subalpine varieties. Among them are hidden many of the primary forms, which gave rise of all our cultivated plants.

Agricultural crops in mountains quite often differ gigantism and high accumulation of sugar. In South Georgia, at an altitude of 2200 m individual instances of radish reach 600 g, black radish - 2 kg, potatoes - 800 g [3].

The highest physiological limit of agriculture is located in the mountains with a sharply continental climate, which is largely similar to the natural conditions of the continental North. If there are no other opposing factors, the upper and northern limit of crop production coincides with an average temperature of summer 5-8 degrees. Moreover, early maturing varieties of many agricultural crops in the mountains and the Arctic are very cold-tolerant plants - usually barley or potatoes. But the healthfulness of their properties is much higher than our usual varieties.

The highest barley are in the mountains of Central Asia, on the shore of Tibetan Lake Dangrayum (31 ° 15 N), the upper limit of agriculture reaches 4660 m [4], and there is an information that in Southern Tibet hull-less barley grown even 4900 m [5].

The upper limits of agriculture are described in fig. 1. Reason for the agricultural limitation on the upper mountain level were described in the article by G. V. Kovalewskij [4] with an additions information of the authors. The heights of the upper forest boundary are given on the basis of the work of P. Wardle [11], S. Arno and R. Hammerley [2], there was some additional information included as well. Such a boundary for the forest in the mountains of the Central Asia there is often lower because of the specific high-altitude zonation and often shrubs mark this border.

| Area | Latitude (◦) | The height of the upper limit of the forest (m) and forming tree species | The height of the upper limit of the agriculture (m) and forming of its culture |
|---|---|---|---|
| Scandinavia | 61 | 1000, *Betula pendula* | 700-800, barley, oats, potatoes |
| Northern Okhotsk Sea (township Arka, Ohota valley) | 60 | 400-600, *Larix daurica* | 800, cabbage, potatoes |
| Great Britain | 52-57 | 500-700, *Pinus sylvestris* | 400, barley, rye |
| Eastern Sayan (Belskie golts, township Botogol) | 52 | 1600-2200, *Larix sibirica, Pinus sibirica* | 2240, radish, black radish, potatoes, cabbage |
| Altai (Lake Markakol) | 48 | 1800-2200, *Pinus sibirica, Picea obovata, Larix sibirica* | 1600, cabbage, barley |
| Carpathians | 46-47 | 1800-2000, *Pinus sibirica, Picea abies* | 1200, barley, oats, rye, flax, hemp, potatoes |
| Mongolian Altai | 46-47 | 2500, *Larix sibirica, Pinus sibirica, Picea tianchanica* | 2130, barley, oats |
| Swiss Alps | 46 | 2250-2300, *Larix decidua, Pinus sibirica* | 2480, turnip, radish |
| | | | 1200, grapes |
| Apennines | 44-46 | 2000-2300, *Fagus sylvatica, Pinus sylvestris* | 2000, barley, rye, potatoes |
| Pyrenees | 42-44 | 2100, *Pinus montana* | 1800, rye, potatoes |
| Chechnya | 43 | 2000-2200, *Pinus sylvestris, Betula raddeana and B. pubescence, Fagus orientalis* | 2100, barley |
| Dagestan | 41-42 | 2000-2400, *Betula raddeana and B. pubescence* | 2490, barley |
| Lesser Caucasus | 40-41 | 1800-2000, *Fagus orientalis, Acer trautvetteri* | 2700, barley |
| | | | 2000-2100, apple, pear |
| | | | 1700, grapes |
| Tianshan | 40-41 | 2600, *Picea tianchanica* | 2700, barley |
| Alai Range | 39-40 | 2500, *Juniperus seravschanica* | 2980, barley |
| Zeravshan range | 39-40 | 2600, *Juniperus seravschanica* | 2500, barley, peas |
| Hissar Range | 39 | 2700, *Juniperus seravschanica* | 2700, barley, peas |
| Ridge of Peter Great | 39 | 3000, *Juniperus seravschanica* | 2890, barley |
| Minor Asia | 38-40 | 2000, *Fagus orientalis, Picea orientalis, Juniperus excelsa* | 2800, carrot |
| Sicily (Etna) | 38 | 2300 *Fagus sylvatica* | 1700, rye |
| U.S. Cordillera | 37-40 | 3400-3600, *Picea engelmannii* | 3100, barley, potatoes |

| | | | |
|---|---|---|---|
| Nanshan | 37-39 | 4100, *Hippophae rhamnoides* | 3100, barley, oats, lettuce |
| Yazgulem ridge | 38 | 4200, *Berberis kaschgarica* | 2720, barley |
| Western Pamirs | 37-38 | 4200, *Berberis kaschgarica* | 3500, barley, peas |
| | | | 3400, rye * |
| | | | 3000, apricot, mulberry |
| | | | 2900, county<br>2800, apple, pear |
| | | | 2700 beans |
| | | | 2400, cherry, walnut |
| | | | 2320, grapes |
| | | | 2200, peach |
| Rushan and Shugnan ridges | 37-38 | 4200, *Berberis kaschgarica* | 3200-3600, barley |
| | | | 2770, apricot |
| | | | 2590, apple |
| Andalusian mountains (massif Sierra Nevada) | 37 | 3300-3650, *Pinus albicaulis* | 2700, rye, potatoes |
| Kunlun | 36-37 | 3600, *Picea tianchanica Juniperus sabina* | 4600, barley |
| Central Japan | 35-36, | 2500-2600, *Picea ajanensis, Abies veitchii, Larix kaempferi (Pinus pumila* up to 3200) | 2000, mulberry |
| Hindu Kush (Badakhshan) | 34-37 | 3500-4000, *Juniperus polycarpos, Pinus wallichiana, Pinus gerardiana* | 3480, barley |
| | | | 3300, spring wheat |
| | | | 3000, rank * |
| | | | 3020 apricot<br>2800, opium poppy * |
| | | | 2700, chickpeas * |
| | | | 2650, cucumber, carrot |
| | | | 2580, corn |
| | | | 2300, grapes |
| | | | 2100, rice, cotton |
| Ladakh | 34-35 | 3500-4000, *Betula utilis, Juniperus polycarpos* | 4570, barley |
| Lebanon | 33-35 | 2000, *Abies cilicica, Cedrus libani* (juniper up to 2400) | 2000, barley, wheat, corn |
| Zaskar | 33-34 | 3500-4000, *Abies cilicica, Cedrus libani* | 4170, barley |
| Moroccan Atlas | 30-32 | 2600-2900, *Cedrus atlantica* (juniper and rhododendron up to 4700) | 2000, potatoes |
| Tibet, the Karakoram and the northern slope of the Himalayas | 31 | 3500-4000, *Betula utilis, Juniperus polycarpos* | 4900, barley * |

| | | | |
|---|---|---|---|
| | | | 4500, Tatar buckwheat *, peas *, mustard *, potatoes *, * turnip, radish * |
| | | | 4200, oats *, beans* |
| Lake Dangrayum (the border of Nepal and China) | 29-30 | 3600, *Betula utilis*, rhododendron | 4100, wheat *<br>4000 apricot * |
| | | | 3900, millet * |
| Lhasa | 30 | 3600, *Betula utilis*, rhododendron | 3660, peach *, orange *, walnut * |
| | | | 2850, dry valley rice *, grapes * |
| | | | 2700, amaranth * |
| West China | 28-33 | 3600, *Centralasian juniper* | 4000, barley |
| | | | 2900, corn |
| Central Himalayas (Nepal) | 27-28 | 3600-3800, *Betula utilis*, rhododendron | 4230, barley, turnips, radishes, potatoes |
| Eastern Himalayas (Sikkim) | 27-28 | 3600-4000, *Betula utilis, rhododendron, Picea smithiana, Abies densa* | 3200, barley |
| Eastern Tibet | 27-28 | 2600-2900, *Pinus pinaster, Larix pantanii, Picea tianchanica* (juniper and rhodo-dendron up to 4700) | 3900, barley |
| Taiwan | 24 | 3600, *Abies kawakamii, Picea alcoquiana* | 3500, barley, oats |
| Yemen | 15 | 2700, *Acacia senegal, Juniperus phoenicea* | 2600, barley |
| Ethiopian highlands | 9-11 | 3000-3500, *Podocarpus sp., Euphorbia sp.* | 3900, barley, teff |
| Venezuelan Andes | 10 | 4200, *Polileptis serikea* | 3300, barley, peas, eye |
| New Guinea | 6 N.L. | 3900-4000, *Podocarpus kompaktus* | 2500, barley, potatoes |
| Ecuadorian Andes | 0-3 S.L. | 3800-3900, *Polyleptis sp.* | 3500, barley |
| Kilimanjaro | 4 S.L. | 3800-4000, *Yushania alpina, Hagenia abyssinica, Erica arborea* | 2200, barley |
| Colombian Andes | 0-10 S.L. | 4000-4200, *Polyleptis sp.* | 3700, barley, potatoes |
| Peruvian Andes | 2-12 S.L. | 4000-4200, *Polyleptis sp.* | 4400, potatoes |
| | | | 3700, alfalfa |
| Bolivian Andes | 10-22 | 4900, *Polyleptis tomentella* | 4200, barley, potatoes, eye, quinoa |
| Chilean Andes: tropical zone | 19-24 | 3500, *Polyleptis racemosa, Nothofagus sp.* | 3800, potatoes |
| Patagonian Andes | 23-28 | 2500, *Polyleptis racemosa, Nothofagus sp.* | 3700, potatos, quinoa |
| Chilean Andes: subtropical zone | 29-35 | 2500, *Polyleptis racemosa, Nothofagus sp.* | 3200, potatoes, barley |
| Chilean Andes: temperate zone | 40-44 | 1700-1800, *Nothofagus menziesii* | 1000, potatoes |

Fig. 1. The upper limits of the forest and agriculture in the mountains of the world. * The highest point in the world.

N.I. Vavilov [8] has found the significant similarity between the alpine plants of Hindu Kush, Pamir, the Ethiopian Highlands, and the Atlas with arable crops of the Russian North. Rye and oats in subtropical mountains are considered as weeds at wheat fields. It has never been cultivated at low altitudes, and even rye is translated from the local language as "a plant that invades the wheat fields." But at the higher heights rye and oats are often cultivated and entirely replacing wheat.

The same situation we can observe moving to the north. At the most southern areas there is just wheat fields. Rye and oats are weeds there. But further to the north, rye and oat is the most popular plant, which came from farmers of Finnish tribes. In the river basins of the Western Pamirs at an altitude of 2700-3000 m N.I. Vavilov has found primary northern flax-fiber, which came there from Russia. There was found rye and very large corn, twice exceeding European varieties. A variety of spring wheat, barley, and peas is the same as in Siberia and northern Europe.

Furthest in the mountains there are barley found any cultivated cereal plants due to the short growing season. Something like this is observed at the far north. On the southern coast of Norway Varanger Fjord, near the border with Russia, the barley fields cover all territory till the shores of the Arctic Ocean. Further to the norther there are potatoes, oats, rye and wheat. In the Western Pamirs barley and peas are grown up to 3500 m below the area where potatoes, wheat and rye grow. At an altitude of 3400 m there is a boundary for the rye culture.

N.I.Vavilov has developed successfully matured high-class Mediterranean and Ethiopian barley and oats at the polar stations in the Khibiny and Pechora. Scientists are predicting a huge value of wild mountain forms of crops for the northern agriculture. That's why it is important to collect seeds from the ancient centers of agriculture, as a scientist N.I.Vavilov did.

N.I.Vavilov paid special attention to the implementation of potato species from the Andes. All know potatoes were borrowed from the Indians of the island of Chiloe off the coast of Southern Chile and all European selection was based on these 2-3 random samples of the same species. Hence the scientist brought 18 new potato varieties and most of are growing at far north successfully and are having normal tubers and exceptional fruiting. Some of the wild species with small tubers was resistant to frost, which carried lowering the temperature to -8 degrees.

Alpine plants, not only can be used in the northern agriculture, but also marked by rapid development. Characteristically, in the mid-latitudes such a successful high-productivity was not found. The reason is simple: plants collected in the mountains, near the snow border, should be growing in similar periglacial conditions in the North.

Researchers of Polar Alpine Botanical Garden in Chibins proved that it is possible to grow there more than 1200 useful plants from different climatic regions. Exotic alpine species were very good growing there, some of them has very high speed of development in the North, and the faster than in highlands. 68 species of alpine and subalpine perennial herbs of the Himalayas was good fruiting in Khibiny, reaching the age of 25-30 years or more. Among them there was food, medicinal and ornamental plants [1].

Some of projects, unfinished by N.I.Vavilov, can be implemented in private gardens, for example the introduction of a great variety of different plants could be done. Mountaineering and mountain tourism in this field might be successfully combined with the summer-resorts, cottage holidays and relaxing.

William Stefansson [7] wrote that the Spaniards sought gold in America, not potatoes. But the value of the tubers brought far surpassed all the gold mined in the world. In periglacial areas there are a lot of stored reserves for world agriculture. But their wealth decreases dramatically nowadays. In Asian Highlands disappeared hundreds of varieties of hard and soft wheat's, and the Ethiopian Highlands - many types and varieties of barley. N. Vavilov and D.Bukinich [10] identified primitive forms of cereals, carrots, and other crops in the Western Pamirs and the mountains of Afghanistan. They are important plant for the North, but it is now hopelessly drowned in the mass of diverse seed material. Entire survey should be conducted with no guarantee of finding anything better existed here. There was a catastrophically quick decline in the reserves of wild nuts and fruits in the mountains of Tajikistan, Kopetdag, Kyrgyzstan, and Altai. The same time there was rapidly growing crops of tobacco and narcotic plants. Not only drags prevail in the former collective and state farm fields, but also melons, vegetables and fruit, as in home gardens.

Preservation of ancient forms of cultural plants is an important part of protection of biodiversity. It is important to protect wild species. For this purposes it is very important to create a specialized information system, for example Atlas Information System (AIS) [6]. This system can integrate a variety of information resources, simulate, visualize and perform various analyzes. In the Integrated Mapping Laboratory of the M.V.Lomonosov Moscow State University, together with other departments of the Geographical faculty and

other organizations of Russia, we had began to develop the AIS "Russian Arctic". One of the initial stages of its creation we had formed a database of the main mountainous areas in the world, considered as analogues of the Arctic environment. One of the thematic subjects of this work is the characteristic of the high-altitude farming and agriculture.

## Acknowledgements

The research was supported by the Russian Fund of Basic Research and the National Science Council of Taiwan (project 11-05-92004) and the Russian Geographical Society (projects № 33/08/2011 and № 38/08/2011).

## References

1. Andreev, G.N.: Introduction of herbaceous plants in the Subarctic. Nauka, Leningrad, (1975). In Russian.
2. Arno, S., Hammerly, R.: Timberline. Mountain and Arctic Forest Frontiers. Seattle, (1990) 304 pp.
3. Davitaia, F.F: Problems in studying and protecting mountain in the USSR. MAB. Moscow (1979). In Russian.
4. Kovalevsky G.: Vertical farming zone and upper limits of agricultural plants in the mountains of the world.
   Izvestia of the Geographical Society, vol. 70 (1938). In Russian.
5. Mei'e R., Renzhang Y., Haosheng B.: An outline of China's Physical Geography. Beijing (1985).
6. Ormeling F.: Atlas Information Systems. 17th Int. Cartogr. Conf. and 10th Gen. Assembly ICA. Barcelona,
   Sept. 3rd - 9th, 1995. Proceedings, vol. 2, Barcelona, 1995, pp. 2127-2133.
7. Stefansson V.: The new country in the North. Moscow (1933). In Russian.
8. Vavilov N.I.: Selected Works in 5 volumes. Problems of origin, geography, genetics, plant breeding, crop and
   agronomy, vol. 5. Moscow – Leningrad (1965) 786 p. In Russian.
9. Vavilov N.I.: Speech on the fiftieth memory N. Mikluho-Maclay. Soviet pedagogy 8 (1988). In Russian.
10. Vavilov N.I. Bukinich D.D.: Agricultural Afghanistan. L., (1929).
11. Wardle P.: Alpine timberlines. Arctic and Alpine Environments. London (1974).

# The "Ejido" as a Focal Unit for Spatial Analysis of Nature-Society Relationships

Daniel López L.[1], Aristides Saavedra G[2]., Luis Castellanos F.[3], Jorge Homero Alfonso V.[4]

[1,2,3]Centro de Investigación en Geografía y Geomática Ing. J. L. Tamayo
Contoy 137, Lomas de Padierna, Del. Tlalpan, CP 14240, México D. F
dlopez@centrogeo.org.mx, asaavedra@centrogeo.org.mx,
lcastellanos@centrogeo.org.mx

[4]Instituto Tecnológico de Comitan, Ingeniería en Desarrollo Comunitario
Comitán Chiapas, México
homerin_hit@hotmail.com

**Abstract.** One of the biggest changes in the nature of geographic knowledge over the past fifty years has been the development of relevant spatial theories about the location, the arrangement and distribution of objects and geographical events and space-time interactions between their physical and human components. On the other hand one of the most pressing needs in territorial planning and the design of public policies at the local level is the availability of spatial information at this level. This study shows how the "Ejido" - the most common landtenure in Mexico - can serve as a focal unit for spatio-temporal analysis of nature-society relationships. As a key concept to analyze these relationships is the "farming system" which corresponds to the modes of agricultural exploitation of space by a society, result of the combination of natural, socio-cultural and economic factors. The ejido/community was considered as part of a self-organized hierarchy where the top level of analysis corresponds to the municipality or watershed units, and the lower level to the plots of the ejidatarios. For the characterization of agrarian systems, 25 communities were interviewed. This information was supplemented with data from the Population Census. Using spatial analysis, a geospatial hierarchical model was built (with geology, geomorphology, climate and vegetation land use attributes), which served as the basis for spatial analysis of agrarian systems and their relationship with environmental characteristics. Based on spatial data analysis a typology of agricultural systems was generated, grouping them in 11 types of systems, for which their spatial distribution and its relationship with environmental characteristics were mapped. Additionally for each one of community/Ejido, it was possible to show the spatial distribution of the status of the different types of capital (natural, social, cultural and economic). In conclusion, the project allows explicitly show and analyze the large spatial heterogeneity that may exist among municipalities entities, their knowledge would allow the design of better public policies, as well as a more realistic approach to local problems, resulting from the interaction of the social actors with the environment.

**Keywords:** Nature, environment, interactions, spatial analysis, agricultural systems

## 1. Introduction

The understanding of the nature-society relationship has been a constant theme throughout the history of geography. Today this aspect is becoming more relevant because the landscapes are increasingly cultural, which has the particularity that the services provided are based less and less in ecosystems not disturbed, but rather a complex and extensive human settlements and land use history (Antrop, 1997; Jones-Walters, 2008). During the last fifty years, one of the biggest changes in the form of geographical knowledge has been the development of relevant spatial theories about the location, the arrangement and distribution of geographical phenomena and the spatial interactions between physical and human components of these phenomena (Golledge, 2002).

Small farmers produce much of the developing world's food. Yet, they are generally much poorer than the rest of the population in these countries, and are less food secure than even the urban poor. Therefore, one challenge for developing countries is to identify spatially, specific agricultural and rural development needs and opportunities, and to focus investment in areas where the greatest impact on food insecurity and poverty will be achieved. Investment priorities and policies must take into account the immense diversity of

opportunities and problems facing small farmers. This identification and resource allocation process can be facilitated by analyzing farming systems in order to develop an understanding of local factors and linkages. In the course of this analytical process it is also extremely helpful to be able to aggregate locations with similar development constraints and investment opportunities through the application of a farming systems framework.

A farming system (Agrarian Systems, Land use systems, depending on the analysis scale) is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate. The Farming System Approach considers both biophysical dimensions (such as soil nutrients and water balances) and socio-economic aspects (such as gender, food security and profitability) at the level of the farm – where most agricultural production and consumption decisions are taken. The power of the approach lies in its ability to integrate multi-disciplinary analyses of production and its relationship to the key biophysical and socio-economic determinants of a farming system (Dixon J. Gulliver A. and Gibbon D., 2001). This approach allows the connection between social and ecological systems, and therefore will allow understanding the key interrelations that exist between these systems.

There are only few studies that analyze farming systems explicitly addressing the spatial context. At a global level, Dixon J. Gulliver A. and Gibbon D., (2001) mapped the major farming systems; Kruska, Reid, Thornton, Henninger, and Kristjanson (2003) and Wint and Robinson (2007) mapped farming systems in the developing world from a livestock perspective using spatial data on agro-climatology (length of growing period), land cover, and human population density.

At regional level, Verburg and van Keulen (1999) analyze the spatial distribution of livestock in relation to land use change in China. A more detailed mapping of farming systems for a region in Northern Argentina was presented by Duvernoy (2000). In Mexico, only one study is known about mapping farming systems, at local scale (centroGeo, 2002)

The objective of this study was shows how the "Ejido" - one of the most common land tenure in Mexico - can serve as a focal unit for spatial analysis of nature-society relationships and accounts for spatial variation in environmental and socio-economic conditions to explain differences in farming systems across a region. The ejido/community was considered as part of a self-organized hierarchy where the top level of analysis corresponds to the municipality or watershed units, and the lower level to the plots of the ejidatarios.

The purpose of this geographical perspective of the agrarian systems analysis is increase our understanding of the relationships and variations of those systems and obtain a more complete knowledgebase for interpreting human–nature relations, in aspects such as the vulnerability of agricultural systems to global environmental change, at scales ranging from local to the global and contribute to design of better public policies, as well as a more realistic approach to local problems, resulting from the interaction of the social actors with the environment.

## 2. Methods

The study area is in Santo Domingo watershed, which comprises the greater part of the Las Margaritas municipality and a small sector of the Independencia municipality. The Santo Domingo watershed is part of the great Usumacinta River basin (see Figure 1). The selection of the ejidos/communities to study was based on the following criteria: accessibility of services by communities (based on its geographical location with respect to the municipality settlement or the presence of services within or near community) and the knowledge about some communities concern with their farming systems. According to these criteria 4 zones were selected, namely (see Figure 1): a) San Juan Chamula, b) Vicente Guerrero - Rosario Buenavista, c) Las margaritas – Yasha, and d) Los Ranchos. The communities studied in each sector are listed in table 1.

To characterize the study area and define the biophysical characteristics associated with each ejido/community, through spatial analysis, a geospatial model was built based on the following information: physiographic landscapes (Saavedra A. and Castellanos L., 2012), slopes (calculated from Shuttle Radar

Topographic Mission elevation model – SRTM), land use – land cover (supervised classification based on SPOT image, 2008), soil map (, series II, INEGI, 2009).

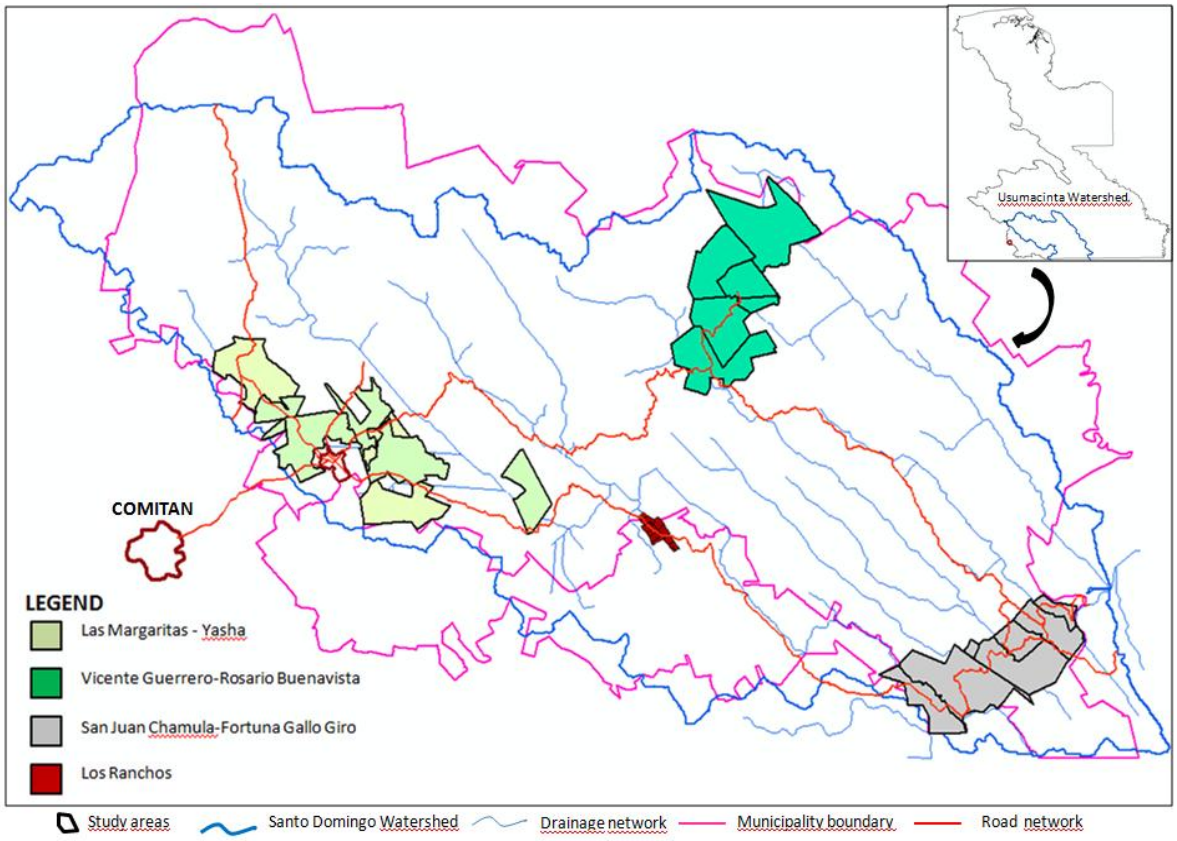



Figure1. Location of the study areas

| Zone o sector | Communities/Ejidos |
|---|---|
| San Juan Chamula | Amparo Agua Tinta, Nuevo San Juan Chamula, Linda Vista, Nuevo Huixtan, Nueva Poza Rica, Jerusalén y La Fortuna Gallo Giro |
| Vicente Guerrero/ Rosario Buenavista | Vicente Guerrero, Santa Ana La Laguna, San Vicente, San Juan Bautista, La Candelaria y Rosario Buenavista |
| Las margaritas/ Yasxa | Las margaritas, Francisco I. madero, Bello Paisaje, Plan de Agua Prieta, Yasha y San Sebastián |
| Los ranchos | Santa María, San Jacinto, Guadalupe, San Francisco, San Jose Liquidambar, El Rosario, La reforma, San Caralampio, Las delicias y Fracción Trine |

Table1. Communities/Ejidos studied in each zone

In order to understand the social, demographic, cultural and economic characteristics that frame the agricultural systems in each community as well as the agronomic characteristics and forest and animal management associated with existing farming systems, 25 communities were interviewed. The interviewed

were conducted, either to the Ejido Commissioner or an ejidatario with a long tradition and knowledge of the ejido, or to the owners of each one of the ranches. For some communities, this information was supplemented by information contained in "notes about alternative development and challenges of agrarian units" prepared by the Inter-American Institute for cooperation on Agriculture (IICA).

Based on the information acquired through surveys, the communities were grouped in 11 agricultural systems according to the following criteria:
(a) The type of main activity which is carried out in the community, namely: agricultural, livestock and/or a combination of them.
(b) The combination of the cultivated species
(c) The type of land tenure: private property and Ejido.
(d) The accessibility of services by communities (health, education, market) based on its geographical location with respect to the municipal settlement and the connectivity.

## 3. Results and discussion

### 3.1 Geospatial Model

Figure 2 shows the landscape units resulting from the integration of the geology, geomorphology and climate variables; based on average annual rainfall the landscape units of Santo Domingo Watershed can be grouped in three landscapes classes as follow: Sub-humid landscapes with an average annual rainfall less than 1,500 millimeters, humid landscapes with average rainfall between 1500 and 3000 millimeters and very humid landscapes with an annual average rainfall greater than 3000 millimeters. In each of these groups of landscapes one zone of the studied communities is located respectively, as well: the zone known as Las Margaritas is in the sub-humid landscapes namely as crest, gently sloping karstic hills and flat Valley, in these landscapes most representative soils are vertisols and luvisols. The zone of Vicente Guerrero-Rosario Buenavista is located in the humid landscapes namely as ridges and gently sloping karstic hills, being the leptosols and to a lesser extent luvisols the dominant soils. Finally, the zone of San Juan Chamula is in the very humid landscapes called as cuesta-creston, karstic hills and Valley flat, the dominant soils correspond to the luvisols and leptosols and to a lesser extent cambisols.

### 3.2 Farming systems

The studied communities, according to the land use and management characteristics, were grouped in 11 agricultural systems, for which the principal characteristics are describe in table 2. Its location in the study area is shown in Figure 3.

The agrarian system described in table 3, according to their location with respect to services supply and its connectivity (based on road network and transportation facilities), can be regrouped into four classes as follow: a) a first group consisting of mixed private, livestock private and mixed ejidal3 systems, which are located very near the municipal settlement or have own transport, and therefore can have access all the services available in the municipality: financial, education (primary, secondary and technical), health (hospital services), transport, market); in addition these communities have a high connectivity; b) a second group with intermediate conditions of accessibility to services, and of connectivity, include the systems: mixed ejidal1, mixed ejidal2, maize-beans-coffe-private, maize-beans- coffee ejidal and livestock-Ejidal; these communities have access to primary and secondary education, health center, and local market, and (c) a third group that has very little access to services as well as a poor connectivity, include the system mixed Ejidla4 and, finally the Mixed Ejidal5 system that has a very little access to services as well as a very poor connectivity. The last two groups only have access to primary education.

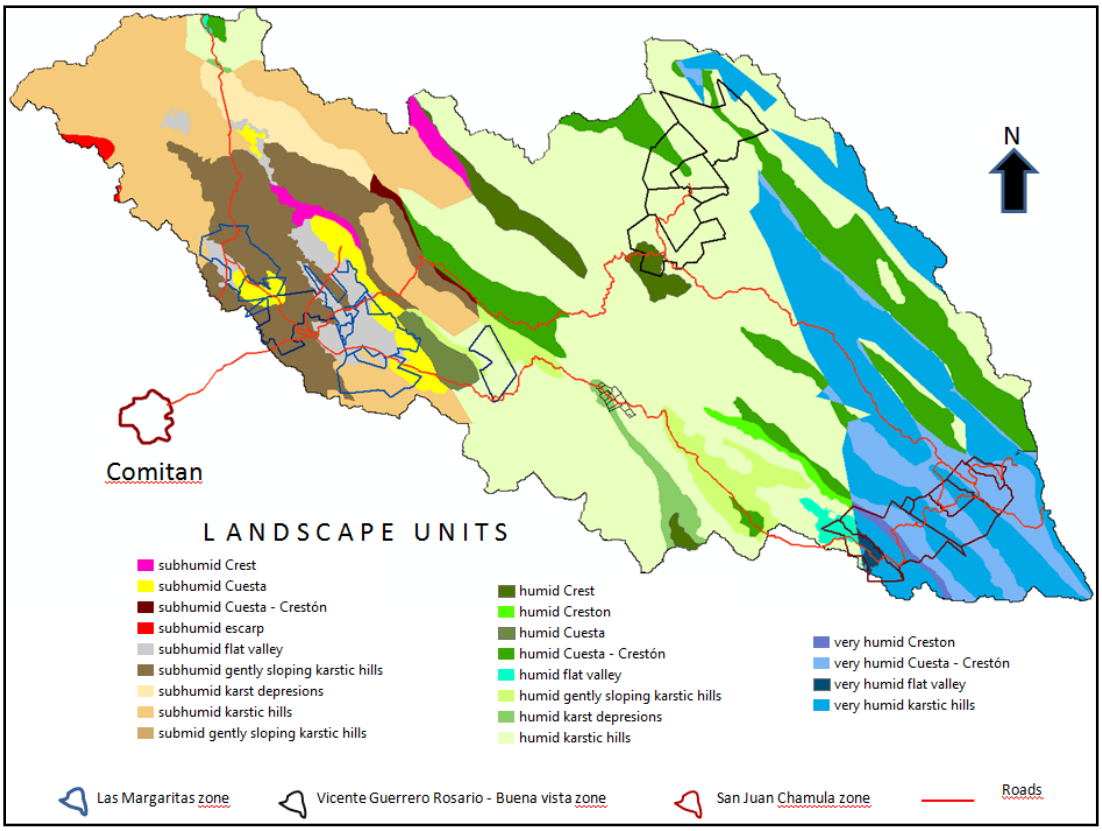



*Figure 2.* Landscape Units map *of* Santo Domingo watershed

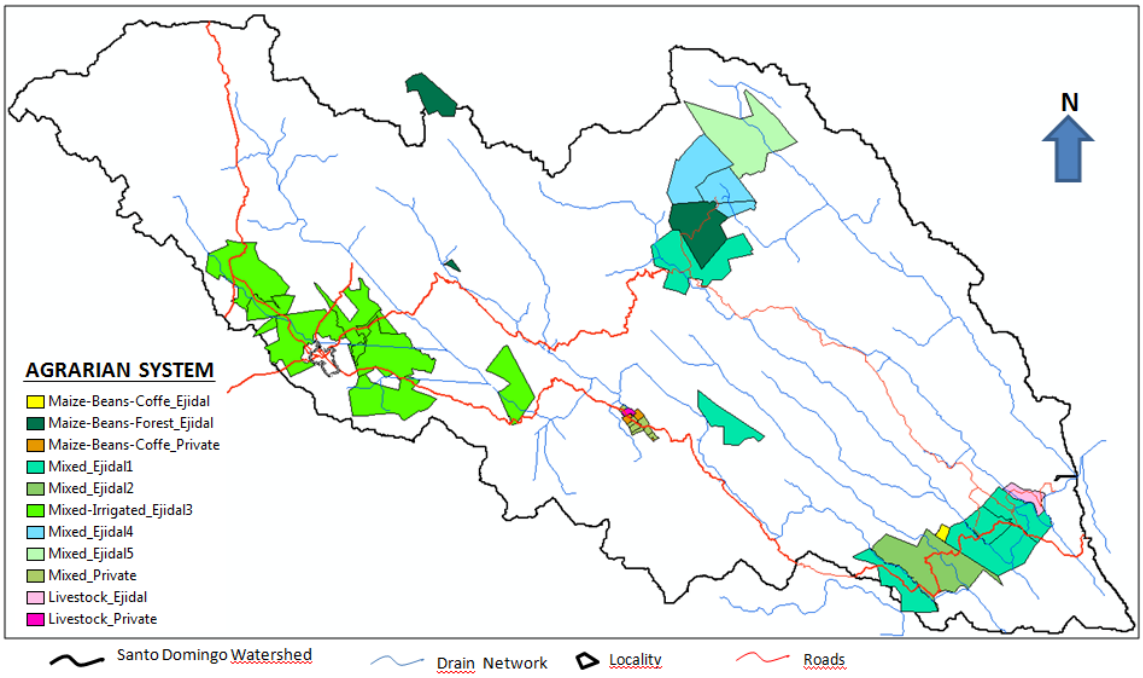



Figure 3. Agricultural system Map of three sectors of the Santo Domingo watershed

| KIND OF SISTEM | COMMUNITIES | MAIN CHARACTERISTICS |
|---|---|---|
| Mixed Private | Santa Maria<br>Guadalupe<br>San José Liquidámbar<br>La reforma, El Rosario<br>Las Delicias, San Luis | *Livestock Subsystem* Breeding Beef (Zebu, Swiss, Charolay), sale of calves.<br><br>*Crops Subsystem*: Coffee, banana,<br>Hired labor, direct marketing |
| Mixed Ejidal-1 | Jerusalén, Nueva Poza Rica<br>Nuevo Huixtan<br>Amparo Agua Tinta,<br>Laguna Las Delicias<br>Santa Ana La Laguna<br>Vicente guerrero | *Livestock Subsystem* Breeding Beef (Zebu, Swiss, Charolay), sale of calves.<br><br>*Crops Subsystem*: Maize, beans, coffee<br>Family labor, indirect marketing |
| Mixed Ejidal-2 | Nuevo San Juan Chamula | *Livestock Subsystem*: Breeding Beef (Zebu, Swiss), sale of calves.<br><br>*Crops Subsystem*: Maize, beans, coffee, Pineapple<br>Family labor, indirect marketing |
| Mixed Ejidal-3 | Yaxha<br>Las Margaritas<br>San Sebastián<br>Francisco y Madero<br>Plan Agua Prieta, San Mateo | *Livestock Subsystem*: Raise livestock ( Zebu and Swiss)<br><br>*Crops Subsystem*: Maize, beans with fertilization<br>Family labor, direct marketing |
| Mixed Ejidal-4 | San Vicente<br>San Juan Bautista<br>La Candelaria | *Livestock Subsystem* : Raise livestock ( ZeBu )<br><br>*Crops Subsystem*: Maize, beans, without fertilization,<br>Family labor |
| Mixed Ejidal-5 | Rosario Buenavista<br>Rio Corozal | *Livestock SubSystem*: Meat purpose cattle (zebu)<br>Family labor<br><br>*Crops Subsystem* : Maize, beans: without fertilization,<br>Family labor, |
| Maize- beans-coffee Private | San Francisco<br>San Jacinto<br>Fraccion Trine | *Crops Subsystem :* Maize, beans, coffee, without fertilization, Family labor |
| Maize-Beans-Coffee Ejidal | Linda Vista | *Crops Subsystem*: Maize, beans, coffee; without fertilization, Family labor, indirect marketing |
| Maize-Beans-Forest Ejidal | Carmen Chiquito<br>Ninguan Limón | *Crops Subsystem:* Maize, beans – Forest, with fertilization, Family labor |
| Livestock Private | San Caralampio | *Livestock System:*<br>Raise livestock ( ZeBu ). Hired labor, direct marketing |
| Livestock Ejidal | La Fortuna Gallo Giro | *Livestock System:* Dual purpose catlle (Zebu). Family labor, indirect marketing |

Tabla 2. Agrarian Systems Characteristics of the study area

### 3.3 Capital Social

According with Matthews and Selman (2006) social/human capital – include the networks and institutions that underlie trust and civicness, the potential for social learning within familiar and tangible settings, and levels of education and skills. Whether at the micro, meso, or macro level, social capital exerts its influence on development as a result of the interactions between two distinct types of social capital—structural and cognitive. Structural social capital facilitates information sharing, and collective action and decision making through established roles, social networks and other social structures supplemented by rules, procedures, and precedents. Cognitive social capital refers to shared norms, values, trust, attitudes, and beliefs. From social capital point of view the studied communities were classified in two groups: (a) Communities without social capital: Conform these group communities or families whose land tenure form is private and do not have any kind of social organization. If it is considered that the absence of social capital can become a limiting factor for access to services and/or Government subsidies, this group in turn is divided into two sub-groups. A first subgroup consisting of the communities/families of Santa María, San Jacinto, Guadalupe, San Luis, San Francisco and fraction trine, which due to their low incomes, deficiency in services of education, health and market, the absence of social capital can be a determining factor that contributes to a greater marginalization. The second subgroup, consisting of the families of San Caralampio, San Jose Liquidambar, El Rosario, La Reforma and Las Delicias, since they have a medium level of income and living in the urban area of Las Margaritas or Comitán, therefore have better access to services, therefore, the absence of social capital is not a determinant factor of the living conditions of these families. (b) Communities with some form of social capital: this group make up the rest of communities studied, whose form of land tenure is the Ejido. These communities have an internal regulation; it is a policy document that describes the General bases for the economic and social organization, the rules for admitting new ejidatarios, and for use of the common use land. This document is known and respected by a good portion of its inhabitants. Each community makes ejidal assemblies with some frequency, involving landowners, residents and the neighborhoods; this Assembly is the channel for the resolution of disputes or to inform about issues important to the life of the ejido. In general, each community has an Ejido Commissioner, a Secretary and a Treasurer.

### 3.4 Capital Natural

According with Matthews and Selman (2006) the ecological/natural capital – is considered as the 'life support systems' underlying biodiversity and natural resources. The natural capital is a good indicator of both the grade of disturbance as well as the health of the systems and therefore of the capacity of the system to provide environmental services. An ecosystem is healthy if it still provides primary production, nutrient retention and cycling, nitrogen fixing, soil stabilizing, water purification and other functions. An ecosystem that provides at least a substantial proportion of ecosystem services may be considered healthy, although it may not have integrity. In this research, the analysis of natural capital was made based on two criteria: the availability of lands with natural forest, which was evaluated base on a land cover-use classification and the availability of suitable land for agriculture, which was assessed based on the slope and soil type.

#### 3.4.1 Availability of land with forest cover

The figure 5 and table 3 show the percentage of forested land for each community. Having account the percentage of area under forest cover available in each community three groups were established: a) communities with a very low percentage (less than 5%of forest cover) included the communities of Fortune Gallo Giro, Nueva. Poza Rica, Las Margaritas; b) communities with a percentage between 10 and 50% of forest cover, included Jerusalem, N. Poza Rica N. Huixtán, N.S.J Chamula, Amparo Agua Tinta, Candelaria, Rosario Buenavista, S. Vicente, Vicente Guerrero, S. Ana Laguna, Francisco I. Madero, S. Sebastian; and (c) include communities that have more than 50% of forested land, Espiritu Santo, Yaxhá and Linda Vista.

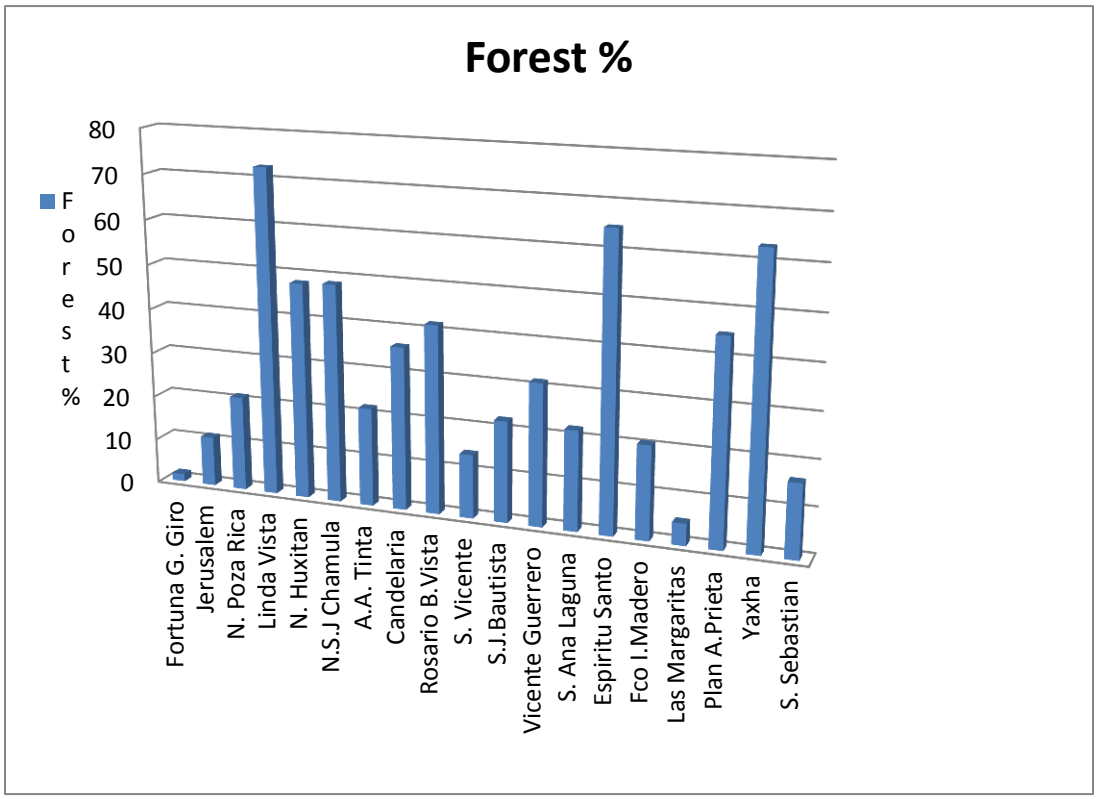



Figure 4. Percentages of lands with forest land cover in each community

| EJIDO | Total Area_Ha | Forest-Ha | Forest % | Sec. Forest-Ha | Sec. Forest % |
|---|---|---|---|---|---|
| Fortuna G. Giro | 461.88 | 7.76 | 1.68 | 54.52 | 11.8 |
| Jerusalem | 1456.84 | 162.44 | 11.15 | 121.32 | 8.32 |
| N. Poza Rica | 858.12 | 181.96 | 21.2 | 115.24 | 13.42 |
| Linda Vista | 127.88 | 93 | 72.72 | 0.96 | 0.75 |
| N. Huxitan | 2372.72 | 1142.56 | 48.15 | 91.56 | 3.85 |
| N.S.J Chamula | 3559.8 | 1728.92 | 48.56 | 181.08 | 5.08 |
| A.A. Tinta | 1483.64 | 324.64 | 21.88 | 189.12 | 12.74 |
| Candelaria | 381.96 | 138.32 | 36.21 | 113.32 | 29.66 |
| Rosario B.Vista | 3752.32 | 1564.76 | 41.7 | 1274.92 | 33.97 |
| S. Vicente | 2073.44 | 293.84 | 14.17 | 1183.68 | 57.08 |
| S.J.Bautista | 1155.92 | 259.36 | 22.43 | 347.2 | 12.49 |
| Vicente Guerrero | 2778.68 | 875.16 | 31.49 | 1116.16 | 40.16 |
| S. Ana Laguna | 2119.68 | 469.4 | 22.141 | 1187.76 | 56.03 |
| Espiritu Santo | 3926.77 | 2549.95 | 64.93 | | |
| Fco I.Madero | 2148.93 | 444.69 | 20.69 | | |
| Las Margaritas | 3578.08 | 173.61 | 4.85 | | |
| Plan A.Prieta | 912.7 | 410.76 | 45 | | |
| Yaxha | 2676.53 | 1692.53 | 63.23 | | |
| S. Sebastian | 482.54 | 79.04 | 16.38 | | |

Table 3. Lands with forest and secondary forest cover in each community

### 3.4.2 Availability of land suitable for agriculture

The gradient or slope angle has always been a topographic attribute important and widely used. Many suitability land classification systems use the gradient as the parent element to describe the classes, along with other factors such as the depth of the soil, drainage and the fertility of the soil. Base on this criterion the lands were considered as suitable, if the slope is less than 8%, moderately suitable, with slopes between 8 and 16%, low suitable with slopes between 16 and 45%, and land not suitable to agricultural activities, if the slope is larger than 45%. Figures 5, 6 and 7 show the distribution of land according to the slope classes for each community.

Based on the analysis of figures 5, 6 and 7, the communities studied, were classified, based on their natural capital (estimated by the availability of land suitable for agriculture) into four groups: a) a first group in which more than 70% of the lands are suitable for agriculture, most of the soils (vertisols and luvisols) have from moderate to high fertility, include the follow communities: Las Margaritas, Plan Agua Prieta, Espiritu Santo, Francisco. I. Madero, San Sebastián and Amparo Agua Tinta (see figures 6); b) a second group of communities in which 50% or more of their lands have a moderate to high suitability, the soils predominantly Luvisols and cambisols, have moderate to high fertility,, include the communities of Nuevo San Juan Chamula, Jerusalem, Nueva Poza Rica and Fortuna Gallo Giro (c) a third group in which between 30 and 50% of their lands have moderate to high suitability , the soils predominantly luvisols and cambisols, have moderate to high fertility; includes the communities of Lindavista, Nuevo Huixtán, Candelaria, San Juan Bautista, San Vicente, Vicente Guerrero and Santa Ana La Laguna; and (d) a fourth group formed only by the community of Rosario Buena Vista where less than 10% of their lands are suitable for farming, the most soils are leptosols, of low fertility.

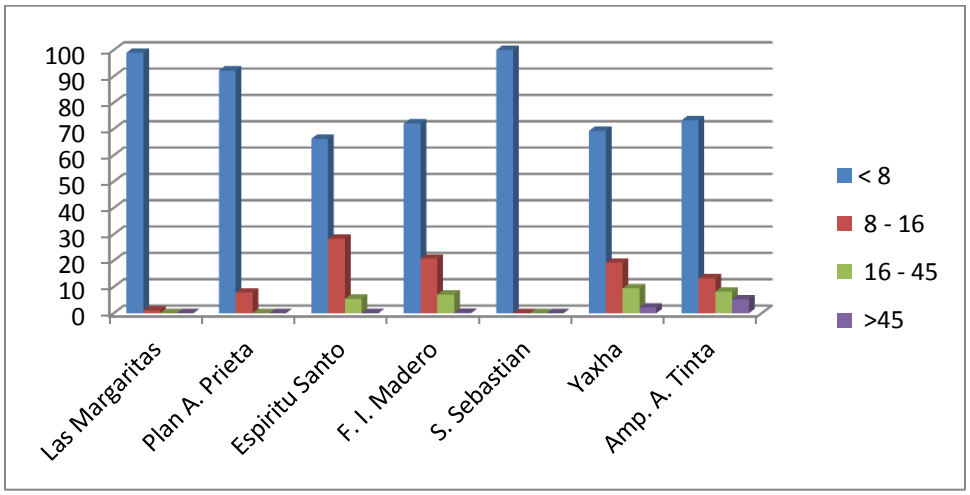



Figure 5. Percentages of land based on slope classes for each community

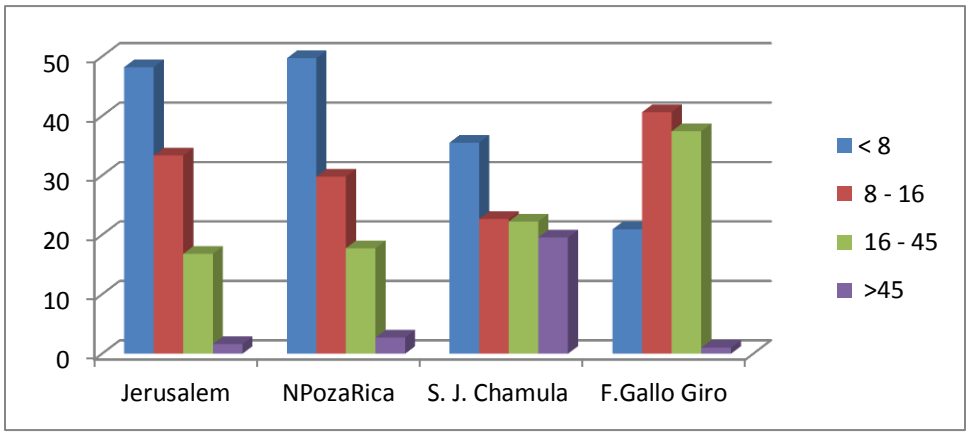



Figure 6. Percentages of land based on slope classes for each community

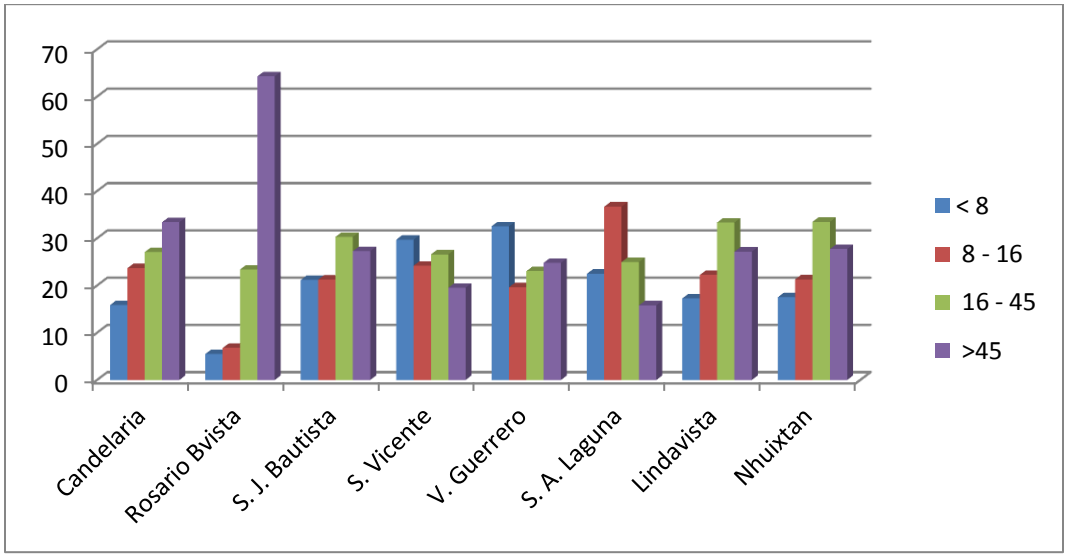



Figure 7. Percentages of land based on slope classes for each community

## 4. Conclusions

When the social and environmental characteristics of a territory, as well as their interactions are analyzed, the results described in the preceding paragraphs show the great heterogeneity that exists within the municipalities, which in the case of Mexico can be analyzed taking the ejido as a spatial unit of analysis.

Another important conclusion that can be extracted from the analysis of the results is that the spatial location and degree of connectivity that presents a spatial entity, in this case a community, are determinants of spatial functioning of such entities. So for example, spatial properties of the environment such as natural capital and differences in services accessibility can influence the trajectory of change of a system (a community) within the landscape, kind and magnitude of social transformation as well as the ability of the system to respond and adapt to different types of disturbances.

## REFERENCES

Alfonzo V. J. H. Caracterización y cartografía de los sistemas de producción a nivel ejidal/comunidad, en tres sectores de la cuenca del rio Santo Domingo. Proyecto de tesis. Instituto Tecnológico De Comitan. Ingeniería en Desarrollo Comunitario. Comitán,, Chiapas. (2012)

Antrop, M. The concept of traditional landscapes as a base for landscape evaluation and planning. The example of Flanders Region. Landscape and Urban Planning 38: 105–117. (1997)

Centro de Investigación en Geografia y Geomatica - CentroGeo. Complex Geomatic Solution for Territorial Planning. (Not published). Mexico.

Dixon J., Gulliver A., Gibbon D.. Farming Systems and Poverty. 2001. Improving Farmers' Livelihoods In A Changing World. FAO and World Bank Rome and Washington D.C. (2001)

Duvernoy, I. Use of a land cover model to identify farm types in the Misiones agrarian frontier (Argentina). Agricultural Systems. (2000) 64, 137–149.

Fresco, L.O., Huizing, H.G.J., van Keulen, H., Luning, H.A. & Schipper, R.A. Land evaluation and farming systems analysis for land use planning. FAO working document. (1992)

Jones-Walters, L. Biodiversity in multifunctional landscapes. Journal for Nature Conservation.( 2008),16: 117–119.

Golledge G R. The Nature of Geographic Knowledge. Annals of the Association of American Geographers, (2002), 92(1), pp. 1–14

Kruska, R. L., Reid, R. S., Thornton, P. K., Henninger, N., & Kristjanson, P. M. Mapping livestock-oriented agricultural production systems for the developing world. Agricultural Systems, (2003), 77(1), 39–63.

Matthews R. and Selman P. Landscape as a Focus for Integrating Human and Environmental Processes. Journal of Agricultural Economics, Vol. 57, No. 2, 2006, 199–212

Nachtergaele Freddy and Petri Monica. Mapping Land Use Systems at global and regional scales for Land Degradation Assessment Analysis ,Version 1.0.(2009)

Saavedra A. and Castellanos L. La Clasificación Fisiográfica de la Región de la Cuenca del Río Usumacinta, como componente básico para la Eco-regionalización. (Not published).

Van de J.A. Steeg, P.H. Verburg, I. Baltenweck, S.J. Staal. Characterization of the spatial distribution of farming systems in the Kenyan Highlands. Applied Geography (2010), 30: 239–253

Verburg, P. H., & van Keulen, H. Exploring changes in the spatial distribution of livestock in China. Agricultural Systems, (1999), 62, 51–67.

Wint, G. R.W., & Robinson, T. P. Griddel livestock of the world. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). (2007), p. 131.

- empty page inserted -

# AGRO-ICT Backbone for Central and Southern America: Technology + Business Models Supporting LPIS/IACS, FMIS and CAP

DI Walter H. Mayer

PROGIS Software GmbH
Postgasse 6, 9500 Villach, Austria-
mayer@progis.com

**Abstract.** High Return On Invest for agriculture and forestry comes from integration of newest technologies and cooperation of public and private stakeholders. 30+/-cm ortho-images, GIS, Land Parcel Information System, farm- and/or forest-management systems supporting also advisory services, covering regions or countries for logistics-, precision-, or virtual- farming needs embed farmers support of GAP or more environmental-or risk-management tasks based on new models and precise information. Know-How transfer and setup in a country need 2-3 years, integrates local know-how and costs a neglecting amount on large scale for images, agro-sensor stations and ICT-solutions. Technology-integration and stakeholder-cooperation is a win-win-model for a bright agro-forest future supporting food/feed, biomass for energy and environmental caretaking and risk-management! The technology was developed in cooperation with a consulting office. Technologies, org-solutions and business-models support today thousands of customers worldwide.

**Keywords.** Land-& farm-management, environmental management, risk- and resource-management, GIS, AGRO-ICT, agro-sensors, agro consulting, Return on investment

## 1 Introduction

Based on the use of precise ortho-images such as those available from Microsoft Bing™ Maps, GIS based agro-ICT technology of PROGIS, agro-sensor technology and related data and rural area-management consulting services, the AGRO-ICT-Backbone® concept was developed. It provides not only the necessary IT-tools but is also a holistic model to establish an agro-infrastructure throughout a whole country and to foster better agricultural development. It contains of:

- The production of a high resolution 30cm ortho-image for the whole country as base for further planning and control with an update frequency of 3-4 years.
- Based on ortho-images and PROGIS´ GIS software WinGIS® the setup or if available as in Europe the upgrade of existing LPIS systems (Land Parcel Information System) - or a cultivation register and/or a rural Open Street Map (OSM) is possible.
- The implementation of a sophisticated FMIS (Farm-Management Information System) which also supports farm advisory (extension-) services and serving the Ministry for regional or country-wide statistical needs
- The installation and integration of a logistic system incl. mobile solutions to support farmers and their chain partners as the industry, for any just in time delivery needs for seeds, fertilizer, harvest etc. or for traceability needs
- The installation of agro-sensor networks – consisting of agro-weather stations and soil sensors - for decision support and guidance
- Value added services for needs like precision-, virtual-farming, land consolidation, environmental management, carbon calculation, risk-management, after 2013 CAP needs etc. including consulting if needed. A special training concept enables users to develop own on-top applications solving local needs.
- Capacity building incl. education- and training-models enable local experts to be ready for a rollout.

- The intelligent business-model enables the owner of the ICT infrastructure (public, private or pp) to generate Return On Investments (ROI) by supporting stakeholders such as banks, insurance companies, large farms, large forest enterprises, the chain partners like food-industry, suppliers of farm equipment, agro-chemistry and agro-resources as well as international investors

Beneficiaries are farmers and forest holders, also small-holder enterprises, groups of farmers, cooperation, advisory/extension services, other service providers, affiliated industries, Ministries, banks and insurance companies, researchers, rural population, the environment and the public as a whole.

## 1. SOLUTION FROM PROGIS

The implementation of this agro-ICT-backbone has to be realized within a large scale project together with a range of local partners and experts. It can be done in a public, public-private or private project and is partitioned into the following steps:

### a. Ortho-image

Production of 30cm ortho-images with a vertical DSM of < 1,5 m resolution and a 60 cm infrared image. For examples of technical specifications of compliant ortho-images please look at the article of Microsoft (MS). "Global Ortho: Rapid, High Efficiency Ortho Update Technologies"

### b. Preparation of LPIS

The first mission is the implementation of the GIS system WinGIS® and on base of MS images the setup of the LPIS- or cultivation register including the assignment of owners or leaseholders to the single plots and to build up a country-wide land parcel database. An Open Street Map technology can be integrated. As far as LPIS systems are implemented already (as in most of EC (27) countries) the update can be done directly by farmers or farm-advisors to increase precision and lower land administration costs by data transfer to the existing LPIS/IACS system (see details later).

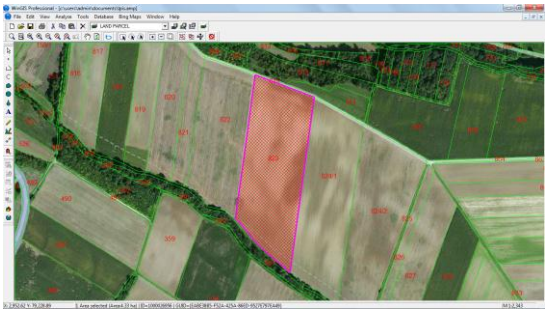


Figure 1: LPIS polygons on ortho-image

### c. GIS services

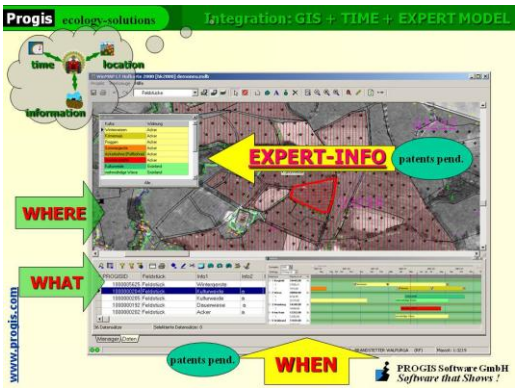
GIS-services for the generality and not only for experts was the name of the game of PROGIS when developing WinGIS® It is an easy to learn and use GIS software running on everyone's PC , with extensive geographic application possibilities and facilities. Due to the ability to integrate online map data such as for example that of Microsoft Bing Maps as „embedded Module", the access to worldwide available geographic data like satellite and aerial images, road maps and address databases is already part of the software package. Import and export interfaces support the most common GIS/CAD file formats like the ESRI™ shape files, the AutoCAD™ DXF, MapInfo´™ MIF and also text based file formats like CSV or GPX for data import from e.g. GPS devices. In a few steps external spatial data can be loaded into the user´s project.

By using the developer component, application developers have the possibility to link their application with WinGIS® in order to visualize, edit and administrate any data with a geographic relation. This is very relevant for realizing suggestions for local to be implemented IACS (Integrated Agricultural Control System) applications, to monitor GAP/CAP compliance or for on-top consultancy applications.

With the help of such an SDK (Software Development Kit) local IT experts managing the local IACS system of an EC member country can easily implement an application to generate a subsidy form out of the FMIS and transfer it via Internet to the government homepage. The effect would be a "one stop shop software", managed by a trained farmer or by an advisor that in parallel with the subsidy form also manages the business calculation, a nutrient balance, a carbon balance, integrates data for other future documentation needs like food traceability, business-plan, insurance data or after 2013 CAP´s ICT needs; not only governments would save enormous money, but farmers will save travel- and time-costs from driving to a subsidy centre. With the similar time effect, much more output can be realized on one side and if advisors are supporting farmers within a region – in all negotiations about a CAP reform new advisory concepts are asked for - much more can be reached in all sectors where single farmers alone can´t reach the targets but in groups they would be able. It are mainly environmental ones, landscape targets but also logistics, precision farming, land-consolidation missions etc.. This is also something the new GAP regulations will support – more see later.

**d. Implementation of FMIS**

When EU launched the CAP-reform (Common Agricultural Policy of the European Union) to increase food-quality and safety to the welfare of EU citizens, PROGIS developed on top of the described GIS-software tools for farmers and advisors to manage the many needs which this new legislation brought along. It was called DokuPlant™ and integrates expert database (all agricultural data and cultivation recommendations sustainably supported by local experts) and a perpetual calendar and documentation tool, facilitates planning, calculation, control and traceability. Extension officers/advisors are enabled to aggregate with it the data from fields, farms or a whole region and to prepare them for a Ministry or other public authority for statistical use or for projects.




The following information will be generated from every field and can be accumulated countrywide:

- Activity management
- Crop rotation
- Cost calculation
- Nutrient balance and carbon balance
- All input/resource needs
- Harvest estimations

Figure 2: Farm-mgmt: where– what– when– expert-data

PC-GIS, real-time management and the expert-data base are integrated. The mapping of plots/fields is supported and a perpetual calendar enables the display of any performed activity: what – when - where. The integrated database is filled with agro expert data, generated in close cooperation with local agro-forest-environmental scientists/experts and contains (sample: agro-Germany) 2.500 agro-machine data (KTBL, costs, time, …), data on thousands mineral-/organic-fertilizers, 850 herbicides with contents, crops incl. varieties and 400 plants with average yield and seed needs. The complete working process for a year with all activities and relevant data is predefined for all crops and enables planning with one click: Where (plot in the map) do I plan what (select crop from the expert data bank). This database is consequently also a knowledgebase and know-how transfer from scientists to the base, the farmers and foresters – daily and sustainably. After planning the data entry of the realization can be done manually or automatically.

**e. Forest management**

ForestOffice is FMIS for forest enterprises. It deals with sustainable forestry planning, forest facilities, forest management and forest logistics; the expert database contains local growth tables of different trees. Both

agricultural and forest expert data have to be modified by local experts working within a "farmer/forester - advisor – expert" business model.

### f. Logistic services

The protection of the environment and of natural resources is on everyone's lips. Within the agricultural sector group management, activity based planning and sharing of production facilities contributes to reach these targets. PROGIS developed thereto a smart logistic solution. The base data are the accumulated ones from the a.m. FMIS and farmers, foresters and the industry deduce therefrom their planning. Process and time optimization, further "where to deliver what" or "where to pick up what and when" and how to come to a location (with the help of the rural Open Street Map (OSM)) supports all process related partners.

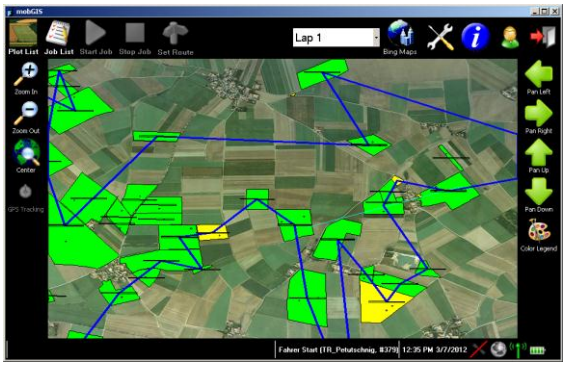



Figure 3: logistics – where to do what

The system leads to an optimization of daily and seasonal routing, accurate information of harvest status, GPS position data visualization, online two-way communication (GPRS/UMTS) between central and mobile terminals and order processing.

The system consists of a central station and a number of mobile units ("mobGIS"). It handles crops for food/feed or biomass production, liquid manure deposits, forest harvesting or any other logistic task. Up to 30 % cost reductions or even more can be achieved. The environmental pollution is far smaller than with conventional methods and due to the recordings ongoing improvements may happen.

### g. Agro-sensor networks

A sustainable cultivation and protection of soils depends a lot on the application of fertilizers, pesticides and water. Agro-sensor-stations help to take decisions and to optimize rates: A network of agro-climate sensors - one station for every microclimate - and soil moisture sensors are needed. Based on the data and a tool-set, experts can provide farmers with tailor made recommendations (e.g. forecasts for weather situations) but also get protocols of the climate situation of the past and the related impact for the future – for example mass reproduction of a fungi or a beetle with an SMS induced decision "start spraying".

The expert models - e.g. after which meteorological conditions collected during the last 4 weeks, which fungi or beetle will tend to outbreak – have, based on existing know how, training or know how transfer to be adjusted or developed and fine-tuned from local phytopathology experts. With the soil moisture sensors, also available in different depths, all necessary data for irrigation can be collected. It can be the fundament for an automatic controlled irrigation system.

Figure 4: Agro-sensor-network

## 2. TECHNOLOGY AND CAP REFORM

The aforementioned developments in relation to the EC CAP Reform 2014-2020: Analyzing the new demands of CAP reforms, there is asked on one side more competitive capacity (some countries consider demanding a business-plan for every farm) and in parallel to strengthen local initiative innovation, sustainability of natural resource management and a balanced regional development. Without tools as described and regional support provided by advisors this will NOT be possible!

### a. Europe 2020

The Europe 2020 strategy is asking for

- intelligent growth (technological know-how and innovation, quality products with high added value, eco-friendly methods, information- and communication technologies, investment into vocational training, motivation for social innovation in rural areas, better integration of new R&D results),
- sustainable growth (preservation of all basics for a sustainable food- and feed production, for renewable energies, sustainable land-management, provision of public goods, more biodiversity, animal- and plant-health increase, higher efficiency of natural resource management due to innovation, reducing of emissions or increase of the carbon buffer capacity)
- integrative growth (use the potential in rural areas, growth of local markets including employments, support for restructuring of farms etc.).

These targets can never be reached without the use of new technologies. Neither the planning of these targets nor the management and control of them can be done, neither for a single farm nor for complete regions and no environmental friendly growth and management can be implemented without being supported by new technologies and educated, trained and certified advisory structures for small and large farms.

### b. Eco-element

Today we know that many of the new CAP reform targets will have new eco-components to reach above cross compliance. To reach them new technologies like precision farming will be useful but due to the small structures they can be managed in many European countries only in a cooperative approach – managed by advisors or service providers equipped with latest ICT technology.

However, Precision Farming will be the future of agricultural management. To realize it, one needs a communication network between farmers, advisors and mobile units on agricultural machines and the integration of these machines via interfaces (ISOBUS, others). The implementation of precision farming is focused on using variable rate technology based on local measurements or created spatial recommendation maps. A decision support system (DSS) combines detailed data of the soil, plant and data from different sources like satellites, sensors, weather stations, FMISs. With the help of such DSS, experts are enabled to create spatial recommendation maps based on crop requirements, which will be transferred to mobile units to realize the optimized m² precise application of inputs and also protocol m² precise harvest results. This allows finally a m² precise cost benefit calculation.

## 3. ORGANIZATIONAL COMPONENTS

In the same manner as ICT has supported many other sectors throughout the last decades, ICT is able to support the agriculture but we need enabling structures and a new form of cooperation. The farmers will be able to support also the new requirements of the CAP reform, but they need better support, assisted by new advisory structures focusing on the farmers needs and NOT only on the stakeholder needs alone. The farmer is the integrative factor within the food/feed-, bioenergy- or even environmental- or natural-risk-chain-management and HE has to be supported. Then all other chain members will also benefit from the ICT structure.

**a. New business models**

New business-models are necessary – and available - that take care of the leverage effect due to integration of technologies and cooperation of structures! Less group egoism in agro-forest chain management is a must!

A prerequisite to start such an agro-solution is a local infrastructure comprising local hardware, communication technologies and the whole appropriate personnel organizational structures. It contains the hard- and software for aggregation of the data at Ministry level, the countrywide structure for LPIS and FAS (Farm Advisory System), the mobile solutions and the communication layout. Access to ortho-images and weather-data supporting all farmer´s needs is a must in the future. Making data available like Finland´s cadaster department did it recently is a must, private ortho-image suppliers like MS-BING an ideal option for future cooperation.

Benefits and beneficiaries who are the stakeholders in such a concept are described in in chapter V and VI and to all groups mentioned there, the ICT-backbone can produce valuable services. For these services lots of ROI-money can be acquired due to the benefits delivered by the ICT, but it stays always a political decision to which extent the Ministry will support the achieved benefits or how much beneficiaries for the use of this ICT backbone will have to pay. (On request ROI calculations for single sectors can be done).

The business models may be different – public, private or public-private. A model is imaginable, where public (MOA) and private (banks, insurance, and investors) share the investment and setup a common structure to support the different beneficiaries with information against a fee.

**b. New land management models**

To reach 2020 targets, innovative concepts for a sustainable environment- and risk management have been developed in cooperation with the University of Natural Resources, Vienna and are a base for a new land management concept. They deal with biodiversity, sustainability, multipurpose land-use and economic advantages based on the carrying capacity and reliable criteria which must become part of a sustainable economy.

Another concept pursues the goal of land-consolidation. What is land consolidation? It means the re-parceling of the properties in a region by the exchange of plots according their values to optimize the situation for all farmers including the public (roads, landscape). Together with the Lower Austrian Government, a tool based on clear concepts and values to achieve reallocations and consolidations of agricultural land holdings was developed. PROGIS has the exclusive right to market them worldwide.

Another similar approach is virtual farming. To overcome the expensive cultivation of small and bad shaped fields, virtual land consolidation ("Gewannebewirtschaftung" in Germany) is also possible with technology. The farmer remains owner of his field but cooperates with neighbours for machine use on virtually new shaped fields. Costs (tillage, fertilizing, etc.) and/or returns (harvest results) are collected with m² precision (precision farming – technology) and the contribution margin is shared according to the original field layout.

**a. Consulting**

As emphasized above, for a sustainable development of agriculture and/or forestry there is essential a close cooperation with experts. Thereto we have integrated into our AGRO-ICT-Backbone concept also the ability of a growing network of consultants who there are best educated researchers, scientists and practitioners with long lasting experience and international reputation as well as trainers for a technology support for these experts how to use the WinGIS-SDK that allows to develop more local applications and link them to the existing ones. They can cover the following topics – as samples, further expert´s enquiries for cooperation welcome - which in many fields are also part of the new CAP reform:

- Natural resource- and environment- management
- REDD+ projects and management
- Natural hazard and risk reduction management
- Wild-life management, natural parks, hunting, fishing,
- agro-forestry, nature conservation, eco-tourism, rural development etc.
- Infrastructures for rural areas.
- Carbon modeling and technology enabling carbon financing for complete countries
- Livestock and nutrients and the impact on fields
- Cooperative structures and their setup
- Machine- or other Cooperatives
- Inventory methods, forest management
- Precision farming
- Local land consolidation models
- Cloud based trust center
- Desertification (technology influencing drought, rainfall)

A "Train The Trainer - TTT" model gives within an education and training program relevant information for stakeholders, decision and policy makers, provides general information on agricultural, ecological situations and specific information on GIS and ICT technologies, as well as on responsibilities, expectations and chances for new farm / farm advisory systems is a very important pillar of the whole concept to assure its durability and sustainability. Local IT experts may develop their application based on local needs

## 4. BENEFICIARIES

A crucial effect of this agricultural ICT backbone concept is that data will be generated displaying the whole situation and the planning for the today and future situation of agriculture and forestry in a country. A certain time after implementation, the empirical knowledge derived from the storage of the history together with latest R&D leads to further actions. Many stakeholders are interested in these data and need them for their daily work. With an appropriate model data sharing can happen to bring benefits for several businesses. You can take it for granted that chain-partners will be ready to pay to get access to this information. The model in detail has to be worked out together with local structures and representatives from different stakeholders, based on a trust center concept that respects the ownership of information.

A public-private used ICT infrastructure, consisting of new ortho-images for the country covering GIS and IT solutions for rural area management in connection with land-management and extension-services, agriculture management and logistics can in that case be used by different governmental organizations, can also be used by private structures and can:

- Support the Minister of Agriculture for his needs to organize subsidies,
- Support the Minister responsible for landscape changes or for the cadaster and ground tax,
- Support consultants in their advisory work,
- Support food chain partners for traceability and for the documentation of the production,
- Support logistic service experts to do the right actions at the right field to find the right roads to the field and be there at the right time as well as deliver goods to the food industry "just in time"; it is a support to all suppliers and buyers of farm goods,
- Support the agro control organization for subsidies,
- Support the bankers to get a business-plan to be able to finance the farmers/forest holders and get output from the LPIS incl. a calculation of the growth period (costs and expected return),

- Support insurance companies to make right policies for the right crops on the right fields as they also can get output from an LPIS system that tells which farmers has which crops, how many hectares incl. a map and use this as a base for the insurance-policy,
- Support the ecology expert or also the natural-risk-manager for the appraisal of the risks related with field or ecological coherences,
- Support the human medicine expert to judge the influence of the activity of the farmers (food and environment) towards the people,
- And last but not least, support the farmer to give him tools for his economical calculations.

## 5. BENEFITS - COSTS

Whatever we do with ICT in agro-forest-environment-risk we have to verify costs and benefits. The latter has to show economic benefits but also benefits in ecology and valuate both of them. Different models are possible and also the change of the value of a piece of land, if it is managed well or bad has to be taken into consideration. The future integration model must verify that farmers are able to influence the quality and quantity of production of "water and bread" and not to optimize one element against the reduction of another one. We need both of them. In the following there are listed up the main advantages and beneficiaries of such an implemented integrated agro-ICT-concept:

### a. On a MACRO-economic level

Imports will be substituted due to higher production based on better technology use within the country. Further, a higher productivity and clear ownership situation increases the value of farm land and in summary the value of the entire country. A farm-management system employed in a certain region provides the necessary data for local carbon financing projects *(World-Bank recently requested for it).*Well organized agro-management leads to an increased income of small holders, to better living standards, to more sustainability and a higher percentage of the agriculture to the GNP. Also investors will benefit from such an ICT backbone and the value of the land will also in parallel increase due to the better presentation with maps, calculations, available infrastructure, etc. ICT supporting extension-, advisory-services lead them to better performances and administration bodies will be able to optimize control. Also the cooperation between farmers and scientists will be increased and the implementation of cooperatives will change agricultural structures with positive effects. The shared use of an ICT backbone within the agro-chain reduces costs and has a positive impact on budgets. Further, banks and insurance companies can be integrated and will directly or indirectly benefit from such an ICT structure by getting tools to support financing (business plans for microfinance on click) and insurance of smallholders (insurance policy on click). Not to forget the education impact that farmers get through the system and the relatively easy way to guide them into the direction of an eco-social market economy. This again has effect on ecological- and natural-risk-factors. It is always cheaper to support farmers in preventing risk factors or environmental problems than to repair them at a later stage (CAP-reform!).

### b. On A MICRO-economic level:

GIS (Geographic Information System) gives detailed information on size and location of fields of single/group of farms. This information is the base for ALL further planning incl. logistics. Farm management tools allow cultivation planning, documentation (e.g. GLOBALGAP), traceability, nutrient- and $CO_2$-balance, cost calculations and control and above all provide information for trust centers and support advisory services profiting also from the embedded scientific local know how.
Logistic solutions with central and mobile systems allow precise and accurate planning of logistic needs serve farmers, food-industries, contractors and the environment and will lead to enormous cost savings. Agro-meteorology data and soil moisture data allow better decisions based on integrated local expertise. Risk management solutions are mainly for optimizing carrying capacities, plant protection, and food and feed safety etc.; and beyond that, such solutions can help to better define and measure farmer's integration into environmental caretaking. Business-plans assist the cooperation with banks and insurance companies.
Machine interfaces allow the set-up of precision or virtual farming solutions for group of users. Further, statistical analysis for regions or countries becomes possible and new NPK sensors measuring Nitrogen, Phosphorus and Potassium can also be integrated for optimized fertilizing. Forestry- and/or environmental-caretaking solutions are supported also by applications.

ICT supports the fast distribution of scientific know how; and an organized feedback will allow verifying and optimizing results over the time!
ICT enables farmers to become part of decisions and implementation of environmental caretaking measures which are based on defined targets of beneficiaries, defined work plans and returns for farmers.
As the farmer is in many cases not working alone but in cooperation with neighbors or cooperatives, an intelligent ICT solution has also to reflect the needs of that groups and the integration of parts of the farm management into these group needs. Large farms can be seen as "one owner of horizontal integrated fields". Small farms will be integrated and benefit from these new technologies together with service providers supporting farm-management and horizontal and vertical ICT needs. Land consolidation set up on LPIS datasets optimizes the farmer´s ownership structure and virtual land-consolidation optimizes the future of smallholder's cultivation management.
Trust centers will be a need and further possibility to work with the data for traceability solutions.

## 6. CASE STUDY

The largest project today is the cooperation with the German Machine Cooperatives with 250.000 members, more than 200 offices and 7.2 Mio ha throughout Germany. Beside DokuPlant that was evaluated within a customer satisfaction study based on at that time 574 answering PROGIS users in 2007 already (high satisfaction more training required 75% prized highly the integrated expert data); we enlarged the cooperation within a 2nd step with logistics integrating at first Südzucker – the largest food industry in Europe – and their 40.000 sugar beet supplying farmers. Key was beside technology integration also the cooperation of all chain partners: 40.000 farmers, 45 machine cooperatives running the central logistics servers and managing the contracts towards hundreds of mobile devices like sugar beet harvesters, pickups and trucks supporting 6 factories with just in time delivery of predefined amount of trucks per day. Every stakeholder is always online with central GIS stations and mobGIS™. The technology was fine-tuned during the last years integrating also the factories HQ-IT solution as well was successfully rolled out to other crops like biomass, potatoes etc.

## 7. DISCUSSION AND CONCLUSION

The technology is able to support all the needs of farmers today – technology integration is a must and available and possible. For the future the main challenges are:

First the cooperation of stakeholders as today the main target of many large chain partners is to get access to the information of the farmer´s field and the farmer refuses to give the data out of his hand. A "trust center" that defines in detail who is the owner of which information and when information must be transferred to the government (legal definition) or a chain partner (bilateral agreement) will solve this problem.

Second the business model behind, that allows many partners to cooperate around an integrated solution where every partner receives that information that he needs for his purpose and many partners share the costs and the benefits out of such an integrated system. Such systems will only be accepted if the costs are low. This is only possible if large projects integrating the Ministry of Agriculture and several other stakeholders set projects up together.

The third challenge is the environment-risk-management integration but based on such a structure as mentioned above. The farmers will together with partners be heavily involved in environment- and risk-management as supplier of defined benefits to defined beneficiaries / groups of beneficiaries based on new eco-social policy models. The farmers create values for groups or for all of us and the whole society will benefit as farmers become social responsibility and get funded for clear defined benefits supported by the so called commons.

- empty page inserted -

# gison3dmap – Efficient Geographic Communication with GIS Data Projection on Solid Terrain Models

Carlos Coucelo[1], Pedro Duarte[2], Rita Crespo[1]

[1]CCCGeomática Lda, Taguspark, Núcleo Central 234
2740-122 Porto-Salvo - Portugal.
carlos@cccgeo.com, ritacrespo@cccgeo.com

[2] ALDAPE Lda, Rua Sargento Monteiro Ferreira, 15, Albogas
2715-211 Almargem do Bispo - Portugal
pduarte@aldape.pt

**Abstract**: Developed with the purpose to improve the communication capabilities of solid terrain models, gison3dmap transforms a solid terrain model surface into a physical 3D screen. With a GIS database at the core of the system, data themes are rendered and projected on the solid terrain model surface, in an easy, dynamic, interactive and understandable way. This paper describes the gison3dmap system and shows examples of implementations made so far.

**Keywords.** Geographic Communication, GIS Data Projection, 3D Solid Terrain Models, Public Participation, Decision Making, Education, Territorial Management, Sustainable Tourism.

## 1 Introduction

3D models have been used effectively throughout the centuries to present an immediate and direct impression of a landscape in a way which is easy to understand for the majority of the people.

Being used first mostly for military purposes, their use evolved to very diverse applications, such as teaching and education at all levels of training, from primary schools to universities, presentation of infrastructure projects, to enhance and facilitate urban and regional planning, and for the study of geologic and geomorphologic phenomena.

Model production techniques evolved from artists work to recent computer assisted rapid prototyping and milling processes, and modified 3D inkjet printing, with increasing degrees of representation quality and positional accuracy.

With the advent of Geographical Information Systems (GIS) new computer techniques emerged for territorial management and analysis and for decision making support.

Although 3D virtual models and presentation techniques have also emerged, and play currently a complementary and important role mainly at the urban analysis level, the interest for the use of 3D solid terrain models has not diminished. This results mostly from the fact that 3D solid terrain models are tangible products. People can gather around a physical model, touch and view it from any angle, allowing for a deeper understanding of the information presented.

With solid terrain models people understand topography in a direct and reliable way – scale, distance, slope, orientation, points of view, sight line, etc., are immediately perceived by an audience in a clear and consensual way. Physical models are democratic tools. People will find it easy to understand others and make themselves understood and this will contribute to better and faster decisions in public participation processes

## 2 gison3dmap – A Geographic Communication Tool

### 2.1 The Idea

The idea behind gison3dmap is very simple; to tell stories about the morphology, history, occupation, building heritage and human activities, which occur in a given territory, synchronized with the video projection of selected geographic information on top of a physical model of that same territory.

Nowadays, Geographical Information Systems are mandatory tools for all aspects of territory management and analysis and are used to consistently abstract and organize past, present and prospective data about the territory. As a consequence and by design, gison3dmap is database driven, and has at his core a Geographical Information System (GIS) database. This means that, with gison3dmap, all the images which will be projected on the surface of a solid terrain model will be rendered directly from a GIS database.

### 2.2 Examples

CCCGeomática has implemented so far 14 gison3dmap systems in Portugal, 13 of which include printed terrain models built by Solid Terrain Modeling, Inc.

The first gison3dmap system was installed in 2005, at the "Lamas de Mouro" entrance of the Gerês National Park, in the North border of Portugal, and includes a 1:15000 scale model of the Melgaço County (Fig. 1). The system is used to introduce the territory to students from elementary and preparatory schools, selecting the maps to project on the model surface with the ArcGIS ArcView gison3dmap client.


**Fig. 1**. The first gison3dmap system installed

The Coimbra Agriculture Superior School (ESAC) has a portable gison3dmap system with a 1:25000 scale model of the Arganil County, which was first used in 2006 to present the scientific results of a 100 year projective and prospective forest land cover analysis for that County, and is now used for educational purposes.

During the TTT (third Tagus River bridge) exhibition, that took place in Lisbon and Barreiro between October 2008 and February 2009, a gison3dmap system with 4 video projectors, and a 1:32000 scale circular model of the Lisbon metropolitan area (Fig. 2), was used for the public presentation of this infrastructure development project. At this exhibit the public was able to hear an audio explanation of the project reasons, objectives and proposed implementation solutions, illustrated with the projection of explanatory related maps on the model surface.

**Fig. 2**. The gison3dmap system used for the TTT Exhibition

Visitors at the "Serra da Estrela" Interpretation Centre (CISE), located in Seia, on central Portugal, select which geographic themes they want to see projected on top of the 1:35000 scale model of the "Estrela" mountain Natural Park (Fig. 3), interacting on a touch screen with a HTML multimedia client application. Two video projectors located on the ceiling, connected to a server running the gison3dmap software, project on the 3D model surface, images rendered directly from a GIS database, in response to client requests.

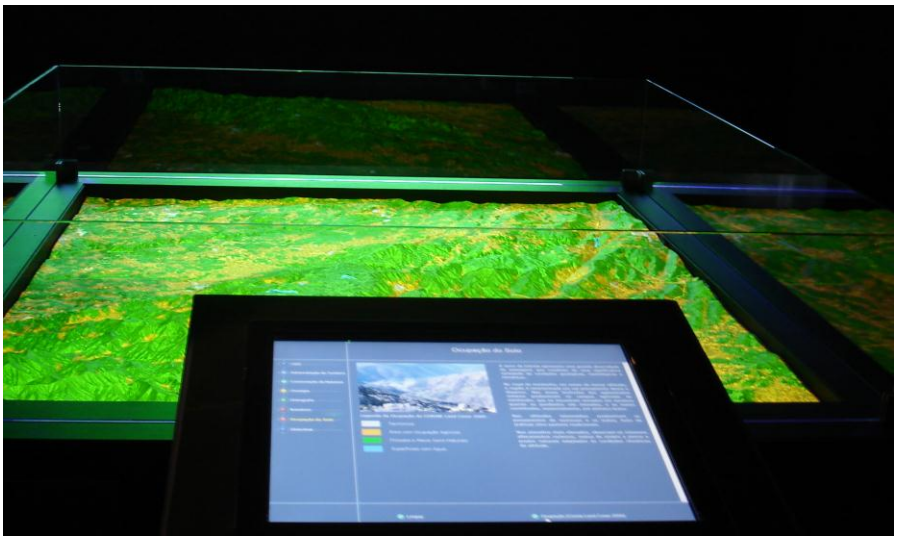


**Fig. 3**. CISE Interpretation Centre gison3dmap system

At the "Revelim de Santo António" Territory Interpretation Centre located in Castro Marim, at sunny South Portugal, a 1:10000 scale 3D model of the Castro Marim county, and a gison3dmap system with 4 video projectors and 4 LCD screens (Fig. 4), is used since August 2009 to offer visitors a county virtual sightseeing. Here, visitors can see a video about the history, heritages and people activities, with sound tracks in Portuguese, English, French and Spanish, illustrated with the projection of related geographic information on top of the Castro Marim physical model, and are invited in this way, to depart on a county discovery journey.

The Portuguese National Forestry Authority uses since 2009, a gison3dmap system and a 1:5500 scale model of the Contenda property, a major deer reserve with 5268 hectares, to promote Contenda at hunting fairs in Portugal and Spain.

**Fig. 4**. The gison3dmap system in use at the Castro Marim Territory Interpretation Centre

In the "All about us" area of the Batalha County Community Museum permanent exhibition, open to the public since January 2011, visitors can discover on their own, the natural, cultural, religious and gastronomic routes of the County (Fig. 5).

**Fig. 5**. The Batalha County Community Museum gison3dmap system

Located close to the "Palácio da Pena" (Pena Palace), the most visited monument by tourists in Portugal, the "Paisagem de Sintra 3D" (Sintra 3D Landscape) exhibition, opened since April 2011, uses a gison3dmap system with a 1:3000 scale map of the Sintra mountain, to offer visitors a global perspective of the Sintra mountain, the Sintra World Heritage Landscape, its monuments and visiting routes.

The Guimarães County master plan revision public participation process, which took place during January and February 2011, was implemented with the help of a gison3dmap system and a 1:10000 scale model of the county territory (Fig 6). Together with the slide shows prepared by the county officials, that were presented to the public using the gison3dmap Powerpoint client, the system has revealed to be an extremely valuable tool to help citizens have a better understanding of the county master plan development strategy and proposed changes.

"Companhia das Lezírias", the largest agriculture and cattle-breeding company in Portugal, occupying 20,000 hectares of land just 30km away from Lisbon, has since December 2011 a gison3dmap system with a 1:10000 scale model of the "Herdade da Charneca", to introduce visitors to the company activities and history, and to present the foot, bike and horseback riding visiting routes available.

**Fig. 6**. Public participation on the Guimarães master plan revision process

A 1:7000 scale model of the Cascais County, is being used since June 2012 at the Cascais Cultural Centre for touristic purposes, allowing visitors to locate beaches, cultural equipments and parks, and know more about the county (Fig. 7).

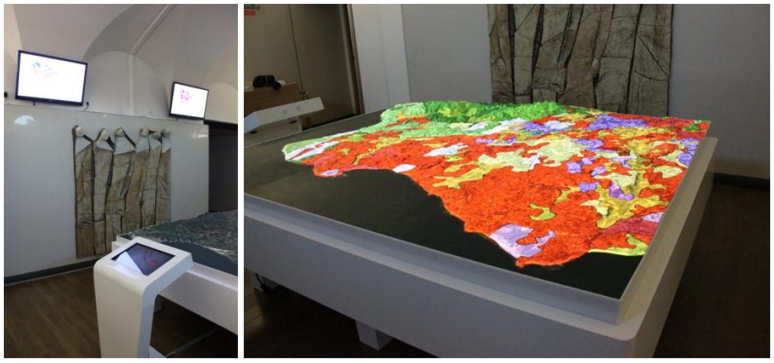


**Fig. 7**. Cascais County gison3dmap system

On June 2012, the gison3dmap system was used to present a new touristic, services and housing development plan (Fig. 8. A video presentation of the project phases and proposed zoning was illustrated with the synchronized projection of data layers on the surface of a 1:1000 architectural model.

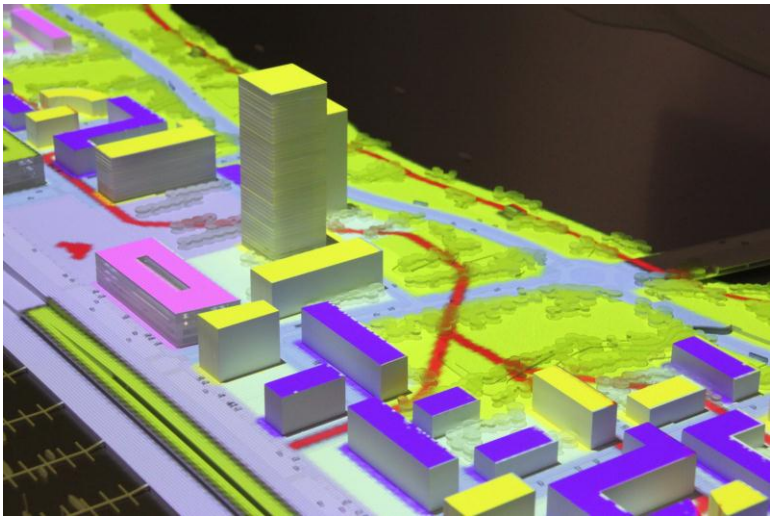


**Fig. 8**. A gison3dmap being used for a development plan presentation

The Lima River, located at the North of Portugal, is part of the NATURA 2000 European Union nature protection areas network. Following the conclusion of a requalification and valuation project of the River Lima margins, the Ponte the Lima County has decided to implement the Lima River Information Center (CIL). Inaugurated on October 2012, the CIL purpose is the education, awareness and advertising of the environmental, historical and socio-economical values associated to the Lima River, and uses a gison3dmap system with 2 x 2.8 meter 1:10000 scale model of the Ponte de Lima County (Fig. 8) to help accomplish this.

**Fig. 9**. During the CIL inauguration (Source: Ponte de Lima County)

Arouca Geopark is renowned for its exceptional geological heritage of international significance, in particular the giant Trilobite of Canelas, the Castanheira's "Pedras Parideiras" and the ichnofossils of Paiva valley, and is a member of the UNESCO Global Geoparks Network.

Since December 2012, Arouca Geopark has a gison3dmap geographic communication system with a 1:5000 scale 117 x 88 cm model of the Freita plateau (Fig. 10), installed at the "Casa das Pedras Parideiras" (house of rocks delivering stones), aimed to enrich the Geopark visitor's experience.

An application running on an Android tablet, is used to project predefined maps on the model surface, control the presentation of thematic videos with synchronized map projections, execute sunrise to sunset shadows simulations for different days of the year, and to do acetate layer hands free drawing redlining on the model surface.

### 2.3 System parts

Common to all the gison3dmap systems previously referred are a 3D solid model, either terrain, surface or both, a GIS database, one or more video projectors, the gison3dmap software, hardware with as many graphic video outputs as the number of projectors and multimedia displays that will be used by the system, and a client which will be used to interact with the system.

The number and layout arrangement of the video projectors used for each system depends on many aspects, such as the size as aspect ratio of the model, the projection resolution and luminosity, and room installation constraints.

Both the model and the video projectors need to be installed in a way that ensures they are placed on fixed relative positions, and that projectors are easily accessible for maintenance purposes.

**Fig. 10**. The Arouca Geopark gison3dmap system

### 2.4 Required data

Once the software is installed, and before one can start using the system, it is required to have the following GIS data sets:

1. A digital representation of the physical model,
2. A shapefile defining the division of the model area between the video projectors, i.e. MapWindows uniquely identified with a MapWindow ID,
3. A shapefile defining at least four calibration points for each MapWindow,
4. The GIS database containing the data which will be rendered and projected on the model surface,
5. In the case of an irregularly shaped model, a mask shapefile with the model limit is required to darken the projection outside the model limits.

## 3 The gison3dmap System

### 3.1 Architecture

The diagram shown next (Fig. 11) shows the main hardware and software components of a gison3dmap system, and how they relate to each other: the hardware, including the display devices (video projectors and LCDs), the core GIS database and the gison3dmap client and server software components.

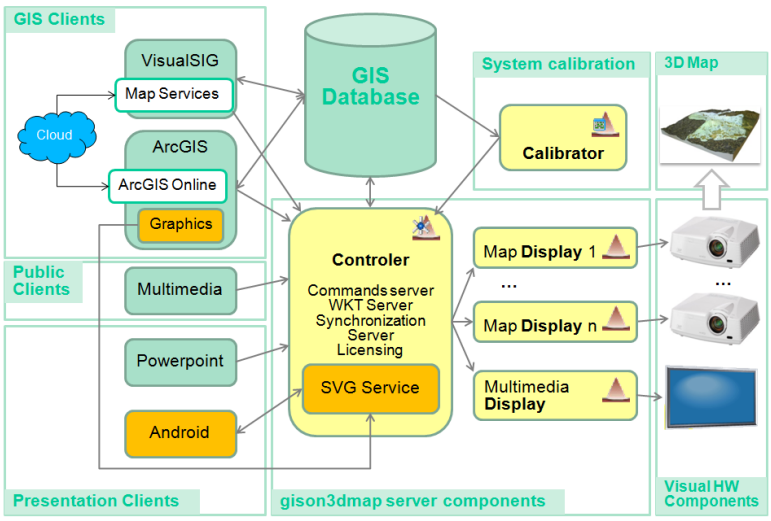



**Fig. 11**. gison3dmap system architecture

The gison3dmap software is organized into four components: Clients, Display, Calibrator and Controler.

Clients submit drawing requests to the system, either using directly the gison3dmap command methods exposed by the gison3dmap .NET/COM open API, or sending gison3dmap command sequences using a network socket connection.

The Display component controls the visualization part of the system, and a Display process will exist for each graphic board video output available to the system. Display processes can be distributed along multiple computers, to support an unlimited number of projectors and multimedia devices. Displays can be either Map Displays, which handle the video projection of map data, or Multimedia displays, which handle the presentation of images and videos.

The Calibrator is a special client used to configure and calibrate the system. With the calibrator, displays available to the system are set either as Map Displays, Multimedia Display or Undefined. Each Map Display needs to be allocated to a unique Map Window, ensuring the correct allocation between Map Windows and video projectors.

The Controller component handles licensing and dispatches client requests to each Display, ensuring that the projection will occur simultaneously for all the MapWindows.

The gison3dmap system was developed with Microsoft .Net and the following Open Source Libraries:

- SharpMap - a mapping library used for web and desktop applications
- GeoAPI - GeoAPI.NET project provides a common framework based on OGC/ISO standards to improve interoperability among .NET GIS projects.
- NetTopologySuite – an API for modeling and manipulating geometry
- GDAL/OGR – GIS data library
- Proj.4 - Cartographic Projections library
- ShapeLib – Shape file library
- SharpGPS – GPS library
- OpenTK - advanced, low-level C# library that wraps OpenGL, OpenCL and OpenAL

### 3.2 Data Formats Supported

A large number of vector and raster data formats are supported by gison3dmap.

Vector formats supported include ESRI Shape File, ESRI Personal Geodatabase (MDB), ESRI File Geodatabase (GDB), ESRI ArcSDE (additional plugin), ArcInfo coverage, Google KML/KMZ, SQL Server 2008, PostGIS, MySQL and SQLite.

Raster formats supported include TIFF/GeoTIFF, ECW, ArcInfo Grid and WMS services.

### 3.3 GIS clients

Because all projections made with gison3dmap on a model surface, result from a dynamic access to a geographical database, GIS clients are the natural system interface.

Although simple to use, GIS clients are meant to be used by people with basic GIS skills, to define what GIS data to project and how to do it, and are currently available for ArcGIS 10 and VisualSIG freeware GIS desktop software. A geographic layer, with its selections, legend, text and transparency, as defined on the GIS interface, is transformed into a group of projection commands that once sent to gison3dmap will reproduce on the model surface the map as seen on the GIS client window (Fig. 12).

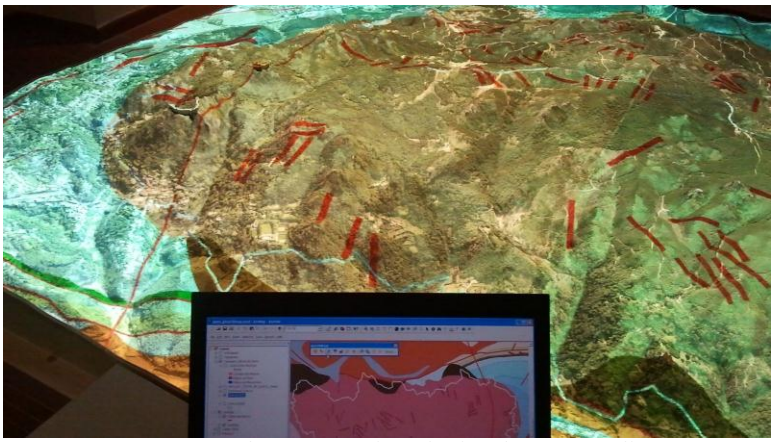


**Fig. 12**. A geology map projected using the ArcGIS client

Commands can be captured into text files using the GIS clients, for later reproduction of the exact same projection results, from within the Powerpoint client to reproduce the same projection results, by anyone skilled enough to create a Powerpoint presentation.

### 3.4 Public clients

Public clients are applications with convey multimedia contents is a way which makes them easily understandable and accessible to the general public. Although CCCGeomática can offer a off the shelf multimedia application, custom applications can be built by any programmer with minimum GIS skills, using the gison3dmap .NET/COM open API, or sending gison3dmap command sequences created with the GIS client, using a network socket connection.

### 3.5 Presentation Clients

Any person with basic computer skills, with a specific knowledge about the territory represented on the model which is part of a gison3dmap system, should be able to make a public presentation using the system, in an easy and timely manner.

Text files with gison3dmap commands created with the GIS clients can be easily integrated within Powerpoint presentations to reproduce specific maps, associated to slide transitions. The presentation will be made

using a laptop connected to the gison3dmap system via Wi-Fi. People watching the presentation will see the slide show on a LCD screen (Multimedia Display) and the projections on the model surface.

The Android client is a presentation and cooperation analysis tool for gison3dmap, which provides the following functionalities:

- Graphics and freehand drawing on top of the base gison3dmap GIS data projection,
- The projection of previously defined maps,
- The execution of previously defined gison3dmap command sequences organized as text files.

Each client running the Android tablet or smartphone will use a dedicated acetate layer. Different people using the android client will be able to redline the model (Fig. 13), independently from the other users and from the map being projected.


**Fig. 13**. Redlining with the Android client

### 3.6 Calibrator

The purpose of the gison3dmap system calibration, is to make sure that the projected geographical information, will match as exactly as possible, the geographical entities visible on the solid terrain model.

In order to accomplish this, gison3dmap needs to build an internal model based on the Digital Terrain or Surface Model and the position and characteristics of the projector. This model is built as an OpenGL surface that matches the physical model, obtaining a pose for the projector (i.e. find the real world position of the projector). The pose is calculated using OpenCV library methods.

Using the resulting model, the GIS data can be modulated using OpenGL shaders to produce images that match the solid model. The processing is made by the GPU (Graphics Processing Unit), which results in a very good performance. In order to obtain a pose, at least for calibration points are required for each projector and MapWindow.

Fig. 14 shows a map divided into 4 map windows, and the attribute table of the calibration points shapefile. Calibration points are defined in map coordinates, are allocated to a map window, and have a label which will be visible both on the terrain model surface and on the calibrator interface.

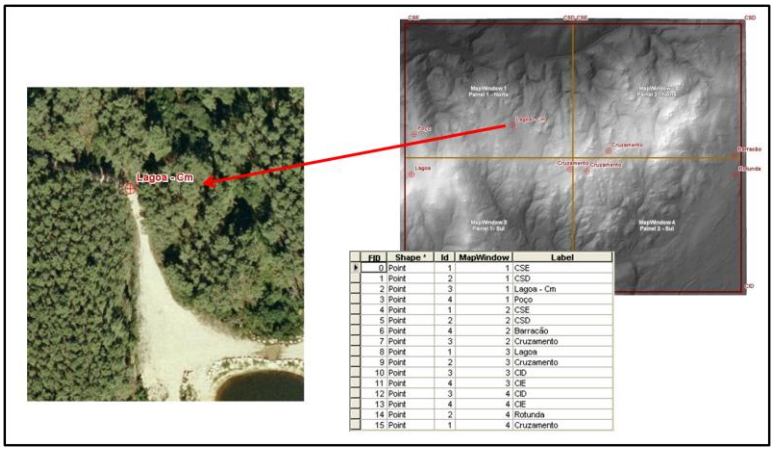



**Fig. 14**. The calibration points are required to obtain a pose

For each calibration point available for the selected map window, the corresponding calibration target needs to be displaced to its correct location on the model surface.

Once the targets location process is concluded for each calibration point, it will then be possible to project a grid that will certify the existence of a calibration solution (a pose). After this it will be possible to project geographic data adequate to validate and refine the calibration, such as the road network.

Once the calibration process is completed for all the projectors, the system will be ready to accept gison3dmap projection commands.

Optionally, the calibration process can be partially automated using optic fibers which will cross the model at tiny drills perforated at the calibration point's locations, connected to light sensors installed on a Arduino board. This capability gains importance, when dealing with many projectors, to quickly recalibrate the system projectors, following a maintenance intervention.

## 4 New Developments

Several prototypes have been developed and successfully tested to be ready to expand the gison3dmap system to new functionalities and to new requirements at the user interaction level.

Some of the following ideas are already ready to market, and others have been tested to an extent which will allow its easy implementation on a project basis.

**Project videos on the solid terrain model surface**
This is typically what a Video Mapping solution does, and the system is ready to be expanded in this direction. Meanwhile, because gison3dmap is a GIS application which relies on GIS database, it will be possible to implemented animations which will represent data with a time dimension.

**Natural and laser interfaces**
Using a Kinect sensor it is possible to query the model and obtain information about a specific location, by touching its surface or pointing a laser. This was successfully implemented with a single projector system.

**Geographic games using Buzz controls**
An application has been developed to implement geographic games. Geographic questions in the form of "Where is …. Located?" with an identifying image and four possible answers are defined and kept in a database. For each question, the corresponding image will be shown on multimedia display, and four areas corresponding to the alternative answers, will be projected with different random colors. Answers will be given by the players using the matching color Buzz command button.

**Model navigation with portable devices**
An application has been developed, which allows people to navigate on the area represented by the model, using a tablet or a smartphone, without losing the context within the model. Once connected to the system via Wi-Fi, a web application is accessed which will present a web map interface, with an OpenStreetmap map and Panoramio image locations. Each user will see the rectangular extent of the map shown on his mobile device, projected on the model surface with a specific color. Pan and zoom at the web map interface, and device rotation, will change the size and orientation of the projected rectangle. Clicking on a Panoramio location on the device, the user will see the image location projected on the model surface. The system can be expanded to include additional maps, as well as match 360 degrees images and fly through sequences to the model surface.

**Integration with audiovisual media tools**
Due to its open nature, gison3dmap can be easily integrated with commercially available audiovisual media tools. Using either the gison3dmap API or commands send through a network socket connections, solid terrain models can be added as 3D terrain screens to such systems, enhancing their communication capabilities with 3D map projections.

## 5 Conclusion

With gison3dmap CCCGeomática provides a commercially available tool which extends the use of 3D solid terrain models and architectural models to a new level of geographic communication.

The areas of application are immense. Museums, territory interpretation centers, visitor's centers, environmental awareness, sustainable tourism and education, the presentation of infrastructure project developments, and the implementation of the public participation processes, are among the uses made so far with gison3dmap.

From user feedback, gison3dmap has proven to be a very efficient way to communicate geography to disparate audiences, contributing to better explain the impact of proposed developing or conservation strategies, and empower the knowledge for more meaningful and participated decision making processes.

Because the system has a GIS database at its core, projection is dynamic, with map projections immediately reflecting the changes in the data.

The interaction with the gison3dmap system can be achieved with different software tools at different levels of expertise, and can be easily expanded to include new user interaction requirements.

## References

1. C. Coucelo, P. Duarte, and R. Crespo, "Combining 3D Solid Maps with GIS Data Video Projection," Proc. 2nd Int'l Conf. Geographic Information GIS Planet, CD-ROM, 2005
2. L. Faulkner, "Physical Terrain Modeling in a Digital Age", Solid Terrain Modeling, Inc. (http://www.solidterrainmodeling.com)
3. GDAL/OGR web page (http://www.gdal.org/ )
4. OpenTK web page (http://www.opentk.com/ )
5. OpenCV web page (http://opencv.willowgarage.com/wiki/ )
6. Arduino web page (http://www.arduino.cc/ )

# Using Environmental Information to Support Decisions Making

Sonia Montecinos[1], Inge Bischoff-Gauss[2], Norbert Kalthoff[3], Marco Molina-Montenegro[1], Pablo Salinas[1], Luisa Bascuñán-Godoy[1]

[1]Centro de Estudios Avanzados en Zonas Aridas (CEAZA)
Raul Bitran s/n Colina El Pino, La Serena, Chile
sonia.montecinos@ceaza.cl
mam-m@ceaza.cl
luisa.bascunan@ceaza.cl
pablo.salinas@ceaza.cl

[2]Steinbuch Centre for Computing (SCC)
Karlsruher Institut für Technologie (KIT)
Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany
ingeborg.bischoff-gauss@kit.edu

[3]Institut für Meteorologie und Klimaforschung (IMK)
Karlsruher Institut für Technologie (KIT)
Hermann-von-Helmholtz-Platz 1, D-76344 Eggenstein-Leopoldshafen, Germany
norbert.kathoff@kit.edu

**Abstract.** Environmental conditions have a great influence in many economical activities. Having a map of climatic conditions can help to decide which areas are the most suitable for developing particular economic activities. In this article we use atmospheric modeling to evaluate the mean meteorological conditions on the semi-arid Coquimbo Region (30°S, Chile). We generate maps of mean values of temperature, wind speed and other atmospheric variables, and show applications of these results in two specific cases: On the one hand we generate wind maps, which allow to identify areas where wind energy can be harvested to produce electricity, and we evaluate the spatial distribution of the performance of a specific wind turbine in the entire region. On the other hand we superimpose maps of diurnal air temperature amplitude with experimental data obtained by controlled field experiments to generate maps of performance of two varieties of Quinoa, helping to decide which variety is better adapted to different sites of the region.

**Keywords.** Atmospheric modeling, climatology, spatial analysis, temperature, wind energy, agriculture sustainability

## 1 Introduction

Environmental conditions have a great influence in many economical activities. The knowledge of the climatic characteristics of an area can represent a very important tool to analyze the profitability of economic activities. Meteorological variables such as temperature and wind speed and direction are strongly influenced by the topography and soil characteristics. Therefore, in a region with complex topography they can experience large variations in relative small distances. So, its spatial distribution cannot be easily deduced by taking as a reference just a few meteorological stations.

Mesoscale atmospheric modeling allows the evaluation of meteorological variables in an extended area taking into account orographic and synoptic conditions, as well as the physical processes relevant for their behavior. In this work, we use the KAMM model (Karlsruhe Atmospheric Mesoscale Model) to evaluate the mean meteorological conditions in a period of 16 years, from 1990 to 2005, in the semi-arid Coquimbo Region in Chile (~30° S). The results have a large potential applicability. In this work we combined climatic characteristics with additional information to generate secondary maps and showed their applicability to make decisions in two particular cases:

### 1.1 Wind maps

Wind maps are graphic representations of the spatial distribution of the mean wind velocity at a fixed high above ground level (agl). Because the performance of a wind turbine depends not only on the wind speed but on the distribution of wind speed, we applied the manufacture curve of a specific wind turbine in combination with model results to generate maps of the so called plant factor. The plant factor is an indicator for the efficiency of the wind turbine and allows estimating the spatial distribution of the electric energy that could be generated from the wind using a specific wind turbine.

Because of the high costs involved, before a wind farm is installed it is necessary to measure the wind for a long time (5 years or more). Both, wind maps and plant factor maps, can help to identify the areas with good wind resources and therefore they are a powerful tool to select the right place to install a monitoring tower, helping to save money and, more important, time.

### 1.2 Maps of performance of Quinoa varieties

One of the species best adapted to adverse climatic conditions such us drought, is Quinoa (Chenopodium quinoa Willd). Because of its high nutritional properties, it has been an object of attention of many investigators (see for example [1]). However both, harvest factors and nutritional properties depend on environmental conditions, especially on the temperature [2]. In this article we combine climatic information with experimental results that indicate the adaptability of two Quinoa varieties to an extreme diurnal temperature amplitude, to generate maps of their performance for the semi arid Coquimbo Region of Chile.

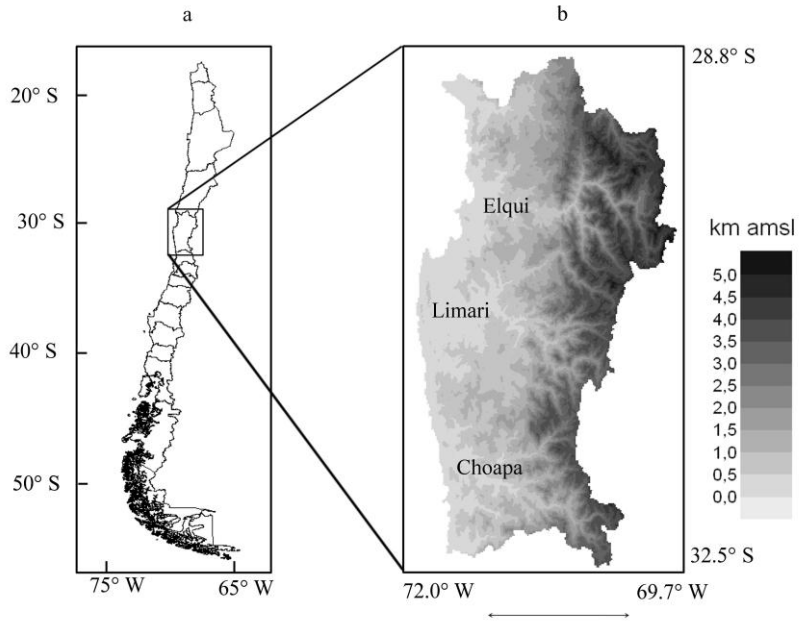



**Fig. 1.** a: Localization of the Coquimbo Region in Chile; b: Coquimbo Region. The grey scale represents the topography in km above mean sea level

## 2 Methodology

The evaluation of the atmospheric conditions was performed with the three-dimensional non-hydrostatic Karlsruhe Atmospheric Mesoscale Model (KAMM)) [3]. The model consists of two components, the atmospheric and the soil vegetation module [4]. It solves the momentum, heat, and humidity equations, transformed onto a coordinate system which follows the terrain. It needs as input data information from the large-scale

synoptic weather situation (profiles of temperature, humidity and wind) as well as topography, soil types and land use. More information about the model can be found in [5] and [6].

We evaluated the mean meteorological conditions for a period of 16 years, from 1990 to 2006. The methodology was based on cluster analysis ([7], [8]), which is a method to identify groups or clusters with common patterns. The variables used to define similarity were the zonal and meridional winds, both at 500 hPa, and the temperature amplitude between 850 hPa and 500 hPa. For each cluster a simulation with the KAMM model was performed. The simulations of the clusters were averaged taking into account the statistical weight of the clusters.

Model results were validated with experimental data registered in 27 ground meteorological stations. The applications shown in this article were evaluated by combining spatialized meteorological variables with additional information:

Wind maps were generated evaluating the yearly mean wind speed at a fixed height agl. To estimate the energy that could be generated in the area, we used model results to evaluate the probability distribution of the wind speed at each point in the area. We combined these results with the performance curve of a specific wind turbine (V90-2.0 MW 50 Hz VCS, from VESTAS), leading to maps of plant factor for the Coquimbo region.

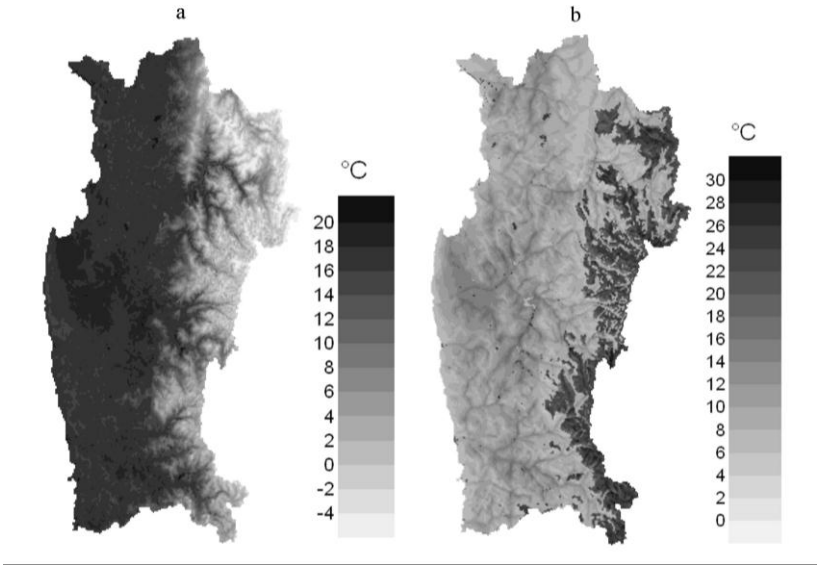



**Fig. 2.** a: mean temperature at 2 m above ground level (agl); b: diurnal thermal amplitude at 2 m agl

Performance maps of the Quinoa varieties were generated as follow: in order to understand the physiological response of the Quinoa to diurnal temperature amplitude, plants of two varieties of Quinoa, BO78 and PRP, with initial homogeneous characteristics were transplanted to plastic pots and distributed in growth chambers maintained under different diurnal temperature amplitudes conditions. The manipulative experiment lasted for 6 months, and during this period the survival of the plants was recorded; at the end of the experiment two additional parameters: the normalized photochemical efficiency (Fv/Fm), and dry biomass were measured. The Fv / Fm parameter has been widely suggested as stress indicator for plants. Thus, the whole performance was defined by:

$$\text{Performance} = (0.5 \times \boldsymbol{S}) + (0.25 \times \boldsymbol{Fv/Fm}) + (0.25 \times \boldsymbol{B}),$$

with $\boldsymbol{S}$ and $\boldsymbol{B}$ the survival and dry biomass, respectively. The statistical weight we applied to the different parameters that influence performance were chosen by taking in account the relevance to obtain a successful yield in the semi-arid Coquimbo region. For a detailed description of the experiment see [9]. On the other hand, we evaluated the spatial distribution of the diurnal thermal amplitude as the difference between the mean maximum and mean minimum temperature. The maps of performance were generated by superimposing the experimental results with diurnal thermal amplitude fields.

### 2.3 Study site

The study was carried out in the semi-arid Coquimbo Region of Chile, south of the hyperarid Atacama Desert (Figure 1). It is characterized by a complex topography with altitudes that varies from the sea level in the West increasing to the East, reaching heights of about 5000 m in the Andes (see Figure 1b). The climatic conditions are determined by the Pacific Ocean, the cold Humbolt Current and the south eastern Pacific anti-cyclone, resulting in low precipitation rates [10].

The mean annual precipitation varies from about 100 mm at the coast to about 300 mm at the top of the Andes and has a marked decrease to the north, which is important orographically influenced [11]. Favored by the water resources coming from the nearby Andes Cordillera, agricultural activities are possible in the transverse valleys, Elqui (30,0° S), Limarí (30,5° S) and Choapa (31,6° S), so that high differences in the surface properties between cultivated and natural areas exist.

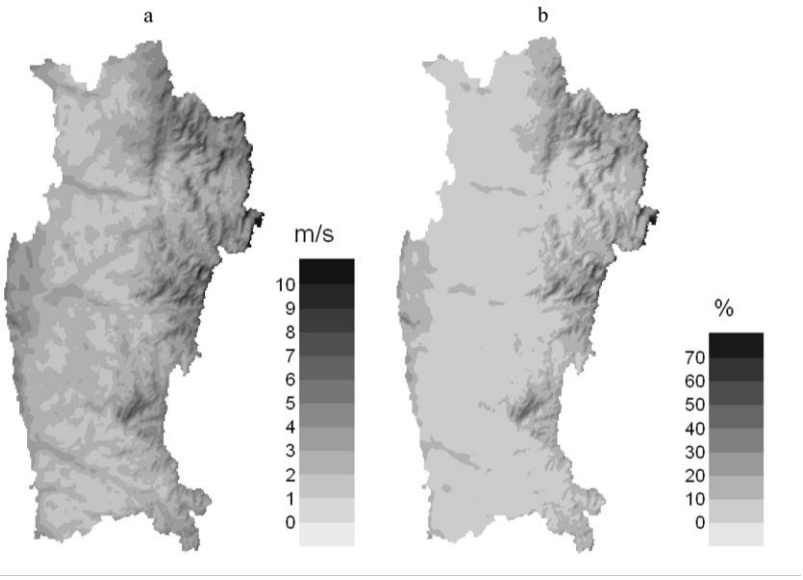



**Fig. 3.** a: map of mean wind speed at 70 m agl; b: map of efficiency by using the VESTAS turbine V90-2.0 MW 50 Hz VCS

## 2 Results

We evaluated the mean meteorological characteristics of the Coquimbo Region. We found that thermal winds are induced during the day in the three transversal valleys of the region, in agreement with the results reported in [10]. Figure 2 displays the fields of temperature (a) and of the diurnal temperature amplitude (b), both at 2 m agl. We can see that the spatial distribution of both fields is strongly influenced by orography. Near the coast the mean temperature ranges from 16 °C to 20 °C, while low temperature values, close and below 0° C, are achieved at the high Andes Cordillera (Figure 2a). The diurnal temperature amplitude shows an opposite behavior: low values of about 4° C to 8° C are present near the coast, increasing to the east reaching values of more than 25° C in the high Andes Cordillera (Figure 2b).

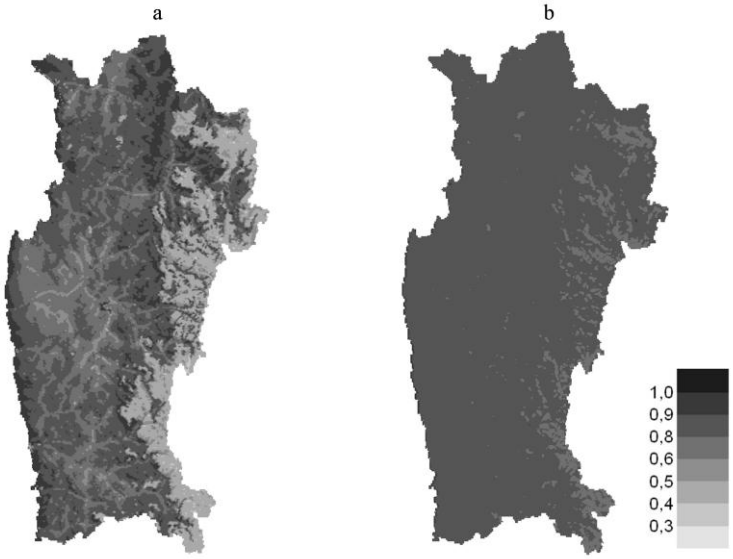



**Fig.4**. Maps of performance of Quinoa varieties I the Coquimbo Region; a: B078; b: PRP

### 2.1 Wind maps

Figure 3a shows the mean wind speed at 70 m agl. The highest values of wind speed are achieved mostly in sites near the coast and in the high Andes Cordillera. However, not all places with high wind speed agree with high plant factor values, as obvious from Figure 3b. In fact, because in many areas of the region the wind speed is very low during nighttime, in these areas the wind turbines work only during daytime, resulting in low performance. In the coastal area, where the wind blows during day and night, it is possible to find sites with both, high wind speed and high plant factor.

### 2.1 Maps of performance of two Quinoa varieties

The performance of the Quinoa varieties B078 and PRP are shown in Figure 4 a and b, respectively. We found that, though the performance of both varieties decreased with increasing thermal amplitude, the effect is most obvious in B078 than in PRP. Individual of the variety B078 showed higher performance values near the coast, decreasing sharply eastwards with decreasing thermal amplitude (Figure 2b). Inversely, the variety PRP maintains its performance relatively constant in most part of the region, decreasing in the high mountains, where the diurnal temperature amplitude exceeds 30° C.

## 3 Summary and discussion

In this investigation we used mesoscale modeling to evaluate the mean meteorological characteristics of the semi-arid Coquimbo Region in Chile, and showed how the results can be applied to generate secondary information to evaluate the convenience of using a territory for economic activities depending on climatology.

We showed two applications: wind maps and maps of plant factor for a specific wind turbine, which can help to select appropriate sites suitable to generate electricity from the wind.

Additionally, we built maps of the performance of two Quinoa varieties, B078 and PRP, by superimposing maps of the diurnal thermal amplitude with experimental data performed under controlled conditions. The experimental results show that the diurnal thermal amplitude influences the three factors that determine its performance: survival, photosynthetic parameters and the biomass of the plant. The generated maps can help farmers to choose the Quinoa variety best adapted to his ground. The maps of performance showed in this

article can be improved incorporating the response of the two Quinoa varieties to other climatic variables such as temperature, radiation, etc.

Finally, we would like to emphasize that atmospheric modeling enables to evaluate mean meteorological characteristics of any region. Maps of climatic characteristics, superimposed with additional information allows to generate maps that can help to evaluate the profitability of develop an economic activity in a site, helping to territorial planning.

**Acknowledgements.** This work was supported by CONICYT, Project FONDEF D05I10038 and the International Exchange Project BMBF – CONICYT 066-2007. The authors thank SCC (Steinbuch Centre for Computing, Karlsruhe Institut für Technologie (KIT), Germany) for the supply of computing time on NEC SX8 in the context of CampusGrid Project.

## References

1. Rosa, M., Hilal, M., González, J.A., Prado, F.E.: Changes in soluble carbohydrates and related enzymes induced by low temperature during early developmental stages of quinoa (Chenopodium quinoa) seedlings. Journal of Plant Physiology 161 (2004) 683–689
2. Molina-Montenegro, M.A., Zurita-Silva, A., Oses, R.: Effect of water availability on physiological performance and lettuce crop yield (Lactuca sativa). Ciencia e Investigación Agraria 38 (2011) 65-74
3. Adrian, G., Fiedler, F.: Simulation of unstationary wind and temperature fields over complex terrain and comparison with observations. Contributions to Atmospheric Physics 64 (1991) 27–48
4. Schädler, G., Kalthoff, N., Fiedler, F.: Validation of a model for heat, mass and momentum exchange over vegetated surfaces using LOTREX-10E=HIBE88 data. Contributions to Atmospheric Physics 63 (1990), 85–100
5. Bischoff-Gauss, I., Kalthoff, N., Fiebig-Wittmaack M.: The influence of a storage lake in the arid Elqui valley in Chile on local climate. Theoretical and Applied Climatology (2006) 85, 227–241
6. Montecinos. S., Boersch-Supan, W., Favier, V., Astudillo, O., Tracol, Y.: Impacts of Agricultural Activities on the Regional Climate in an Arid Zone in Chile. Die Erde 139 (2008) 77-95
7. Anderberg, M.R. Cluster Analysis for Applications. 1st edn. Academic Press, New York (1973)
8. Ward, J. H.: Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association 58 (1963) 236–244
9. Montecinos, S., Salinas, P., Osses, R., González-Silvestre, L., Molina, M.A.: Linking climatic variability with spatial distribution in two varieties of quinoa distributed in a semi-arid zone. American Journal of Plant Sciences 3 (2012) 1682-1687
10. Favier, V., Falvey, M., Rabatel, A., Pradeiro, E., Lopez, D.: Interpreting discrepancies between discharge and precipi tation in high-altitude area of Chile's Norte Chico region (26–32ºS). Water Resources Research 45 (2009) 1-20
11. Kalthoff, N., Bischoff-Gauss, I., Fiebig-Wittmaack, M., Fiedler, F., Thuerauf, J., Novoa, E., OPizarro, C., Castillo, R., Gallardo, L., Rondanelli, R., Kohler, M.: Mesoscale wind regimes in Chile at 30° C. Journal of Applied Meteorology 41 (2002) 953-970

# The Geo-Citizen Approach: Implementation of a Collaborative Participation Framework for Citizen Collaboration

Anton Eitzinger[1], Karl Atzmanstorfer[2], Richard Resl[3]

[1]Anton Eitzinger
International Center for Tropical Agriculture (CIAT)
CIAT, A.A. 6713, Cali, Colombia
a.eitzinger@cgiar.org

[2]Karl Atzmanstorfer
Department of Geoinformatics – ZGIS, University of Salzburg
Hellbrunnerstrasse 34, 5020 Salzburg, Austria
karl.atzmanstorfer@sbg.ac.at

[3]Richard Resl
Universidad San Francisco de Quito
Av. Diego de Robles y Via Interoceánica, Cumbaya, Ecuador
rresl@usfq.edu.ec

**Abstract.** Nowadays, citizens increasingly make use of mobile devices to access the internet, share their geographic location and to get in touch with other users in their everyday life. The suggested geospatial web-platform (the *GeoCitizen* platform) takes advantage of these technological achievements and brings together citizens allowing them to collaboratively identify, report, discuss, solve and monitor problems in their living environment using one single web-platform that combines geo-web technologies and social media tools. Currently, the platform is implemented and tested in two case studies with two different problem focuses. The first case study refers to a rapidly growing suburban area of Quito, Ecuador where the platform helps citizens who are facing a lack of support by public administration to start their own participatory spatial planning initiatives. The second case study focus on Colombian smallholder farmers exposed to changing climates, in order to provide them with a collaborative instrument for efficient adaptation strategies.

## Keywords

Web 2.0, geospatial web-platforms, social media, Public Participatory GIS (PPGIS), empowerment, spatial planning, climate change

## 1 Volunteered Geographic Information, Web 2.0, Participation and Empowerment

In the last decade, technological achievements like GPS, smartphones, virtual globes, and a variety of other Web 2.0 tools have facilitated the dissemination of (spatial) information and the collection of crowd-sourced (spatial) data [1]. These rapidly evolving technologies have brought new perspectives for redefining participatory spatial planning, public administration and working with communities with the aim to empower citizens to better manage their living environments. Social media like facebook or twitter are increasingly available for a wide range of users, even in emerging societies of developing countries [2]. This creates so far unknown possibilities for communities and citizens to participate in planning processes and to benefit from major scientific findings concerning their living environment, like the mitigation of the negative effects of climate change. An increasing number of consumers of spatial data are not only using, but also producing

spatial data [3]. This use, creation and sharing of spatial data by laypersons is termed Volunteered Geographic Information (VGI) or Neogeography and is a current issue of in-debt discussions in scientific literature [4], [5], [6], [7], [8]. Web 2.0 tools in general, and geospatial web-platforms in specific, facilitate layperson to collect spatial data and identify problems in their habitat in a transparent and traceable manner [9], [10]. In addition, such 'prosumers' of spatial data can increasingly resort to freely available cartographic data like base-maps provided by non-profit initiatives such as OpenStreetMap [11].

In the planning domain, the concept of Public Participatory GIS (PPGIS) emerged in the mid-1990s, referring to the incorporation of non-expert stakeholders in spatial planning processes [15], [16]. [17] define PPGIS as "collaborative and participatory approaches to planning, using GIS" (p. 81). PPGIS link community participation and geographical information in a diversity of social and environmental contexts, involving citizens in decision making processes [18]. For a long time, collaborative mapping initiatives dominated real-world PPGIS applications [19]. However, the last decade brought the development of a considerable number of geospatial web-platforms that aim at enabling citizen participation in the management of their living environment. These platforms mainly call local governments' attention to problems regarding the provision of public services, issues related to security and (public) transportation issues or the environment (e.g. FixMyStreet (http://www.fixmystreet.com/), SeeClickFix (http://en.seeclickfix.com/) or ParcScan (www.parkscan.org)). So far, the use of these applications has been limited to industrialized nations in North America and Europe. In 2012, however, a new collaborative platform for citizen engagement was launched in Cali, Colombia (www.ciudadanosactivos.com).

Recent experiences suggest that information and communication technologies (ICTs) are also playing an increasing role in the capacity of developing countries to withstand, recover from, and adjust to climate change impacts [12]. Especially mobile devices have become an important tool for the collection and communication of such data. [13] examine the growth of mobile phone technology over the past decade and consider its potential impacts upon quality of life in low-income countries. However, implementing successful rural computing applications requires addressing a number of significant challenges: current web-based mobile applications are often hard to use, do not take advantage of the mobile phone's media capabilities and require an online connection [14].

As mentioned above, recently available Web 2.0-techonolgies and their diffusion within society opened up new vistas for participatory planning initiatives and the dissemination of scientific findings. In this respect, [20] created the term 'social geo-communication' referring to the participation of the public in planning processes supported by Web 2.0 platforms. These platforms provide the ground for 'spatial citizens' that are able to "interpret and critically reflect spatial representations, communicate […] and express location-specific opinions with the aid of maps" [21] (p.4). The essential skill of 'spatial citizens' is what scholars such as [8], [9] and [11] refer to as 'spatial literacy'. This is the ability of an individual to capture and communicate knowledge in the form of a map, understand and recognize the world as viewed from above, recognize and interpret patterns, know that geography is more than just a list of places on the Earth's surface, see the value of geography as a basis for organizing and discovering information, and comprehend such basic concepts as scale and spatial resolution [4].

The idea of 'spatial literacy' and 'spatial citizens' are an important approach in order to integrate geospatial web-platforms into the concept of empowerment. [22] defines empowerment "as the process by which stakeholders identify and shape their lives and the society in which they live through access to knowledge, political processes and financial, social and natural resources" (p. 62). By doing so, empowerment of citizens or communities that so far have been excluded from participating in the design and management of their habitat, is an intrinsic aim of any participation initiative. [23] state, that the overarching goal of every PPGIS activity is empowerment, as PPGIS "can be empowering to disadvantaged groups by enabling them to use the language and tools of decision makers and so influence events that affect their lives and local geography" (p. 91). According to [21], the use of geospatial-web tools is a major factor for democratic negotiation and public participation in the spatial domain referring to the concept of 'actualizing citizens' (as opposed to 'dutiful citizens') that act through loose networks using social media and the geospatial-web for communication and interaction. They use digital narratives, which change their relationships to civic knowledge and its components of authority, credibility, production-consumption, and sharing of information.

New technological trends like geospatial web-platforms as well as the use of Volunteered Geographic Information and their embedding into delicate societal issues like empowerment and public participation

trigger research questions in regard to the quality and privacy of data [10]. There is a legitimate concern amongst professional GIS-practitioners regarding certainty, accuracy and quality of spatial data collected by laypersons that may not always meet the quality criteria of data and maps produced by professional cartographers in e.g. public mapping agencies [3],[7], [24]. Furthermore, the publication of Volunteered Geographic Information on geospatial web-platforms may not always meet specific conceptions of privacy that vary throughout different cultures [25]. Recently, web-platforms such as 'RottenNeighbor' (where users have been encouraged to expose 'bad' neighbors like sex offenders, see: http://en.wikipedia.org/wiki/Rottenneighbor.com), or MyBikeLane (where citizens can report traffic violations like illegally parked cars on bike lanes; see: http://www.mybikelane.com/) have been controversially discussed in public and even raised serious legal concerns. Moreover, technological and structural limitations for accessing ICT-tools must be considered when evaluating the potentials and limitations of these new technological achievements. The concept of the 'digital divide' raises the question if the selective access to ICT perpetuates exclusive social structures and hence even more exclude marginalized communities from participation [15], [26], [27]. However, the increasing availability of telecommunications infrastructures (especially mobile devices) even in emerging societies and developing countries have helped to close this technological gap [28]. In order to facilitate the use of geospatial web-platforms for users with no or just little spatial literacy, application developers and researchers put a strong emphasis on usability issues. User-friendly designed tools and frameworks should address also users that do not have the necessary skills for properly handling and processing spatial information. This is what scholars such as [1] and [10] refer to as 'secondary digital divide' that has to be bridged.

Another crucial issue is whether and – if so - to which extent planners resort to participatory initiatives that use social media and other ICT-tools and if these initiatives are turned into real action in the end [2]. Therefore, the conceptual framework in which these technologies are embedded in existing power structures is - besides the issue of usability – an important point to consider when developing geospatial web-platforms for public participation and citizen collaboration. The implementation of the concept of 'social geo-communication' in participatory spatial planning would demand a framework that fully integrates web-mapping tools and social media in one single platform that is accessible also with mobile devices. However, existing geospatial web-platforms do not yet provide proper tools for discussion and problem solving based on community interaction with the limiting effect that communication between citizens and authorities tends to stay uni-directional. Hence, an increasing number of scholars ask for the amplification of these platforms by adding additional functionalities that allow citizens to engage in building communities, programming activities, and in finding sound solutions rather than reporting their complaints to central (planning) offices or other institutions [2], [16] and [29]. This is aimed at with the *GeoCitizen*-framework that is presented in this paper.

## 2 The *GeoCitizen*-framework and the *GeoCitizen*-platform

The *Geo-Citizen* framework allows citizens and communities to identify, report, discuss, solve and monitor problems related to spatial planning, the provision of public services and other issues concerning their living environment at a local level using a geospatial web-platform. This platform – the *Geo-Citizen* platform - merges geo-web technologies and social media in one single, comprehensive and interactive tool for participatory spatial planning, community interaction and citizen collaboration. As citizens are good observers of problems occurring in their habitat, this platform enables them to interconnect their observations and perceptions of their living environment on a neighborhood scale with other citizens in the same neighborhood or community. But it also provides an efficient tool to connect themselves to other citizens, communities, and local initiatives outside their immediate habitat that face the same type of problems and that have similar observations and maybe solution strategies which can be exchanged. This is done in order to find proper solutions for planning-related conflicts (e.g. infrastructure projects, zoning of land, property and cadaster related issues), the provision of public services tailored to the citizens' needs (public transport, public security, energy and (waste-) water management, public health and educational infrastructure, etc.) or problems that are related to deteriorating environmental conditions (e.g. due to the effects of climate change).

The *GeoCitzen*-platform provides a communication framework that constitutes a social network for citizens and their initiatives that is based on geo-referenced observations of what is affecting their quality of life. By discussing these issues in the public space of the World Wide Web, immanent power relations between citizens, public administration and other stakeholders of (spatial) decision making processes should become more transparent, and the flow of information should be boosted. Public authorities should be urged to share information directly to and between the affected citizens and communities. As a consequence, the action of administrative bodies should become more transparent and legitimated by the affected citizens. The framework establishes an open access entry point for every citizen to identify geographically a problem and connect it to a thematically specific problem solving process. In enables users to find collaborators in their neighborhood, get informed regarding the spatial context of the problem and the related conflicts. Experts for specific problem domains can be consulted and best practice examples can be exchanged in order to get inspiration from how other communities have solved the same or a similar type of a problem. GIS tools support the construction of problem focused local knowledge, and evidences the collective spatial decision making process. Issues that so far have been treated in separate frameworks focused on one, single type of a problem (e.g. deteriorating road infrastructure, badly managed recycling of waste) can now be interconnected to an integrative framework that do not treat a problem as a singular issue but as part of a broader (planning) concept. Hence, citizens are empowered to be part of the solution for a problem as they are encouraged to find their proper problem solving strategies within their communities instead of uniquely resorting to external experts or the action of administrative bodies. This is especially important in regions where government and public administration tends to be inefficient, bureaucratic and sometimes even corrupt.

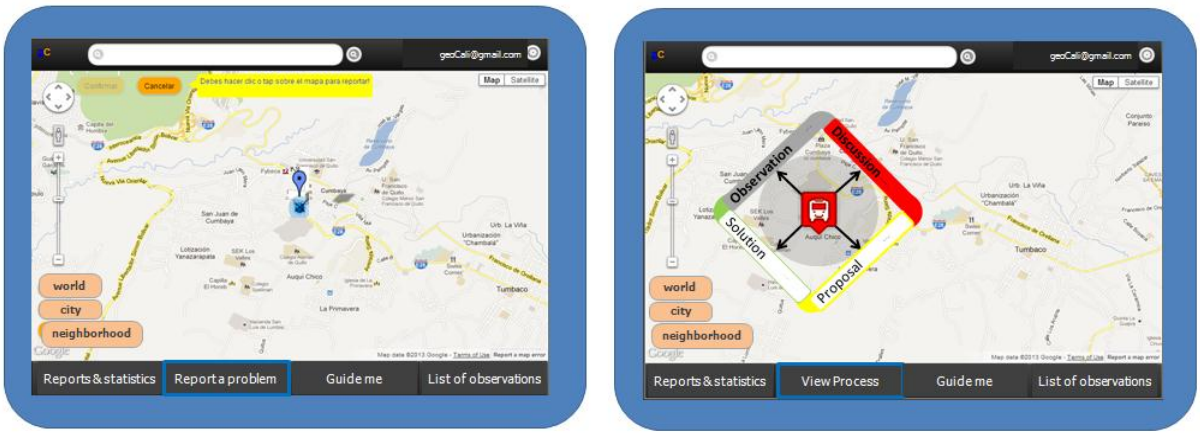



**Fig. 1. the GeoCitizen-platform**

The *GeoCitizen*-platform is designed as a cross-platform for web-browsers on desktop computers and mobile devices like smartphones and tablets. Doing so, the platform provides a framework to communities and their members for exchanging local knowledge, their everyday experiences and observations about issues related to spatial (planning) processes, based on geographical features located on an online mapping platform.

Observations that are reported by a *user* are structured into themes and categories. In these categories, the user provides detailed information about the observed subject for discussion in the neighborhood or community he/she is engaged. The user can upload pictures, documents and links to other sources on the web. After reporting, a problem-solving process can be started by specifying a process aim and the user can invite other *GeoCitizen*-users or personal contacts to participate in the problem-solving process. If the user does not want to start the problem-solving process by him/herself, he/she can leave the reported problem as an observation, even if he/she wants to report as an anonymous user. Converting an existing observation to a problem requires the user to be the *owner* and *moderator* of the problem-solving process. A new observation can also be joined to an already existing problem-solving process if the reporting user considers that the observation fits an existing process in the same thematic category or neighborhood or city.

Once one or more observations became object(s) of an existing problem-solving process, participating users can discuss the problem and possible solutions in a discussion forum. They can add more information and ask external experts for advice. The moderator of the process formulates a proposal for the solution on which the participating users have to vote in order to approve the group's decision. Users can join or leave the problem solving process according to their degree of concern about a topic or invite other people to participate. In their solution finding process they are linked to user groups in other neighborhoods and municipalities that have the same necessities and that may already provide solutions for the same type of problem as best practice examples. The moderator is responsible to guide the group discussion and provide their members with additional information (expert knowledge about factors that drive spatial planning on larger scales) in order to keep up an active discussion and to support the finding of the best proposal for the problem-solving process. Once the group confirms the proposed solution by voting, the result will be evaluated by an external expert in this topic (*evaluator*) who assesses whether or not the proposed solution is feasible. The *evalutator* supervises the ongoing solution finding and can support the group by giving advice or providing best practice solutions from similar processes in the same theme or category. The participations of the discussion process may or may not refer to the evaluator's assessment when deciding upon a final solution for a problem. Finally, the identified solution can be presented to planning authorities, other community members and a broader public by traditional means of printed reports, a *GeoCitizen-blog-post*, by mail or through social networking platforms. In order to follow up on a finished process or a doubt whether or not appropriate measures for implementing a proposed solution have been taken, *GeoCitizen-users* can re-open an already finished process and can start a new discussion on the same topic by request to the evaluator.

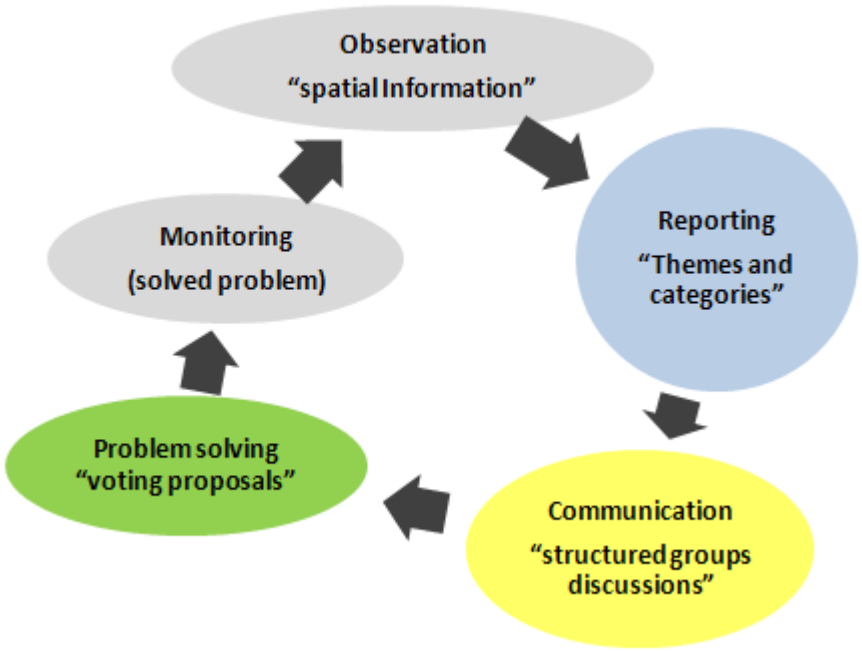



**Fig. 2. the GeoCitizen-Method**

## 3 Case Study Applications

The *GeoCitizen*-framework will be tested in two different case studies in the first half of 2013 in order to investigate basic issues of usability and system performance amongst representative platform users. The first case study refers to a rapidly growing suburban area of Quito, Ecuador where the platform helps citizens that are facing a lack of support by public administration to start their own participatory spatial planning

initiatives. The second case study focus on Colombian smallholder farmers exposed to changing climates in order to provide them with a collaborative instrument for efficient adaptation strategies.

### 3.1 Case Study 1: Spatial Decision Making in the municipality of Tumbaco, Ecuador

The municipality of Tumbaco is located in the central Andean Highlands in the capital district of Quito, Ecuador. With currently 180 000 inhabitants, it has seen an explosion of housing and businesses activities over the last decade that dramatically increased the use of scarce land, traffic and environmental problems [30]. Public authorities have not proven to be able to efficiently manage urban sprawl and related infrastructure projects, land zoning, a sound management of property related issues or the provision of efficient public services [31]. This increasingly courts the resentment of affected citizens which feel to be excluded from decision making processes by the established decision networks in politics and the private entrepreneurial sector. Therefore, this area is considered as a representative case study area for first test-run of the *Geo-Citizen* framework.

Starting in February 2013, the usability of *Geo-Citizen* platform will be tested amongst a selected group of representative users in the municipality of Tumbaco. This group will comprise members of grass-root and community organizations, representatives of the municipal administrative body, but mainly ordinary citizens whose ability to operate Web 2.0 tools is most likely to be limited. Aim of this preliminary usability study is to identify where the user-interface and its functionalities have to be optimized in order to enable users with only little spatial literacy to fully operate the platform. This is done in order to not exclude any potential user or user group from further empowerment and citizen collaboration initiatives. Results of this study will be available by April 2013 and will be immediately used to optimize the *Geo-Citizen* framework for the first case study with the fully operational platform which will take place in the municipality of Tumbaco in summer 2013. Then, the framework will be tested during three months regarding following problem categories: (a) infrastructure projects, (b) land zoning, (c) cadaster/property issues and (d) public services. Main partners in the case studies are the University San Francisco de Quito (USFQ), CBOs (Community Based Organizations) and the municipality of Tumbaco that will act as facilitators for promoting the use of the platform and coordinating affiliated participatory activities. Background data that give additional information about the status-quo and planned projects encompass cadaster and land value, zoning, topography and environment, as well as public infrastructure and facilities. Census and other socio-economic data will be used to analyze framework performance and typical patterns of user behavior in the aftermath of the case study. This systematic analysis will help to answer (a) whether or not the *Geo-Citizen* framework can help to make spatial decision processes more transparent and democratically organized, (b) if it encompassed a representative share of the municipality's population and (c) if it may help to empower those citizens that so far have been excluded from spatial decision making in the future. The *Geo-Citizen* platform will be available for desktop and mobile application. Preliminary results are expected for autumn 2013 and will be used to redesign the framework and platform for further use.

### 3.2 Case Study 2: Mitigating the effects of climate change in rural Colombian communities

The second case study will focus on bringing climate and crop science to communities in order to empower farmers and rural communities to be part of the global effort to mitigate climate change through emission-reduction and carbon-sequestration. Here, the challenge is to combine local community-knowledge and climate science for better adaptation, mitigation and resilience strategies.

The scientific community reports that agriculture in Latin America is prone to suffer severe damage within the next decades because of the negative effects related to climate change [32], [33], [34], [35]. As a result of these studies, a growing amount of data and methods to provide adaptation strategies for farmers and supply-chain actors exists [36], [37], [38]. Based on this data, smallholder farmers and decision makers both need precise pathways to respond to Global Climate Change (GCC) through adaptation measures. By using modern Information and Communication Technologies (ICT's), they could build up virtual user-groups to jointly develop viable adaptation- and mitigation strategies. Evidence shows that good adaptation practices are site-specific. Hence, they have to be tailored according to each environmental setting and with regard to the available livelihood options appropriate for a local scale.

By generating knowledge from a smallholder farmers-crowd, the *GeoCitizen*-platform aims at improving the local relevance of adaptation- and mitigation strategies and at bringing together stakeholders along the problem solving chain in a comprehensive framework taking advantage of complementing research outputs. In this case study, available spatial research data for smallholder agriculture in Colombia will be presented to the platform users (farmers, scientists, decision-makers of agricultural extension services) as easy-to-understand climate change storytelling-maps. In a pilot community, farmers will be invited to manifest their interest by reporting their observations related to the negative effects of climate change on the platform. The platform helps them to build 'virtual' farmer-groups that are challenging similar impacts of climate change. Together with researchers and agriculture experts, they can discuss possible adaptation strategies *(=problem-solving process*) and come up with recommendations for mitigation efforts in their specific case (*proposal and solution).* The implementation of adaptation- and mitigation measures can then be monitored on the platform in public.

## Acknowledgement

This research is funded by the Austrian Science Fund (FWF) through the Doctoral College GIScience at the University of Salzburg (DK W 1237-N23).

## References

1 Sui, D., Elwood, S., Goodchild, M. (ed.): Crowdsourcing Geographic Knowledge. Volunteered Geographic Information (VGI) in Theory and Practice. Springer Verlag, Dordrecht Heidelberg New York London (2013)

2 Evans-Cowley, J.S.: Planning in the Age of Facebook: the role of social networking in planning processes. GeoJournal 75 (2010) 407-420

3 Fischer, F.: Geotagging and the City: Understanding the Use of Social Location Applications in Urban Space. Dissertation, Paris Lodron University Salzburg (2012)

4 Goodchild, M.F.: Citizens as Sensors: The World of VGI. GeoJournal, 69-4 (2007) 211-221

5 Rosser, J., Morley, J.: Rate-my-place: a social network application for crowd-sourcing vernacular geographic areas Proceedings of the 18th annual GIS research UK (GISRUK) (2010) 155-160

6 Elwood, S.: Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS. GeoJournal 72 (2008) 173–180

7 Goodchild, M. F.: Commentary: whither VGI? GeoJournal, 72 (2008) 239-244

8 Blaschke, T., Strobl, J.: Geographic Information Science Developments. GIS.Science - Zeitschrift für Geoinformatik 23-1 (2010) 9-15

9 Bednarz, S.W., Kemp, K.: Understanding and nurturing spatial literacy. Spatial Thinking and Geographic Information Sciences Conference 2011, Tokyo (2011)

10 Haklay, M. (ed.): Interacting with Geospatial Technologies. Wiley-Blackwell Chichester (2010)

11 Goodchild, M.F.: Twenty years of progress: GIScience in 2010. Journal of Spatial Information Science 1 (2010) 3-20

12 Ospina, A.V., Heeks, R.: Making Policy on ICTs and Climate Change in Developing. Centre for Development Informatics. Manchester UK (2012)

13 Aker, J.C, Mbiti, I.M.: Mobile Phones and Economic Development in Africa. Working Paper 211. Journal of Economic Perspectives (2010) 45

14 Tapan, S.: Designing an architecture for delivering mobile information services to the rural developing world. Proceedings of the 15th international conference on World Wide Web (WWW '06). New York (2006) 791-800

15 Ghose, R.: Politics of scale and networks of association in public participation GIS. Environment and Planning 39 (2007) 1961–1980

16 Ramasubramanian, L.: Geographic Information Science and Public Participation. Springer Verlag Berlin Heidelberg (2010)

17 McCall, M.K., Dunn, C.E.: Geo-information tools for participatory spatial planning. Geoforum 43 (2012) 81-94

18 Steinmann, R., Krek, A., Blaschke, T.: Analysis of online public participatory GIS applications with respect to the differences between the US and Europe. UDMS Urban Data Management Systems. Venice (2004)

19 Sieber, R.: Public Participation Geographic Information Systems. Annals of the AAG 96-3 (2006) 491-507

20 Hennig, S., Vogler, R.: Participatory tool development for participatory spatial planning: The GEOKOM-PEP Environment. In: Jekel, T., Koller, A., Donert, K., Vogler, R. (eds.): Learning with GI 2011: Implementing Digital Earth in Education. Wichmann Berlin Offenbach (2011) 79-88

21 Gryl, I., Jekel, T.: Re-centering GI in secondary education. Towards a spatial citizenship approach. Cartographica 47-1 (2012) 2–12

22 Carver, S., Evans, A., Kingston, R., Turton, I.: Public participation, GIS, and cyberdemocracy: evaluating on-line spatial decision support systems. Environment and Planning: Planning and Design 28 (2001) 907 – 92

23 Corbett, J.M., Keller C.P.: An Analytical Framework to Examine Empowerment Associated with Participatory Geographic Information Systems (PGIS). Cartographica 40-4 (2005) 91-102

24 Crampton, J. W.: Mapping: A Critical Introduction to Cartography and GIS. Wiley-Blackwell Oxford (2010)

25 Torrens, P.M.: Geography and computational social science. GeoJournal 75 (2010) 133-148

26 Elwood, S.: Critical Issues in Participatory GIS: Deconstructions, Reconstructions, and New Research Directions. Transactions in GIS 10-5 (2006) 693–708

27 Haklay, M.: Nobody wants to do council estates – digital divide, spatial justice and outliers. http://povesham.wordpress.com/2012/03/05/nobody-wants-to-do-council-estates-digital-divide-spatial-justice-and-outliers-aag-2012/, retrieved 07.03.2012

28 Martin, M., Corbett, J.M.: Creating the new 'new': Facilitating the growth of neo-geographers in the Global South using emergent Internet technologies. Paper presented at GEOINFORMATIK 2011 – GEOCHANGE, June 15-17 2011, Munster Germany (2011)

29 Fu, P. Sun, F.: WebGIS – Principles and Applications. ESRI Press (2010)

30 World Bank Report: Exploring Urban Growth Management – Insights from three Cities: Quito, Xi'an and Hydarabad. Urban Development Unit, World Bank (2008)

31 Resl, R.: GI for Development – Can GIS Challenge Existing Power Structures? Working Experiences from Ecuador. In: Zeil P., Kienberger, S. (eds.): Geoinformation for Development (2006) 125-136

32 Jarvis A, Ramirez J, Bonilla-findji O, Zapata E (2011) Impacts of Climate Change on Crop Production in Latin America. In: Yadav SS, Redden R, Hatfield JL, et al. (eds) Crop Adaptation to Climate Change, First Edit. Blackwell Publishing Ltd., pp 44 – 56

33 Jones, P., Thornton, P.: The potential impacts of climate change on maize production in Africa and Latin America in 2055. Global Environmental Change 13 (2003) 51–59

34 Laderach, P., Lundy, M., Jarvis, A.: Predicted impact of climate change on coffee-supply chains. Tropical Agriculture (2003) 9

35 Lobell, D., Gourdji, S.: The influence of climate change on global crop productivity. Plant physiology 160 (2012) 1686–1697

36 Jarvis, A., Ramirez-Villegas, J., Herrera Campo, B.V., Navarro-Racines, C.: Is Cassava the Answer to African Climate Change Adaptation? Tropical Plant Biology. Springer. Heidelberg, Germany (2012)

37 Crane, T.A., Roncoli, C., Hoogenboom, G.: Adaptation to climate change and climate variability: The importance of understanding agriculture as performance. NJAS - Wageningen Journal of Life Sciences 57 (2011) 179–185

38 Ramirez-Villegas, J., Jarvis, A., Laderach, P.: Empirical approaches for assessing impacts of climate change on agriculture: The EcoCrop model and a case study with grain sorghum. Agricultural and Forest Meteorology (2001)

# Memorial Plants in the History of the Orthodox Church in Russia and the Near Abroad and the Map of Them

Olga I. Kotova

M.V.Lomonosov Moscow State University
Geographical Faculty
119991, GSP-1, Leninskiye gory,
Moscow, Russian Federation
solntsevaolga@rambler.ru

**Abstract.** The history of the Orthodox Church in Russia and the Near Abroad is related by definite mode with world of nature environment. Plants growing now or existed in the past in territories of holy places are elements of this world. These plants were eye-witnesses of miracles, participants in events of Holy History and the life of Christian ascetics. Some of them persisted until the present and have a great value as unique examples of the natural and cultural heritage. Mapping of such objects surviving of last centuries has a large value for their inventory and protection. This corresponds with All-Russian federal program "Trees - memorial of the living nature". Data about extinct plants are important for profound study of the history of holy places and reconstruction there of historical landscape.

**Keywords.** Memorial plants, holy places, the history of the Orthodox Church, federal program, the protection of the natural and cultural heritage, mapping

Memorial plants are closely related with sanctities of monasteries and other holy places. Many pilgrims visit holy places and draw attention for memorial plants too.

Plants are symbolic in the christen history, if they:

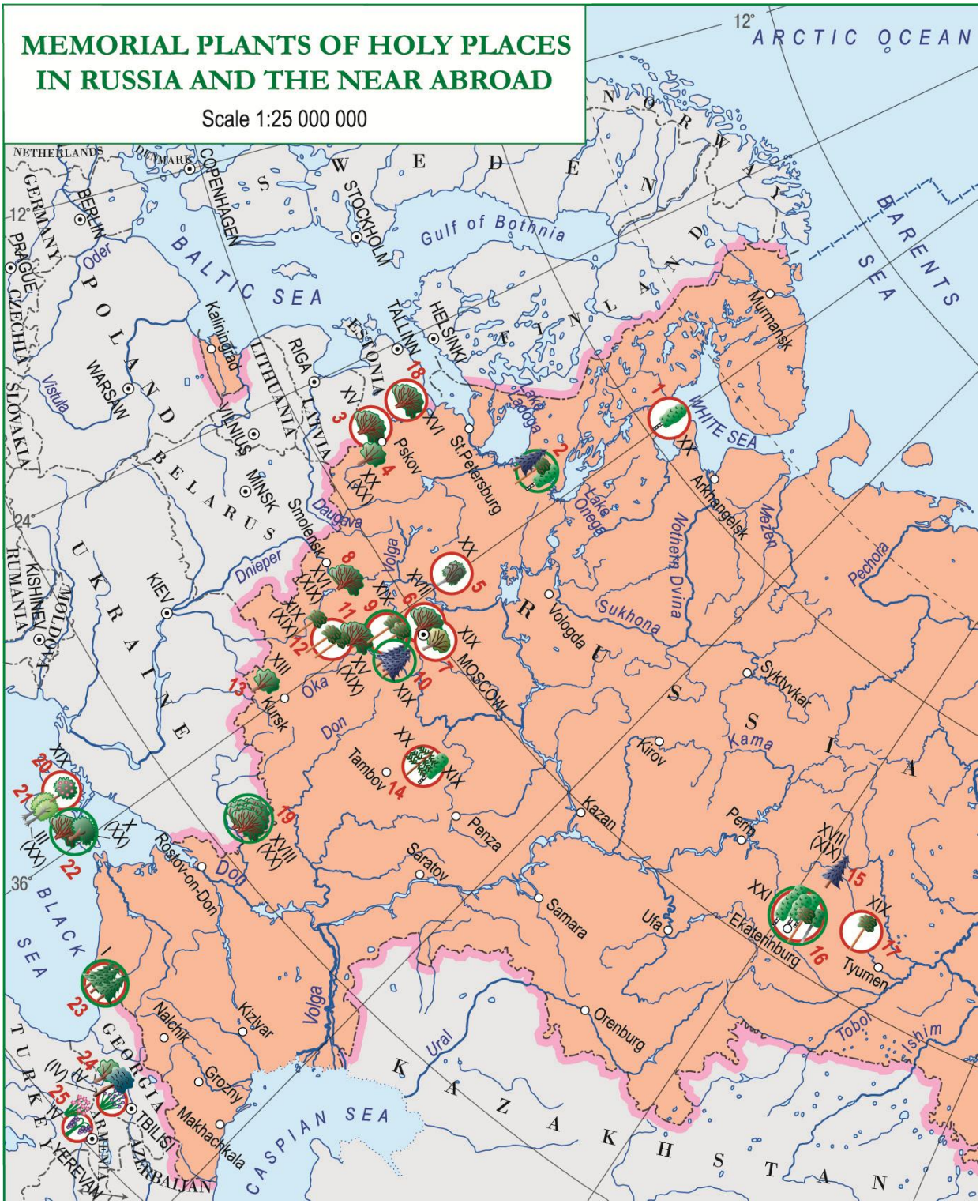
- Mentioned in the Holy History;
- Related with history of foundation of holy place;
- Related founding of miraculous icons;
- Related with life or/and death of saint men (ascetics, martyrs, just men);
- Grown as reminder about important events or saint men;
- Located next to saint sources, rocks or other nature and culture Christian objects;
- Planted in holy places us memorials;
- Are the nature and culture part of the life of the monastery or temple.

Mapping of these plants and creation of database of them is important for ecological condition of holy places and protection of nature and culture heritage and environment.

In the table we can see the data about any memorial plants, but there are very interesting exemplars of plant world and nature and culture heritage.

**Table 1.** Five of famous memorial trees on territories of Orthodox monasteries in Russia and Near Abroad, survived to the present day.

| Trees | Holy place, location, time of foundation | Landsape and environment | Role in the history | Age and state of the plant |
|---|---|---|---|---|
| Oak-tree<br>*(Quercus robur)* | Russia<br>Moscow, center<br>Bogoroditse-Rojdestvensky Monastery (of Nativity of Virgin), 1386 | In the distant past – oak and mixed forests,<br>Before 1917 – monastery garden,<br>After 1917 – city in the asphalt,<br>Now in the territory of Monastery - planting of ornamental plants | Oak is a witness of many historical events in Moscow, including War of 1812 and its big fire.<br>Miraculously survived from cutting of monastery garden in 1935 | 400 years<br>Excellent condition and appearance, very beautiful high harmonic tree<br>Protected by sisters of Monastery,<br>located in a closed area,<br>fence in chains |
| Oak-tree<br>*(Quercus robur)* | Russia<br>Pskov region<br>Pskovo-Pechersky Monastery of Assumption (Uspensky), 1473 | Mixed forests in the part and now around monastery territory,<br>Monastery historical nature and culture territory – Holy Hill. | Oak is a witness of history of Pskovo-Pechersky monastery including the arrival of Ivan the Terrible who killed Saint Kornilius came out to meet him | 500 years<br>Very good condition and appearance, very beautiful harmonic tree in the nature environment<br>Protected by brothers of Monastery,<br>The metal hope is on a trunk of the tree for monitoring of its growth |
| Oak-tree<br>*(Quercus robur)* | Estonia<br>Ida-Vyrumiae<br>Pukhtitsky monastery of Assumption (Uspensky), 1893 (chapel from XVI c.) | Mixed forests in the part and now around monastery territory,<br>Monastery nature and culture territory.<br>Only oak surrounded of the community of trees of other species | Estonian farmers saw Blessed Virgin who climbed up the side of the mountain and stopped at a big oak. In the hollow oak farmers found a miraculous icon of Assumption and gave it to Russian farmers. | At least 1000 years<br>Very old tree, but in the good condition. High 26,5 м, trunk circumference of more than 4 m,<br>In the past foolish pilgrims break off pieces of oak,<br>Now oak is fenced and protected by sisters of Monastery |
| Birch<br>*(Betula verrucosa)* | Russia<br>Nizhny Novgorod region<br>Serafimo-Diveevsky Monastery of Holy Trinity (Troitsky), 1780 years. | Mixed forests in the part,<br>Monastery territory, a mb of Nikolay Motovilov.<br>Very beautiful flower-gardens of Monastery | Birch has grown on the tomb of Nikolay Motovilov, disciple of Saint Serafim Sarovsky. After 1917 authorities tried destroy birch, but unsuccessfully.<br>Excavator bucket tooth was stuck in roots of the tree | 200 years<br>Big and beautiful tree.<br>Burls in the form of a bear's head, that remind us of the history of Saint Serafim who feed the bear.<br>Birch is an excursion object. |
| Larch<br>*(Larix sibirica)* | Russia<br>Nizhny Novgorod region<br>Serafimo-Diveevsky Monastery of Holy Trinity (Troitsky), 1780 years. | Mixed forests in the part,<br>Monastery territory, next to a groove of Virgin | Sisters of Monastery planted a larch in honor of the birth of Tsarevich Alexey in 1905, who born after apotheosis of Saint Serafim by Tsar Nikolay II, the father of Tsarevich. | 110-115 years<br>Very big and beautiful tree.<br>Protected by sisters of Monastery.<br>Larch wooden fence, trunk closed specially |


MEMORIAL PLANTS OF HOLY PLACES
IN RUSSIA AND THE NEAR ABROAD
Scale 1:25 000 000
ARCTIC OCEAN
BARENTS SEA
WHITE SEA
BALTIC SEA
Gulf of Bothnia
BLACK SEA
CASPIAN SEA
NORWAY
SWEDEN
FINLAND
ESTONIA
LATVIA
LITHUANIA
POLAND
BELARUS
UKRAINE
MOLDOVA
RUMANIA
SLOVAKIA
CZECHIA
GERMANY
NETHERLANDS
DENMARK
RUSSIA
KAZAKHSTAN
GEORGIA
AZERBAIJAN
TURKEY
COPENHAGEN
STOCKHOLM
HELSINKI
TALLINN
RIGA
VILNIUS
MINSK
WARSAW
BERLIN
PRAGUE
KIEV
KISHINEV
YEREVAN
TBILISI
Murmansk
Arkhangelsk
St.Petersburg
Pskov
Kaliningrad
Smolensk
MOSCOW
Vologda
Syktyvkar
Kirov
Perm
Ekaterinburg
Tyumen
Kazan
Penza
Samara
Ufa
Orenburg
Saratov
Tambov
Kursk
Rostov-on-Don
Kizlyar
Nalchik
Grozny
Makhachkala
Lake Ladoga
Lake Onega
Volga
Don
Oka
Dnieper
Daugava
Vistula
Oder
Northern Dvina
Sukhona
Mezen
Pechora
Kama
Ural
Tobol
Ishim
12°
24°
36°

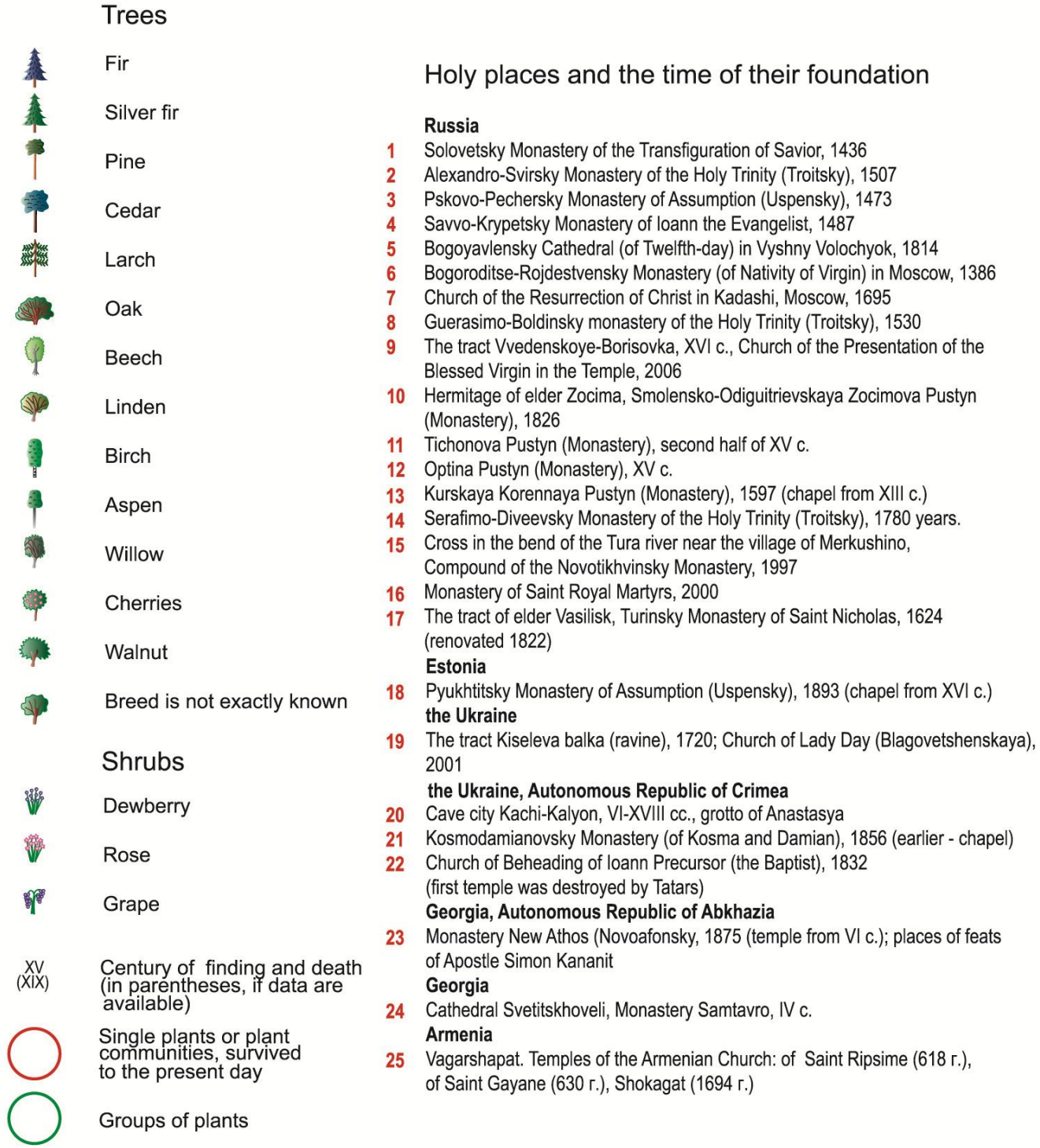



**Fig. 1.** Map of memorial plants (fragment of map of Russia and Near Abroad) and its legend.

# Campos Basin Environmental Oil Spill Mapping

Paulo Márcio Leal de Menezes[1], Manoel do Couto Fernandes[1], Pedro Henrique Ferreira Coura[1], Sirayama de Oliveira Ferreira Lima[2]

[1]Federal University of Rio de Janeiro
Geography Department – Laboratory of Cartography
Av Athos de Oliveira Ramos 274 – Cidade Universitária
Rio de Janeiro – RJ – Brazil - 21949-590.
pmenezes@acd.ufrj.br, mfernandes@ufrj.br, ped.coura@gmail.com

[2]PETROBRAS- Research Center
Av. Horácio Macedo 905– Cidade Universitária
Rio de Janeiro – RJ – Brazil - 21949-590.
sirayama@petrobras.com.br

**Abstract.** Brazil was considerate self-sufficient in petroleum in 2006 and, in a close future, may become one of the world's biggest arms producers and exporters of oil and its derivatives, mainly due to its deep water drilling technology and the recent petroleum discoveries along the Brazilian coast of pre salt. The needs of embarkation and disembarkation marine terminals to oil derivates, practically in the whole coast, as well as several pipelines existence for terrestrial oil transfer, already caused quite relevant accidents in several times to the environment, in approximately 47 notified main occurrences, between 1975 and 2012. From 1998, PETROBRAS (Brazilian Oil&Gas Co) and Ministry of the Environment (MMA), has been developing actions for a unified mapping of the problem, through environmental sensitivity oil spill maps, which are completely adjusted to Brazilian terrestrial and coastal environment. In 2002 the Ministry of the Environment defined as planning unit the sedimentary coastal basins, mapping each one in three different scales: strategic, tactical and operational. The cartography developed for these maps requests specific cartographic design, seeking the development of a database for each one, pointing to the objectives of the three map types. These objectives go from protection of human life, reduction of the leak consequences to environment and to turning efficient all efforts to contention, cleaning and removal operations. In that way, the whole cartographic work is supported on the characterization of terrestrial, coastal and sea areas under potentials oil spill, through cartographic documents and GIS environment in adequate scales. The sensitivity maps serve as a critical tool to planning and answering to oil spilling incidents, as well as to make available the environmental and socioeconomic information on the reached area. This paper aims to present the employed methodologies for the developing the environmental sensitivity oil spill maps of PETROBRAS, in the Campos Basin, along the coast of Rio de Janeiro and Espirito Santo States, as well as the associated database and metadata. All maps and database were worked from existent reference maps according to the project needs, by the Laboratory of Cartography of Geography Department, Federal University of Rio de Janeiro. The socio economical, biological and geomorphology data are acquired by special teams working in on 450 km along the states´ coast.

**Keywords.** Oil spill maps; Petroleum Campos Basin; Environmental mapping.

## 1 Introduction

Brazil was considerate self-sufficient in petroleum in 2006 and, in a close future, may become one of the world's biggest arms producers and exporters of oil and its derivatives, mainly due to its deep water drilling technology and the recent petroleum discoveries along the Brazilian coast of pre salt layer, putting it in a quite comfortable position in terms of reserve to exploration. So, regarding a country of almost continental dimensions, the pipelines net, ports, refineries, and other petroleum facilities, operating great oil volumes

and its derivate, it is ready to have accidents, which oil spills, affecting not only the environment, but also the socioeconomic structure of the reached area.

To have a small idea of the facilities magnitude which just involve the petroleum transport and derivate in Brazil, here are listed some numbers: 7 thousand km pipelines, 4 thousand km natural gas pipelines, total number of operating pipelines: 11 thousand km; 20 land terminals, 28 waterway terminals. Maritime Transport: a fleet of 53 ship, 15 relief/shuttle tankers, for the distribution of ocean oil production, 8 ships for oil and dark product (fuel and bunker) transport, 7 ships for dark and light products (diesel and gasoline), 20 ships for light products, 6 liquefied petroleum gas carriers (LPG), 1 floating oil transfer and storage Unit (FSO), 1 maritime support vessel. However the fleet renewal program includes the construction of 49 new ships, putting PETROBRAS as one of the largest oil fleets of the world.

Load transported in 2011 was by maritime transport, 65 million tons; in terminals, 13,3 million $m^3$; trough the pipelines, 671 million $m^3$ oil, by products and alcohol/year and in the natural gas pipelines, 35 million $m^3$ natural gas/day.

Starting from 1998, PETROBRÁS (Brazilian Petroleum SA), through CENPES (Research Center of PETROBRAS), has concerned in developing an applied methodology to elaborate sensitivity oil spill maps, which should be able to assist all of the company work fronts, including the Amazonian Area, Northeast of the Country, coastal and fluvial lines, as well as the offshore extraction.

Between 1975 and 2008, more than 38 relevant accidents were computed, causing substantial oil spill. These accidents occurred in coastal, fluvial and terrestrial areas, causing serious damages to the economy, as well as to the social, biological and physical structure of the reached areas, including a high loss of human lives in some cases. The last accident occurred in November/ 2008, in Santa Catarina State, when breaking the natural gas pipeline, due the torrential rains that devastated the area.

The project of development of sensitivity maps, was initiate in 1998, with some public agencies and universities, came to get ahead with the support of the Ministry of Environment, starting from 2002, as well as with other research organizations of petroleum and gas, included the National Agency of Petroleum (ANP – regulatory agency).

Starting from that time, several maps and atlases were done, with practically surveyed the whole Brazilian coast. Since 2006, the research is developed about terrestrial sensitivity, as well as the linking with coastal sensitivity. This research is developed by a pool of research organizations, among them, is the Laboratory of Cartography, Geography Department of the Federal University of Rio de Janeiro, GeoCart, which works to support updated maps to the whole work.

This paper aims to present a discussion on the framing of the term sensitivity map and its development structure, including the applied methodology to elaboration of the oil spill sensitivity maps in Brazil, under coastal approaches.

## 2 Environmental Sensitivity Oil Spill Maps

### 2.1 Geoecological Mapping

The initial stage of geoecological mapping remounts to beginning of sixties, by the introduction of ecological themes in Cartography. In that time environmental management maps were developed, following by works of the influence of socioeconomic factors evaluation on the environment, including positive and negative effects, as well as the forecast of space alterations along the time.

There is no effective concept in the literature about Geoecological Cartography, but we need to define it, to support scientifically the research. It is necessary to establish its concept differentiating it from Environmental Cartography. Initially, Geoecological Cartography belongs to Environmental Cartography, according the definitions presented by Ormeling [5]. So it is wanted to present Geoecological Cartography as a dismemberment of Environmental Cartography, considering it as one of their branches.

Geoecological Cartography will be defined leaving of Environmental Cartography concepts, those that include representations of relationships and inter-relationships among the components of the environment and landscape. The geoecological mapping, in that way, will differ of the environmental mapping for three fundamental factors:

- Interaction man-nature and their consequences for the environment;
- Dynamic action (representation of the transformations, vectors and interactions on the time);
- Representation of the relationships and inter-relationships among elements of the landscape.

So the concept of Geoecological Cartography will be linked to phenomena and elements of the landscape mapping, as well as of functions and functionalities, framing evaluation maps, to be included in this category. These kinds of maps are representations of processes occurring on a defined geographical space, as a function of one or more analytical-integrative processes, on the elements of landscape. These processes can be considered from a global to a local, depending on the space and interactions that one wants to represent. They involve vulnerability studies, sensitivities, potentialities and risks, among others. Each one of these terms has an own meaning. For the meaning of the sensitivity maps or environmental sensitivity, the involved concept establishes the sensitivity of the landscape to degradation and loss of its working power, presupposing what can happen in case of the degrading agent exists. In this way, oil spill sensitivity maps, may be framed as belonging to the group of geoecological mapping.

### 2.2 ESI Maps

The Oil Spill Sensitivity Maps (ESI Maps), are essential tools and primary information source for contingency planning and for implementation of response actions to oil pollution incidents, allowing to identify the priority protection environments and defining of eventual sacrifice areas, making possible the correct direction of available resources and appropriate mobilization of contention and cleaning teams.

The Law no. 9.966, of April 28, 2000 (Oil Law) attributed to MMA (Ministry of Environment) the responsibility to identify, locate and define the limits of sensitive areas regarding to pollution caused by oil spills and other noxious or dangerous substances in waters, under national jurisdiction.

It was established the Specifications and Technical Norms for the Elaboration of Oil Spill Environmental Sensitivity Maps for coastal and sea area, work accomplished together with other environmental agencies, taking advantage of the experiences of the Center of Research (CENPES) of PETROBRAS, consolidated in the Basic Manual for Elaboration of Sensitivity Maps in the PETROBRAS System.

The development of mapping methodology was supported on international norms, mainly the established ones for the International Marine Organization (IMO) and for National Oceanic and Atmospheric Administration (NOAA), of United States. For the adaptation and updates to habitats particularities and Brazilian coastal features, the Brazilian Navy and representatives of petroleum industry were consulted. CONCAR (National Commission of Cartography), in September of 2002, validated the developed methodology, and the sensitivity maps was elaborated through the proposed methodology, passing to be considered valid officials cartographic documents, inside of the legislation.

From this moment, sensitivity maps have an obligatory use in contingency planning, general evaluation of damages and in implementation of response actions to oil pollution incidents in coastal and marine areas under federal jurisdiction.

### 2.3 Inclusions and Objectives of ESI Maps

All levels of oil spill, capable to cause environmental damages, should be assisted through ESI maps, from the great spills in remote (offshore) areas, spills of medium dimensions, far from petroleum facilities installations (along coast or waterways), as well as occurred in punctual (specific coastal areas or margin of rivers) places. To take care for these levels of environmental accidents, they should be treated through a visualization in a regional, middle or local geographical scales, allowing the obtaining of information for actions planning, at the levels of marine basins, big coastal areas and for a small coastal area, helping to a detailed planning with information about points of high risk or sensitivity.

On the other hand, the main objectives of the sensitivity maps should be the reduction of the environmental consequences of oil spill; the orientation of contention, cleaning and removal efforts on the reached area; identification of the sensitivity of coastal and sea ecosystems, existent biological resources and socioeconomic activities if they exist, as well as the use of coastal and sea resources in the represented areas. Thus they should allow integrated actions for protection of human life, reduction of the environmental consequences of oil spill and to turn efficient the contention, cleaning and removal efforts.

The Marine Sedimentary Basins, in Brazil, include an area of 1.550.000 Km², which 770.000 Km² in medium depth waters, until 400 meters and 780.000 Km² in deep and ultra depth waters, located between 400m and 3.000m. In that way the sensitivity map design, to assist the several levels of geographical scale of observation needed, demanded the development of specific cartographic scales. Thus it was necessary specific cartographic design for each one of the representation scales. The Ministry of the Environment (MMA) elaborated in 2002 a proposal of a Cartographic Plan for Environmental Mapping of Oil Sensitivity to coastal and sea area, adopting as cartographic unit, the Marine Basins and planning the use of three cartographic levels:

- Strategic, including the whole area of a basin, or contiguous basins, in case of smaller basins. Scales among 1:500.000 to 1: 850 000;
- Tactical, for the whole coast of the mapped basin. Scales among 1:150.000 to 1:250 000;
- Operational or detail scale, for the considered areas of high risk or sensitivity, inside each tactical map. Scales among 1:10.000 to 1:50.000.

Figure 1 shows the Brazilian marine basins and examples of strategic, tactical and operational sensitivity maps, developed by MMA and CENPES / PETROBRÁS.

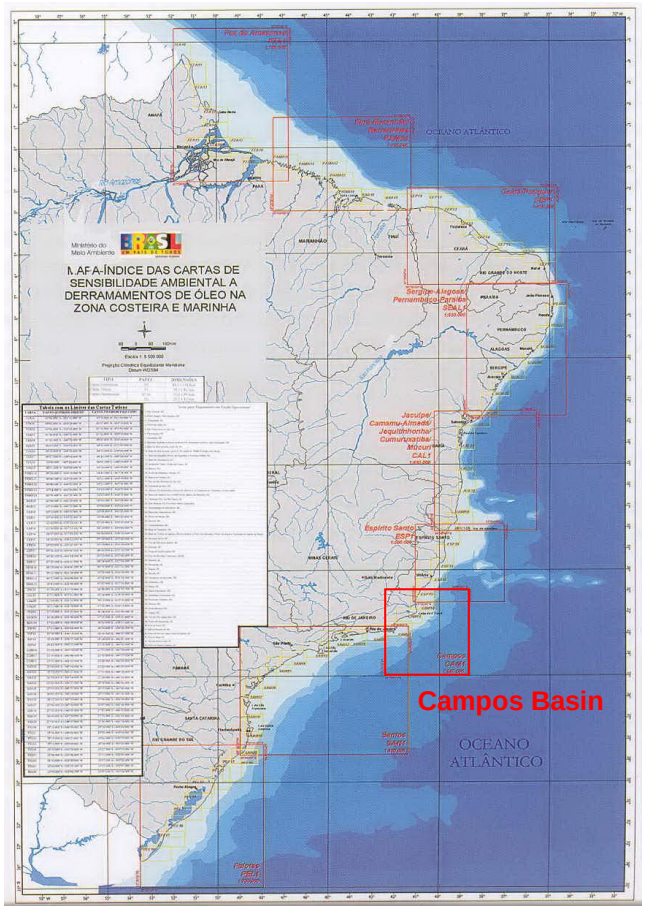



Figure 1 – Brazilian Maritime Basins (source MMA/Brazil) -

### 2.4 Information Contained in ESI Maps

Obligatorily should be contained in the ESI maps three main information types:

- Environmental oil sensitivity of the coast, defined by a Coastal Sensitivity Index (ISL), defined by surveying and knowledge of geomorphologic characteristics of the coastal or fluvial environment, taken into account the substratum type, coastal slope and exposure degree to waves and tides energy;
- Biological resources, fauna and flora, sensitive to oil, existent in mapping area, with information at the species level. Special attention will be given for protected, rare, threatened or in extinction danger species, as well as for the places where occur concentrations or important phases of the life cycle of the species, such as feeding, reproduction, bird nest habitats areas and areas of traffic or migration routes;
- Socioeconomic activities that can be prejudiced oil spill accident or that can still be affected by response actions. Also should be included recreation areas, leisure and summer vacation areas in coast or fluvial margins, fishing areas and marine culture, places under special administration, such as conservation units, historical or cultural sites, points of water captation for industry or hydroelectric dams, salt lakes, ports and terminals.

The ESI maps, besides, should present important information for the implementation of actions of ready response to oil spill, as road network (railroads and highways) to access the coast, airports, heliports, ramps and moorings for boats, patterns of coastal and oceanic circulation, wind patterns, with predominant winds direction, as well as the potential pollution sources of oil and its derivates.

On the other hand the ESI maps present a high potential to be used in environmental planning of coastal and sea area, reinforcing political and administrative instruments of territorial ordering, as a minimum part of the Individual Emergency Plans (PEI), of oil pollution incidents, originate in ports, terminals, pipelines and offshore platforms, as well as in others support facilities.

Thus the oil spill environmental maps serve as important tools for the following situations:

- Contingency planning, for protection priorities planning, contention strategies, removal and cleaning, as well as the quantification of resources to be allocated the accomplishment of the work.
- Actions operations against oil spills, supplying the evaluation of the damages and loss, as well as location and identification of the most sensitive places, fast access, sacrifice areas and the definition and quantification of the equipments to be available for the response.
- Environmental planning, allowing the evaluation of natural resources in danger; to help the studies of environmental impacts, assisting places definition for installation of petroleum industry.

### 2.5 Coastal Sensitivity Index (ISL)

The sensitivity maps in any of the three levels will have the coastal or rivers margins sensitivity, registered through the coastal sensitivity index (ISL). This index presents a hierarchy of the geological and geomorphologic types composition, existent in Brazilian coast, showed in a scale from 1 to 10 for coastal indexes and 1 to 11 for the fluvial indexes, from minor to larger sensitivity. Thus sensitivity 3 is less than sensitivity 4, but sensitivity 6 is not twice larger than sensitivity 3.

Figure 2 shows the levels of ISL for coastal sensitivity.

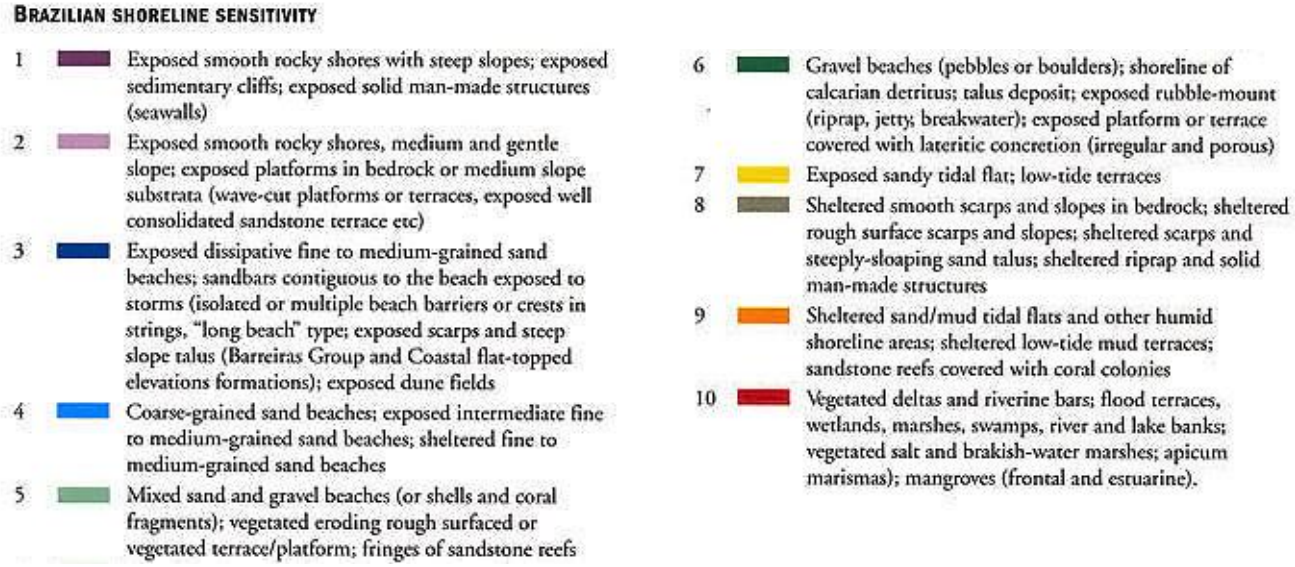



Figure 2 -Levels of ISL for coastal sensitivity – Source CENPES/PETROBRAS/MMA

## 3 Oil Campos Basin – Area Description

Petroleum discovery in Campos' Basin occurred in 1977, representing a great challenge for PETROBRAS and Brazil, showing a new scenery, needing new technological resources to make possible the oil extraction, at that time, a little more than 100 meters depth.

The Campos´ Basin is a sedimentary basin, extending for 100.000 km² from Espírito Santo state, in the vicinity of the city of Vitória, to the City of Arraial do Cabo, in the north coast of the state of Rio de Janeiro

(where is mounted one of the largest oil complex of the world). It includes 13 municipal districts of the Rio de Janeiro State and 7 of Espírito Saint State. The largest Brazilian oil province is considered responsible for more than 80% of the country production (about 1,25 million petroleum barrels) and possessing the largest reserves already proven identified and classified in Brazil. It represents significant importance in the national wealth, being responsible for a Gross domestic product (GDP) about R$ 54 billion a year and possessing about 40 thousand inhabitants (workers) (Figure 3).

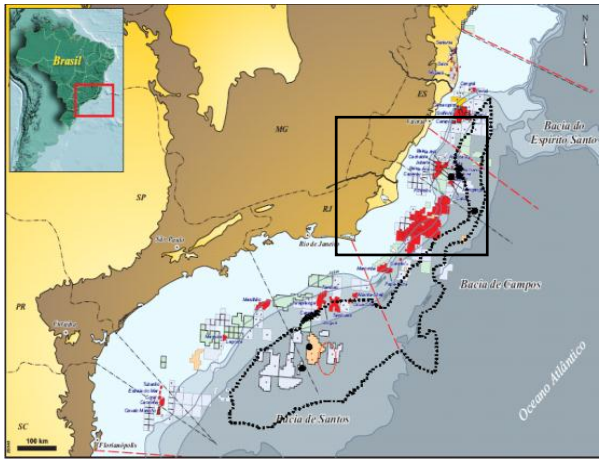



Figure 3 – Campos Basin – source IPB (http://www.ibp.org.br/main.asp?View=%7B58784FF7-BB06-46B8-8200-A72A1FA66ABD%7D&Team=%7BCFA331ED-C047-4441-8EEC-9467D2F58BE4%7D

## 4 Project Applied Methodology

The methodology for the environmental sensitivity oil spill mapping has as a basic support, the methodology for the surveying of the environmental sensitivity index to oil spill. This sensitivity index is presented in a 1 to 10 scale, in growing order, where the 1 index represents the less sensitive environment to the oil impacts and the 10 index represents the places that would probably be more impacted. This hierarchy is based on the knowledge of the physical-environmental characteristics of coastal or estuarine features, fundamental for the determination of the oil permanence time and impact degree, in case of accidents. They will be appraised the physical-environmental characteristics of the study area and it will classify the coastal and estuarine features, according with the index of environmental sensitivity to oil spill, contained in the Basic "Manual for the Elaboration of Environmental Sensitivity Maps to Oil Spill in the PETROBRAS System: Coastal and Estuarine environments " [1] and "Specifications and Technical Norms for the Developing of Environmental Sensitivity Oil Spill Maps".

All social and economic resources that can be affected by any oil spill or for the answer procedures in case of oil spill, or, still, important for that answer type, will be registered in this project, to subsidize the development of the environmental sensitivity oil spill map of Campos' Basin. Like this, harbors, marinas, recreational beaches; fishing, dive, environmental protection areas and of natural resources extraction; mining ranches, archeological sites, cultural and historical places; indigenous reserves, camping, fishermen colony; residential/summer houses, among many other information, will be acquired.

The present project will survey information about sea invertebrate animals, marines, coastal and of interior waters, reptiles, amphibians, terrestrial mammals and coastal birds, aquatic mammals, sea chelonians and sea birds, will be added to the database area. The information will include, mainly, data on threatened species, concentration places, and important areas for some special phases of the cycle of life of the several species. All those information will be represented in the sensitivity map, through specific symbolization, in way to allow a quick evaluation on the areas of special importance for the sea invertebrate animals in Campos' Basin. On the other hand, they will provide necessary information for the answer procedures, in case of

oil spilling accidents, once the data will be inserted in a georeferenced database, providing the access and/or creating specific reports, with the lifted up information for the researchers.

All the data acquired by the Project, to be spatially represented on the sensitivity maps, will be inserted in the georeferenced database of the PETROBRAS´ program called MAPS. This program is in reality, an integrated database system, developed by the company TECGRAF, of PUCRJ (Pontifical Catholic University of Rio de Janeiro), through the UTM projection coordinate system, to indicate, points, lines and polygons of data occurrence, or the common biological resources in the whole area.

This project will also contemplate the survey of information on underwater (macroalgae) and floating (sea phanerogamae) vegetation, coastal corals and special terrestrial plants, also to subsidize the improvement of the environmental sensitivity oil spill map. The information on special habitats will include, mainly, space distribution, substratum type, density, as well as data about associated biological species. The terrestrial plants considered special in this project are those rare native species, threatened or of economic relevant value, located along the sandbanks (i.e., sea sandy deposits coastal) and associated coastal lagoons, which can be affected for occasion of an oil spilling accident.

The information of the biological resources will be represented in the sensitivity map, through specific symbols, in the same way of all other information.

For so much, the present project is divided in 9 (nine) Subprojects:
Subproject 1 - General Coordination, Basic Cartography and Atlas of Sensibility
Subproject 2 - Physical-environmental Information
Subproject 3 – Social and economic Information
Subproject 4 - Information on Sea Invertebrate animals
Subproject 5 - Information on Pisces
Subproject 6 - Information on Aquatic Mammals, Sea Chelonians and Sea Birds
Subproject 7 - Information on Reptiles, Amphibians, Terrestrial Mammals and Coastal Birds
Subproject 8 - Information on Aquatic Underwater and Floating Vegetation, Coastal corals and Special Terrestrial Plants and Special Habitats
Subproject 9 - Information of Protected Areas

## 5 Basic Cartography Applied to the Project

Evidently that the cartography is not configured as the most important project structure, however it should be emphasized that the representation of all of the information obtained by the other subprojects would be impossible without basic cartography, to allow accurately and precise representation, enough to have a perfect visualization of all social, biological and physical information, as well as the occurrence areas of each one.

For the specifications of each scale, strategic, tactical and operational, a Cartographic Plan was developed for each scale, tends for directing the execution of the three mapping types: Strategic, (in scale 1:650 000), including the whole area of the basin; Tactical (in scale 1:150 000, for the whole coast of the basin) and Operational or of detail (in scale 1:50 000). It was defined 1 (one) strategic sheet, 3 (three) tactical sheets and 36 (thirty six) operational sheets.

The figure 4 shows the distribution of the strategic leaves, tactics and operational in the area of the Basin.

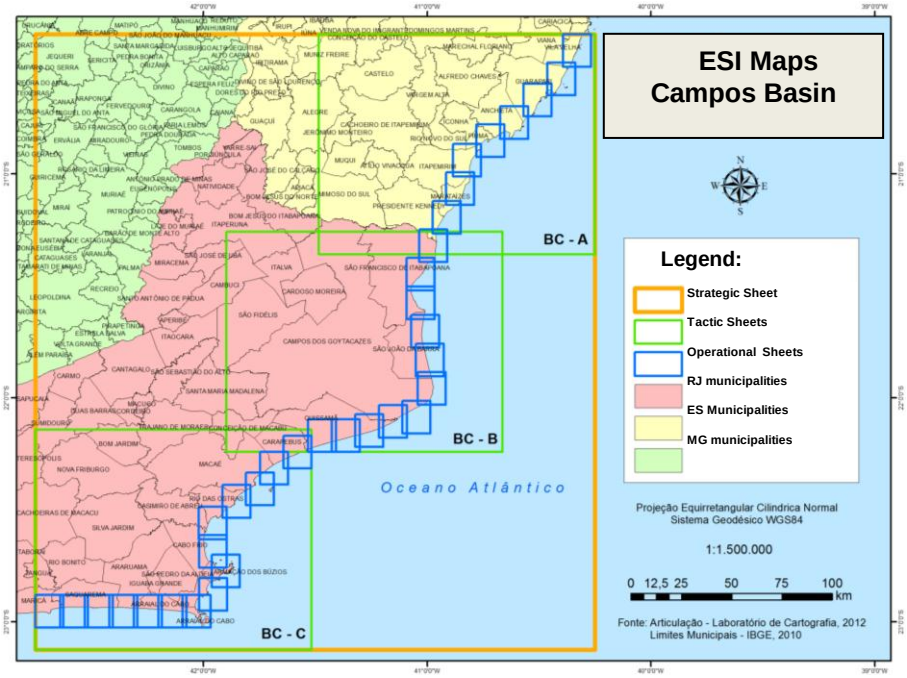



Figure 4 - Defined sheets for the cartographic project, Strategic, Tactical and Operational

For the elaboration of the relative maps to each scale, specifications were defined used in the developed Cartographic Plans, having as the cartographic sources of information, the Brazilian basic cartography, in scales 1: 1000000, 1:250000, 1:100000, 1:50000 and 1:25000.

The cartographic material was treated according the recent National Spatial Data Infrastructure (INDE), as well as to all cartographic data were associated the Metadata structure of the system MAPS.

Basically it was created the following associated layers:

- State and municipal limits;
- Urban areas and location of cities and important towns, through points and areas symbolization;
- Hydrography:
- Coast line;
- Hydrographic network, generalized and compatible with the scale;
- Lakes, dams and larger dams than 4 mm²;
- Bathymetric contour lines;
- Parameters of oceanic circulation.
- Road network:
- Federal highways, with nomenclature symbol;
- State highways, with nomenclature symbol;
- Other roads considered important;
- Toponymy.

It was still established the equirectangular map projection (Plate Carrée) for the strategic and tactic scales and UTM projection for the operational scale. The applied geodetic system was the SIRGAS 2000, current Brazilian geodetic system. An inconvenience for the application of the UTM projection to the area is the change of the zone 23 for zone 24, in the meridian of -42°, but nothing that could not be outlined.

## 6 Conclusions

Until the moment the project is not still ended, and will continue until July of 2013. Almost the acquired data in field was already finished and included in the database of the MAPS system.

The cartography is in final phase of development, because to some problems happened during the work, however the inclusion and positioning test of all data, can be tested by the system.

However, for to have a small idea of the project magnitude, it is interesting to present some quantitative information associated to it.

Table 1 – Total of project researchers

| Subproject | Doctors | Masters | Graduates | Students | Technicians | Total |
|---|---|---|---|---|---|---|
| 1- Head and Cartography | 2 | 2 | 2 | 8 | | 14 |
| 2-Physical and Environment | 2 | 1 | | | | 3 |
| 3-Socioeconomic | 3 | 1 | | | | 4 |
| 4- Marine Invetebrates | 6 | 1 | | | | 7 |
| 5-Pisces | 1 | | 2 | | | 3 |
| 6-Marine Birds , Chelonians and Cetaces | 3 | 1 | 1 | | | 5 |
| 7- Anphibians and Reptiles | 2 | 2 | | | | 4 |
| 8-Special Habitats | 6 | 2 | | | 1 | 9 |
| 9-Protected Areas | 3 | 3 | | 2 | | 8 |
| Total | 28 | 13 | 5 | 10 | 1 | 57 |

These researcher belong to the folowing organizations: Federal University of Rio de Janeiro, Geography and Biology Departments; State University of Rio de Janeiro, Biology Department; São Paulo University and a non governamental organization linked to Bothanical Garden (Rio de Janeiro), Biodiversity Biology Institute.

The geomorphological and environmental data were acquired on about 600 km of coast, during 6 field trips, travelling around 2500 km on highways and trails. This work was accomplished together with the socioeconomic subproject, for economy measure. It was been lifted up the data of 33 municipal districts belonging to the basin.

Relating to the biological data, some of them show that for the area, were found 516 species of mollusks, approximately 400 polychaetes species, abundance of crustaceans (1300 species) and 24 echinoderms species.

Approximately 900 species of sea fish were registered or with probable occurrence in Campos' Basin, 461 were selected in agreement with the distribution criteria in depth bathometric conyour lines. Besides those, other 13 species of continental fish were identified as happening in areas potentially sensitive to the oil spilling, totaling 474 species of fish selected in the creation of the Resources. Some species were selected as threatened of extinction, as well as rare (sharks, stingrays, among others) species.

It were identified 362 species of birds, being 17 coastal seabirds, 30 pelagic seabirds, 49 continental aquatic birds, 18 shorebirds, 24 birds of prey and 225 terrestrial birds.

On amphibians and reptiles were totalized 60 species, distributed in fragments of open and forest habitats, in four main groups of mosaics of habitats: the sandbank, the growth of mangroves, the rocky coastal and the coastal lagoon. They are 38 species of serpents, 16 species of lizards, two amphisbaena species, two turtle species, a land turtle and the pity-crop-yellow alligator, collected in the area interest of the Project.

It can be verified that the project already accomplished a fantastic resources survey that can be affected by oil spill accidents. At the end of the Project, all resources will known and properly represented in the sensitivity maps, as well as available for consults in the PETROBRAS MAPS system.

At the end of the project the three groups of resources will be available in a database and in associated maps where anyone will have in a fast and concise way the sensitivity of each coast area.

## References:

1. Araújo S.I; Silva, G; Muehe, D. Minuta do Manual básico para Elaboração de Cartas de Sensibilidade no Sistema PETROBRAS, 170 pp, Rio de Janeiro, RJ; 2000
2. IPIECA, Sensitive Mapping for Oil Spill Response. IMO/IPIECA Report Series: Volume 1, 1996
3. NOAA Environmental Sensitivity Index Guidelines, Version 2.0. NOAA Technical Memorandum NOS ORCA 115. Seattle: Hazardous Materials Response and Assesment Division. 79 pp and Appendices, 1997
4. MMA, Especificações e Normas Técnicas para a Elaboração das Cartas de Sensibilidade Ambiental para derramamentos de Óleo, Brasília, DF, 2004
5. Ormeling, J. F., Environmental Mapping in Transition. Proceedings of the Seminar on Teaching Cartography for Environmental Information Management. Enschede, Net. 1989
6. PETROBRAS, Mapas de sensibilidade ambiental a derrames de óleo, Rio de Janeiro, 2005/ 2007
7. Menezes, P. M. L., Relatórios de Produção sobre a Cartografia dos Mapas de sensibilidade a Derrames de Óleo, Geocart, Rio de Janeiro, 2004/ 2005/ 2006/ 2008
8. Bacia de Campos, Relatórios Parciais 1, 2, 3 e 4, GeoCart, Rio de Janeiro, 2012
9. CENPES/GEOCART, Projeto Atlas de Sensibilidade Ambiental à Derrames de Óleo, Rio de Janeiro, 2010

- empty page inserted -

# 2 Feeds to Forecast Outcomes from Hazard Analysis Critical Points

Georges RADJOU

27ter, Bld Saint Martin
Boite 0897-BIRD
75003 Paris-FRANCE

gsradjou@outlook.com
gsradjou@gmail.com

**Abstract.** Threats posed to people in risk zones. I have assumed most common hazard is a flood among other natural hazards. One will encounter 3 fundamental questions. Where do these hazards come from. Why people are affected by them and what are we making in a risk zone. In the case of a general disaster assumption, one can answer with a statistics i.e. a data analysis, a human and a physical geography, hazard event classes, probabilities and population resilience. The presentation is an applied art and a personal contribution into the issue of irrational behavior. People affected with a mental disorder is a special feature that makes the success of prevention -particularly to promote crisis post recovery operations. Whether there is a benefit gained by mitigating or acting with innovation or breakthrough.

**Keywords.** hazard management- risk impact- modeling- uncertainty- prediction- people life- injury psychological affectation- brunt- resource- planners- emergency- consultant- causation- affectation processes

**Introduction:**
*"In Burma the bodies of many of those lost in the cyclone receive attention only from the birds."*(Paul Danahar, BBC Correspondent after Burma was struck by a cyclone in 2008 that caused more than 130,000 deaths, cited by Alejandro Quiroz Flores Alastair Smith, Wilf Family Department of Politics, New York University, 19 West 4th Street, 2nd. Floor, New York, NY 10012 February 13, 2010, in Surviving Disasters)
Domestic Product decreases during a period of flood occurrence. European and world capital cities are often flood prone. (Sandy Nov. 2012, Katharina Hurricane 2005, Tokuhu disaster,....) with impacts and multi impacts that can affect people intangible assets (mental health, recovery, well being,...) as well as the tangibles (people life, properties, livelihoods, ….). Each of these 2 categories can be classified in specific categories revealed after monitoring or surveying the organization group concerns. Within these people groups or individuals can move to potential conflicts (between their recoveries- mental health progress -: minimum, average and maximum and/or how the brunts affect them or their community -also, the gravity is marked in 3 classes minimal, medium and high.).

**Figure 1.** The Effects of Natural Disasters On Long-Run Economical Growth
"...However, recent major catastrophes including the Southeast Asian tsunami and Hurricane Katrina heightened interest in this field. The body of research in the literature of economics of natural disasters can be categorized into two groups. One group considers the short-run effects of disasters on GDP7 while the second examines the long-run effects of disasters on economic growth. The short-run studies include: Albala-Bertrand (1993), Kahn (2005), Anbarci et al. (2005), Bluedorn (2005), Raddatz (2007), Strobl (2008), Loayza et al. (2009), Noy (2009), Rodriguez-Oreggia et al. (2009), Leiter et al. (2009), Mechler (2009) and Hochrainer (2009); while long-run studies include: Skidmore and Toya (2002), Noy and Nualsri (2007), Cuaresma et al. (2008), Jaramillo (2009), Raddatz (2009) and Hallegatte and Dumas (2009).8 Compared to the many short-run studies there have been fewer long-run studies conducted in the literature..." (Source: Chul-Kyu Kim, University of Michigan, The Effects of Natural Disasters On Long-Run Economical Growth, text41a.pdf, 11-49 pages :page 13)

**Outlook of the paper:**
How mental disorders can affect Growth Domestic Product (GDP) and an hybrid organization as a model to forecast sufferers in risk zones. Uncertainty and variability curves of the risk impacts. Mental

disorders/irrational behaviors: Two feeds to forecast risk zone people impaired with mental disorders/irrational behaviors is a black box process used to differentiate those people that survived the disaster and were able to cope with positive signs during the post recovery operations, however still being subjugate by the tenses/trends of the irrational behaviors. I have illustrated a survivors' groups with 6 classes. These are *"People which life is a distress for ever and they will never recover i.e. they will never recover physically or mentally- they are very likely to pass after the post recovery operation"* (R1,A1), *"People life is partially affected. People can recover from the disaster either physically or mentally"* (R1, A2 or R2, A1), *" People partially recovered, but stayed without tangible assets -no properties, livelihoods,...- (R3, A1) or opposite are those that benefi*ted *from goods and services*-safety nets or insurance company benefits-, *but stay with poor mental health (R1, A3) and People in the middle as a diplomacy group where it is unknown if they have a brunts with or without mental disorders or are they creative*. Group R2,A2 at the center of the grid (diplomacy group), because they can survive or pass according to their diplomatic cases -uncertainty depending on progress and organization locations. These groups depend on their surrounding environment....(R2,A2), or their organization progress. Also, for the people materialized by the couple (R1, A3), tragically, if the brunt are too important, they will pass either in spite of the safety nets. Status Quo for the symmetrical case (R3, A1). If too important, the mental illness cannot be cured people will move from the instability to lower cases in the psychological tenure until extreme (when the mental illness is maximum- even if the brunt is minimalist- they will pass.)...

**The classes of potential disorders :**

I have assumed an equiprobable- solutions for the disaster classes in the deterministic approach with people recovering and affected at different degrees -levels- medium (m), low (m), high (M). It is the interval between the limits of the brackets. Let us considering, an observer monitor a group of people under the stress of the disaster post recovery operation and monitor people affected and recovering from the hazard impact over the horizon lines. According to these experts one could fine a upper and lower limits to the interval of sufferers with a geographical sites, a station, a region or a country within different part of the territoriality where the hazard was mapped. An example is given in my consulting project of Water Aero Emergency Relief -WAER- project access to water,... (source: Georges Radjou, MBA project 2009, CNAM of Paris, supervisor Head of Project Management, Professor Gilles Vallet, 100 pages). This is a mapping of flood/risk with a Risk Porto-folio Matrix for a region and cells for the risk class marks with various scen in order to use flood detectors in the community village or region. This breakdown of the territory into small squares are for example gauge or dry feet where people are likely to receive more attention than the simple satellite detection giving an overview of the weather- hydrology elements. For example, considering a country like Bangladesh, which well-known for the flood seasons. It is well-known the early warning based on the satellite detection is not perfect. The water board came with an innovative idea to complete flood forecasting based on satellite detection with water monitoring stations. The data are collecting within Bangladesh itself and completed with internet from the weather and hydrology traditional methods from the Indian neighboring country. This can explain a potential spread can be reduced after implementing the right technology or political means.

**Example:** if the number of survivors affected is in the interval (I). I ={ a1, a2, a3, …,ak, ...a (k+1) / k ЄR+ - {1,2,3 and a1 < a2 <...<ak < ak+1}, ak is the recorded figures ranking for a spatial-temporal monitoring station }. I think this spread would be more or less wide depending of the economy zones, the crisis amplitude, the strength of the state, spatial organization...Dec.26, 2004 was a landmark in recent years in term of Tsunami. The Submarine earthquake located close to Indonesia radiate a wave that traveled around the world -according to scientist- the death toll was major in the island of Sri-Lanka, Sumatra and the peninsula of Thailand and Thailand islands. While in Somali cost or eastern Africa or the Maldives archipelago most people survived the the reach of the giant wave.

**Uncertainty and variability:**

It unclear how likely are grids able to ensure a perfect coverage of the risk classes either spatially or timely. Which is the perfect model (deterministic). In order to stop the deterioration of grid status, it is important to figure out what is happening at the junction of the grid cells- it can be nicer depending of the figure and progress or less, and the environment (source,..) can orientate the recoveries (impacts,...)- these data are not easy to catch -to me- and need a real expertise in the hand of the practitioner, health consultant or psychologist (See Hitchcock, YouTube Movie and the story of the girl affected by a mental disorder that was transmitted by the mother to her daughter through her childhood bad treatments)

Some class of affectations or recoveries may not be pure. For example like, the survivors that are going to pass (R1,A1 - bb) or those that have survived successfully (R3, A3 -BB), but hybrid organizations, a combine cases of 2 or more primary mental illnesses. Like an encoding by the DNA of genes, which are combining differently to give an hybrid organization with a probability and a weight depending on the outer environment and the organization structure. For example, (A1, R2) is impacted either by the couple (b,g) → A1,R1 -with a certain probability or (g,b) → A1,R1 with another probability if considering that the 2 couples (b,g) and (g,b) are not symmetrical, but varied according to parameters source of the disaster impacts or causes.

**Why are we here:**
The nature of risk: Risk = hazard event x frequency of the event x (people vulnerability). Most common hazard is a flood with a frequency of 1/10th –(ref. Risk geography). Earthquake events with an enormous energy released in the environment (soil, faults,...). Buildings can collapse when the magnitude on the richter scale is in average 6-7, a tsunami wave can form in and travel a long distance. If the shocks are less frequent, it does not mean there will not be 2 earthquake vibrations at a short time period in the same location. An event risk has 2 components physical geography and a human geography (source: encyclopedia of geography) . In my paper, I have approached the topic of mental illnesses with basic assumptions for affect and recovery classes (model deterministic where the mental illness is prioritized and influencing the physical impairment) or opposite affect and recovery can both lead to the same disorders - one of the 6 scenario cases or several scenarii (in a probabilistic approach where indifferently sources of risk can be either from a physical illness affecting the mental health or vice-versa). Former United Nations International Strategy Disaster Reduction (UNISDR) Managing Director, Mr Salvano Briceno - I met twice- said natural hazards were God events, but disasters were man made.*"- also, he took the example of the aids disease, which can be caught only if people do not use a condom.... i.e the hazard, which is the HIV virus is a God event, but the protection depends on people using it or not-therefore thus, the disease is man made. I added, what the African news had echoed: before, in South Africa aids was a crowd killer. Today, the disease has been slow down, but there are still places in Africa, where schools are closing because there are not enough teachers to replace those killed ones- If schoolchildren cannot attend descent learning, later they cannot have descent jobs...- In Europe, the medical survey are warning of an increase of HIV. In France, UK, Russia... people are more vulnerable because there are not making safe sex. As long as the vaccine against HIV virus is not perfect, the aids disease will remain a man made disaster. Recently, the tri-therapy health mitigation against the disease was greatly improved, if people were able within the week they had unsafe sex to know they had been contaminated with HIV biology hazard- This means people reporting to the local medical health care system, able to monitor people the HIV in the blood and start the mitigation/mediation as soon as the virus is detected in the blood. To conclude, performance of campaign against HIV in post recovery operation depends on how quick people are to monitor the virus in the blood- "* (Georges RADJOU, BIRD)

**Where do I come from with the model:**
People affectations and brunts with hazard impacts in disaster zones during the post recovery: The short answer is I have been invited to participate. Myself what, I can see –(1) particularly with cumulative and combine crises, the post recovery operations tend to fulfill basic physiological needs: water food, shelter, communication, transports, asylum seeker displacement... these are immediate and visible impacts of the disaster on humanity. The real unknown is outcomes from these primary impacts, secondary impacts,....like being looted, women being rapt, children loosing their parents,....These odds are very important sources of brain damages and it is very likely people are rarely properly assessed their brain damages- *"the mental component of health has in many places not improved" (source: World Health Organization (WHO), Mental health: a call for action by World health Ministers, Call_for_Action_MoH_intro.pdf-Adobe Reader, 21 pages : page 6),* –(2) worst, when there is an estimate people are alike in the same class marks whatever their affects and status for recovery. Perhaps for accounting purpose and less for their well beings. It is less detrimental than to separate sufferers in order to enable a successful societal integration according to the disabilities. In France, once a minister claimed he or she was going to help homeless people to find out "the who is who" in the post recovery crisis in order to cater special health care strategies - this never happened. To me the health system failed when one can find normal people living with disabilities potentially cross contaminating the vulnerable through their own weaknesses. This is not helping and it is creating more problems to have everybody whatever their mental health conditions. But, I understood, this can help

temporary the government and the health care system is friendly with empathic moods, unable to have a policy on a long run for normal people and affected people- the risk is for people who are fragile can be the cross contamination from mentally disorder people that can transmit their stresses to the more vulnerable. There should be specific diagnosis in order to separate the light from the severe affected or under recover-illness risk, and –(3) opposite, there is no estimate: the case of children or adolescent under the tenses of the disaster post recovery disaster had their mental cognition affected by the tsunami damages, which has never been reported from experience of the South East Asia Tsunami 26 Dec. 2004. (source: Vinadda Piyasil MD - *Queen Sirikit National Institute of Child Health, Bangkok-*,....Post Traumatic Stress Disorder in Children after Tsunami Disaster in Thailand: 2 Years Follow-up.

**Method and assumption:**
*"The method used to investigate the natural risk impacts are combining real and virtual elements. The approach of the method is based on the mediation linking technologies and solutions I compared from my own Research and Development and comparative analysis of other authors' settings, in Methods brought to International Conferences in the fields of Energy, Engineering and Environmental management. A list of conferences can be found on internet and my own practice, which will give a feel, if the reader wants to pay a visit @ slide share,* http://www.slideshare.net/gsradjou." (Georges RADJOU, BIRD CEO). Also, *"I have considered other mental health issues like irrational behavior in financial investment decisions. These are biases, for example the loss of controls, cognition, biases, heuristic, anchoring... "* (ref. Corporate Financial Management). *" The model used can input any mental illness like excessive love -for example, the one that Romeo had for Juliette, which led them committing suicide because their families would not agree to see them united."* (Shakespeare narrative). *"All these brain disorders in a member group of a society or the society as a whole can explain why some of us are more successful than others. Entrepreneurs are more successful than others. Culture can play a role in determining success or failures, as other organizational behaviors, including management theories, organizations, communication... depending if the managers in organizations can use them or not. Some examples can be found in recent years, (a) in the use of bonus packages in a discontinued manner -the World financial crisis 2007-2009- are powerful incentives to motivation, (b) opposite are the deterrence laws like harassment,... which protect staffs in their workplaces against discriminations or (c) the US Sarbanes Oaxley Act 2002, aiming at stopping top business managers and accountants to cook books...",* also, *"...whistle blowers are reporting the misconducts of their own internal organizations or the some segment of the community wrong doings and this can be detrimental to their own security and freedom, for example a US citizens reports to the US Fraud departments of US nationals hiding from the tax office in Swiss Banks or the Australian owner of wiki-leak, the international online whistleblowing organization, now at risk of being prosecuted and hiding in the Ecuador Embassy in London* (Ref. Organizational Behavior or the International media).

**Assumption 1:** If the crisis is supported by a hazard source, there is no reason why the model would not be used. In fact, it would work, as any natural hazard, a technology risk or a war,...are different risk sources creating the risk issues, but all have the same risk impacts; i.e. basic needs, food, water, shelter, transports, communications, refugee displacements,...(source: Encyclopedia of Geography)

**Assumption 2:** It is a general paper, and not an anthropological research, but supported by online resources compiled to find out better the scale of the subject -and personal experiences. There is a feel of how sufferers are affected and can recover and this need to be taken, not because there is a need for more psychologists, psychiatrists or experts in organizations. Real sufferers are hard to find those days. For example, a radio broadcast that and academic school in Vienna -Austria- awarded to their students degrees in black magic. *"Of course, it is not the same magic that led Joanna d'Arc to be sacrified on the fire for the sacred of King Charles VII"*. But, I wondered what is the direction taken with these studies for work and employment. Also, the BBC columnist, cited by the academics in the beginning of my paper, wrote: *"In Burma the bodies of many of those lost in the cyclone receive attention only from the birds."* These metaphors have spoken for wide places of the earth planet - including wealthy cities of developed nations that experienced pockets *of poverty and "o man land""8221 ". It is so crying that sound organizations would be like the Asian monkey: not see, not hear, an not heard." T*herefore thus the risk portfolio matrix is used in the slide show for Power-point presentation can mirror other statistical survey could follow the same model track. There is also a bibliography resources with online documents where the reader(s) could refer(s) to deep in some specific points or to support the debate - however nothing could replace the reality found with the original experience.

In this way, virtual world has only advantages. In fact, it all the difficulties to make the link between virtual and real worlds. While often, I found real recovery operations are mode of consumptions of a global cooperation based on traditional operations, which can be jeopardized by the local contexts or situations where the rescue organizations reacted to events instead of proper actions with a prospective or anticipation management with a global cooperation based on traditional operations, which can be jeopardized by the local contexts or situations. There are countries, which have no other choices to swing to mass protest in face of climate change, global warming with their potential amplification phenomena and because the change process is awkward and more a threat than an opportunity. Where the rescue organizations reacted to events instead of proper actions with a prospective or anticipation management. Often, it is marketing by the top decision public stakeholders, which choices are guided by cutting costs- while one should not hide the gains acquired through the concept of risk sharing activities and development of the Information Communication technology society (ICT). For a long time, I am interested in the potential of these new paradigms phasing to a powerful low carbon and greener society. I think stakeholders are wrong if there are not taking into account the governance and the local territory to promote the entrepreneurship and empowerment. While with a computer, it is much radical to travel and found resources -and a multi choice solution with a flexibility. Think about markets, goods, services and where products come with their brands. Gravity ranking for health impacts (psychological or physical...). Can be from the less serious form of affectation to the serious impairment. *''Minor emotional distress can be self-limited''* (Bravo et Al 1990)- what I have assumed in my presentation as low impact (Rm), *'some proportion of the population may suffer a major distress' specially anxiety and depression depending''* (Siegel 1999) on their initial status and the influence of the family links. Samples of mental disorders in hazard zones from Federal Emergency Management Administration (FEMA, Crisis Counseling Assistance and Training Program Trainer's Toolkit Handout 4 . Recognizing Severe Reactions to Disaster and common psychiatric disorder, handout4.pdf: pages 1 to 16). Cited severe trauma reactions in an hazard in the document are: social isolation, paranoia, suicidal behavior, depressive disorder, substance abuse, ASD, anxiety disorder, PTSD, dissociative disorder, bipolar disorder, BPD, eating disorder, OCD, schizophrenia, skizoaffective disorder, cooccurring mental illness and substance abuse. Others (brunts): injuries, fatalities, communicable diseases, acute illnesses and chronic illnesses. Indirect impacts: *''due to the fact that heath infrastructures are destroyed, there is a loss of health routines: primary and urgent health care needs, which do not end because the disaster has stopped''* (FEMA, page 61). One can imagine health needs of people that are jeopardized because of the disaster occurrences. For example, people who should seek to get immunized for themselves or their children- *'' In Afghanistan, United Nations health workers were killed to stop the organization immunization campaign''* (ref. UNICEF related media reported: 1over 3 million children will not be protected from fatal diseases.)- Issue with human blood constants: vital elements in the human body should remain fix for the health performance, if not sufferers without medications are likely to suffer injuries -mental or physical- ranging from a minor to a serious gravity. For example in diabetes- the lack of sugar is affecting the normal body functions and create also psychological impairment, also leading to death with the ethylic coma. Salt is an agent factor helps to regulate the blood pressure-for example through the urine function. If the constant is altered, a chronicle low pressure or high pressure is a negative signs and health worrying ahead...It can lead to cardiac diseases and hearth strokes,... Also economical impacts- (not discuss in this paper) Lessons learned from the disaster risks:*''...The main factors causing natural disasters are: a-Degradation of the environment, b- Uneven distribution of the infrastructure, c-Global climate changes, e-Densely populated territories and territories prone to natural disasters, f-Irrational distribution of the economy, g-Violation of land use rules, h-Lack of information and knowledge, i-Construction of cities and big engineering structures, j-Development of new territories, k-Selection of inappropriate areas for residence, l-Unsustainable extraction of mineral resources, m-Economic development...''* (Source: Teaching disaster risk reduction with interactive methods, book for head of class teachers, Grades V-IX, 22730_22730headteachersguideengncac1.pdf –Adobe Reader)

**Questions to be answered:**

In order to reconstruct the course of the various assumptions that led to the mental health disorder one needs to identify the most hazardous conditions of risk occurrences, which is also an issue depending of the uncertainty management.The various degree analysis need to be correlated with a sensitivity system that helps to predict what is most likely. The uncertainty management and the regression curves helps to draw curve that indicated the presence of the risk mental health. I took 9 classes (see section 2 of the paper) to materialize the risk encountered during the monitoring, which is likely to be underestimated, through the lens of an hybrid process, uncertainty and variability of the real hazard occurrence in the natural environment, technology

breakdown, diseases, wars,... (see section 4 on uncertainty). What one needs is a techniques to identify at the earliest stage these health impacts.

**How to improve:**
Going on sites: where a disaster has occurred with a basic knowledge of psychology disorder in order to separate from the population that survived (survivors) the disasters, people who are mentally affected (R: recovery variable) and how their mental recovery can affect their physical health (A: affects or brunts). It is a general approach in emergency management, in order to help them progressing, one should separate those that are not affected from the severe forms of illnesses. Hospital admission should care for these in bed patients Monitoring means: following these people on a various period of time according to the health impact. gravity. Monitoring is a business quality assurance based on the fact, the earliest the detection the cheapest the medical intervention. Use of experts: emergency planners, disaster managers, consultant, psychologists, psychiatrists or any other like a yogist can help to make a progress on crisis recovery and well-beings. *''...Mass disasters like 2004 tsunami and hurricane Katharina caused acute and chronic trauma. Yoga procedures can safely and effectively be used to reduce stress, anxiety, depression, post traumatic stress disorder (PTSD),'even under chaotic conditions. Decilo et al (2009) demonstrated that the survivors' 2004 tsunami proves that SK interventions help to relieve psychological distress following mass disasters..."* (source: International Symposium on YOGism, Dec. 2010, The role of Sudashan Kriya on Mental health) Recognizing Severe Reactions to Disaster and Common Psychiatric Disorders: *"In the course of meeting with disaster survivors, crisis counselors may come into contact with people experiencing severe reactions to the disaster. Because treatment is not part of the Crisis Counseling Assistance and Training Program (CCP), the goal of crisis counseling is to recognize these reactions and know when to alert a team leader or program manager to any concerns. If unresolved, severe reactions, such as social isolation, paranoia, and suicidal behavior, may begin to interfere with daily functioning and develop into psychiatric disorders".* (FEMA) Use of organizational managers able to cope with human group variability, biodiversity and disabilities in multicultural environment in order to take full opportunity from people behaviors that look rather a nuisance for the business as usual, and not taking the opportunity to manage these differences. (Organizational Behavior -OB science)

**Acknowledgments:**
With no doubt, as a visitor of various centers in Paris, the topic of disaster management and mental illness would not be possible for the motivation brought in the experience of poverty eradication (Millennium Development Goal 1 -MDG1), also, human rights, day restrooms...I am grateful too: a) Association Charles Fourier (the Director Mr Françis) in Paris 13- Chinese Suburb district, which Parent company "La Mie de Pain", the most prominent Asylum seeker center in Europe. I had short regular visits (30 minutes daily from Oct. 2007 until recently in Dec. 2012, since the new building *"Arch of the future"* totally completed and integrated the new front of former Panhard family French car manufacturer. There, in the week mornings I was able to meet worldwide paperless people looking for hospitality in France and listening to their needs as much as I could around a couple of warm white coffee cups, b) Next in at a walking distance from the Olympiad Underground Tube station, is Beaudricourt Municipality center, which is both an emergency shelter, and a social restaurant of Paris City, providing free accommodation and free-meals for residents with low-earnings- As I met most of the residents with specific needs, the free services offered by the municipality house completed meager resources with a social safety net, and c) Espace Numeric Paris 13 (EPN13), which is a multimedia center, where people of all walks of life are trained to numerical activities (blog, internet, office skills leading to build new skills with information technologies. I met there a totally dedicated and talented staffs (Christophe and Laurence) and the director (Mehdi) always ready to help by giving their time and attentions to improve the students and schoolchildren skills on the road to numerical and social integration. Myself, from time to time as a normal users, I could help in a tutoring experience when the classroom was fully booked, and finally, United Nations Organizations (UN) or UN related organizations in various cities where I followed their UN meetings on Sustainable Development, disaster management and health and flood plans with new thinking and break through projects.

**Resources**

1- Encyclopedia of Geography - with a risk section-

2- Medical Geology: Catherine W. Skinner, Closing the Gap, OUP, http://www.amazon.com/Geology-Health-H-Catherine-Skinner/dp/0195162048

3- International Symposium on YOGism, (Dec. 2010, The role of Sudashan Kriya on Mental health)

4- Kimberley I. Shoaf, DrPh et steven J. ...Public health impacts of disasters, Australian Journal of Emergency management, on the evidence of people psychological disorder after a disaster: spring 2000, 6 pages: page 1 to 6.

5- FEMA, Crisis Counseling Assistance and Training Program Trainer's Toolkit Handout 4 . Recognizing Severe Reactions to Disaster and common psychiatric disorder, with diagnosis for each mental illness case and treatment options- handout4.pdf: pages 1- 16

6- World Health Organization (WHO), Ministerial round tables 2001, 54th World Health Assembly, Mental health: a call for action by World health Ministers, Call_for_Action_MoH_intro.pdf-Adobe Reader, 21 pages : page 6

7- Vinadda Piyasil MD - Queen Sirikit National Institute of Child Health, Bangkok-,....Post Traumatic Stress Disorder in Children after Tsunami Disaster in Thailand: 2 Years Follow-up-*J Med Assoc Thai Vol. 90 No. 11 2007, post traumatic stress disorder in children after tsunami disaster in Thailand 2 years follow up. Pdf, 7 pages.)*

8- Symentec 2011, SMB disaster Preparedness, Survey, Global Results - Protecting business data form disasters, symc_2011_SMB_DP_Survey_Report_Global.pdf –Adobe Reader

9- Matthew E. Kahn Tufts University and Stanford University , The Death Toll From Natural Disasters: The Role of Income, Geography, and Institutions

10-Post disaster Surveys: experience and methodology, *David King* examines and questions research methodologies used in disaster studies in Australia. Post disaster surveys.Pdf –Adobe Reader

11-W. Kip Viscusi Richard J. Zeckhauser, National survey evidence on disasters and relief: Risk beliefs, self-interest, and compassion Springer Science+Business Media, LLC 2006

12-Teaching disaster risk reduction with interactive methods, book for head of class teachers, Grades V-IX,

22730_22730headteachersguideengncac1.pdf –Adobe Reader)

13-General book on Organizational Behavior -OB- Pearson Education

14-Georges Radjou, MBA project 2009, CNAM of Paris, supervisor Head of Project Management, Professor Gilles Vallet, 100 pages)

- empty page inserted -

# Mapping Standards Principles and Proposals for Disaster Management

Temenoujka Bandrova[1], Milan Konecny[2]

[1]University of Architecture, Civil Engineering and Geodesy
1, Chr. Smirnenski Blvd., 1046, Sofia, Bulgaria
tbandrova@abv.bg

[2] Laboratory of Geoinformatics and Cartography, Department of Geography
Masaryk University
2, Kotlarska, 61137 Brno, Czech Republic
konecny@georg.muni.cz

**Abstract.** Authors propose standardization in data classification and data structuring in the process of preparing all sources for mapping and cartographical visualization for disaster management. The next proposals are connected to symbol systems, color systems and scales of different kinds of maps already accepted as necessary tools in disaster management. The development of proposed standards need international cooperation and discussions in national, regional and international levels to be accepted for map productions in disaster management together with organizations responsible for standard creations (ISO, OGC).

**Keywords.** disaster management, standards, mapping, cartography

## 1 Introduction

Last big disasters – earthquake in Sichuan, China in 2008, Fukushima tsunami disaster in 2011 and last but not least also both hurricane Katrina in 2005 and big tropical storms in East regions of USA in 2012 - warn us again that our preparation for such situations is still not enough and has to be innovated by improvement of all individual elements which are parts of disaster management cycle and by efforts to attach disaster risk reduction targets. It is visible and also documented by requests of several world operating organizations (ICA, ISPRS, FIG, IRDR, CODATA etc.) that we should progressively improve also maps created by newest information and communication technologies as a "channel of information" for decision makers but as well as inhabitants. In humankind history maps are repeatedly found as the most convenient and enough understandable products of cartography ensuring interface between maps and people. One of the basic conditions to develop and make effective such ideas is standardization of maps and mapping process for disaster management.

The authors did several experiences about understanding of cartographical information directed to disaster management in several European countries. The target groups had been students and children. On this base some conclusions were made and proposal for standardization in symbol system presentation of geographical information (including phenomena and objects needed in early warning and crises management) were done [6]. In this area specialists use different kind of sources – the most popular are satellite images or traditional topographical maps. The goal is to present information more understandable not only for professionals but also for wide range of users. The necessary data from different sources should be represented by one and the same way. This could be achieved if we use approved standards.

Mapping of nature risks and disasters and analyses of caused damages with map assistance have very important meaning for preparing of programs for their averting and giving progressively higher potentials for

managing of serious consequences. The visualization way of the concrete phenomena, risks and disasters is important because users could receive clear perception for their characters, volume and size, and conditions.

Cartography is offering new types of maps based on spatial data base; it is using the Internet and creates new kinds of web maps. Today we are talking about ubiquitous mapping, mapping for everywhere, every time and everything. In some countries, there is significant development in the fields of Mobile and Adaptive Cartography.

The International Cartographic Association (ICA) is active in the process of teaching people how to make and use maps created for early warning, nature risks and disasters, for emergency needs. ICA follows resolutions and agreements from World Summit on Sustainable Development (Johannesburg, 2002) and mainly United Nation Hyogo Framework (Kobe, Hyogo, 2005) [13]. The main ICA activity is the establishment of a working group in this field. The results are coming in the form of organization of various meetings and seminars as well as propagation of cartography and GI possibilities in risk processes and crises management. One of the latest activities was a poster presentation for the United Nations EW III titled „Cartography and Geoinformatics in Early Warning and Crises Management" [15].

Working with different international organizations, nature risk and disaster phenomena should be defined and mapping standards for data capture, storage and visualization proposed and adopted for national or international use. There are some first steps in this direction done by United Nations (UN) ISDR Secretariat after successful work in the approaches how to inform people and how to deal in such situations. These organizations publish a lot of brochures and materials, for example [30], proposing training course in Kenya [11], documenting activities of Ministry of Education of Kazakhstan [25] or risk reduction methods for Tanzanian people [27].

## 2 Definitions of nature risks and disasters and standardizations in object and phenomena visualization

### 2.1 Definitions

***Natural hazards*** are defined by UN as natural processes or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage [26]. Natural hazards can be classified by origin namely: geological, hydrometeorological or biological. Hazardous events can vary in magnitude or intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing.

The same organization gives a definition about **risk** as the combination of the probability of an event and its negative consequences [26] (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions.

*Conventionally risk is expressed by the notation*
***Risk = Hazards x Vulnerability***

A ***disaster*** has the following definition, given by the American Red Cross. "A disaster is an occurrence such as hurricane, tornado, storm, flood, high water, wind-driven water, tidal wave, earthquake, drought, blizzard, pestilence, famine, fire, explosion, volcanic eruption, building collapse, transportation wreck, or other situation that causes human suffering or creates human needs that the victims cannot alleviate without assistance" [2].

UN definition says the following: "A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources. A disaster is a function of the risk process. It results from the combination of hazards, conditions of vulnerability and insufficient capacity or measures to reduce the potential negative consequences of risk".

Why do cartographers need these definitions? They give them multi-aspects of mapping objects, phenomena, processes and their results. In the definitions natural hazards are classified, variations of hazardous events are pointed, all kind of disasters are shown as well as their influences to human society, and we can find also reasons and characteristics of mapping features. Cartographers have to propose their classification, modeling and visualization if appropriate data is available. The task could be not very difficult if there are some standards and this will help all specialists and users in communicative process.

The General Clinical Research Center **(**GCRC) defines **risk as minimal, low, moderate, or high**. Their definitions could be seen in [26]. All these variations of risks are visualized in one and the same way by using different systems of presentation.

How cartographers present one and the same phenomena, kind of risk or disaster? They use cartographic methods and technologies, create their author's cartographic symbol system and compile maps or visualize computer based maps.

## 2.2 Visualization

***Context and cartography*.** In a certain sense, adaptability to context is an extension of cartographic generalization, because extent, scale, character of displayed area and purpose of map is contextual information. In adaptable cartography we have to take into account variability of extent of displayed area related to differences in displays of used equipment (e.g. PDA vs. 19" LCD monitor). Related to extent is ***scale***, transformed to the term ***level of detail***. It also becomes a variable characteristic reflecting the necessary amount of information required for taking a decision [18].

Purpose of map is highly specialized, same as characteristics of the user. Purpose specialization is related directly to the involved situation – e.g. tourist map changes its appearance when we plan a bicycle trip, hiking tour or search for attractive views. The user (who was previously only partly considered in the map purpose) is now much more specific – we can consider his level of education, age, cartographic experience and also his individual tastes and preferences.

***The aim is to adjust map to the user's cognitive abilities and shorten time necessary to extract required information from the map.***

Besides specialization of existing contexts, new ones related to environments of use are created. This includes hardware characteristics of visualization environment (e.g. size of pixel) influencing size of symbols, number of distinguishable colors or transmission characteristics indicating amount of available data in certain time, etc. They also take into account external environment – time, season of the year, location of user, visibility and many other environmental characteristics. Examples of changes in visualization according to change of context are given in Figure 1.

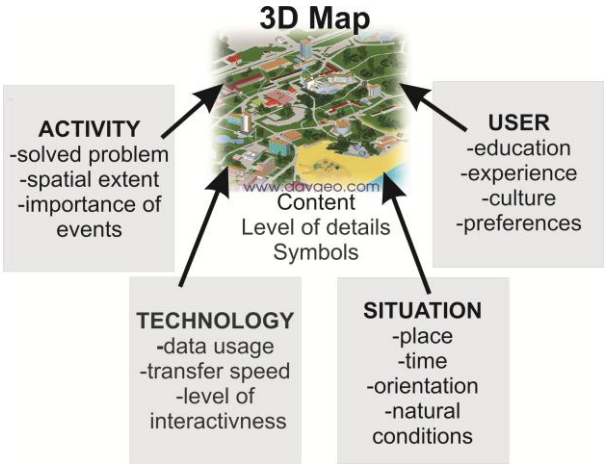



**Fig. 1.** Examples of changes in visualization according to change of context (Adapted for 3D maps on the base of [22])

***User profiles and situation diagrams.*** All combinations of the above mentioned contexts create a large number of potential types of cartographic visualizations of geodata. In real life situations, processing such information is limited by time. In order to be able to generate variable content of map in real-time, we have to limit number of alternatives while preserving all substantial advantages of adaptable cartography. The method leading to required selection of alternatives is ***the definition of generic user profiles***, together with determination of individually adjustable parameters. Similarly, it is possible to determine several typical situations related to map content; such content can be reduced in individual situations.

In order to create profiles and situation diagrams, it is necessary to analyze decision-making processes for which the maps are used – what are the situations like, what are the roles of users, what types of users will probably take part in dealing with the situation. Dependence between user profile and situation diagram is apparent when a certain type of user can only face a specific, determined situation.

### 2.3 Role of cartography in crisis management

Many questions asked during management of a crisis situation begin with the word WHERE – WHERE did something happen, WHERE are the rescue units, WHERE are the sources of danger, WHERE should the threatened people be relocated, etc. It is clear, that a natural answer to these questions is a map. The role of cartography in crisis management is therefore clear – simplify and well-arrange required spatial data. That makes the decision-making process quicker and better and leads to minimization of damage.

Members of crisis management and integrated rescue system include the Fire Service, the Rescue Service (Ambulance), the Police, Ministry of Environment, Ministry of Industry and Trade, Ministry of Transportation, Ministry of Defense, Administration of the State Material Reserves, State Office for Nuclear Safety, local authorities, etc. For many (often historic) reasons, these institutions are equipped with a varied set of referential databases (ZABAGED, DMU25, Geobase, ArcCR500, DMR2, UIR-ADR, and also analogue plans). Moreover, they build their own thematic databases according to their individual internal needs (database of settlements, maps of flood areas, database of sources of hazards, maps of land-use, ortho-photos of selected areas). Variety of used software corresponds to used databases. Most frequent are ESRI or Intergraph platforms supplemented with different application software developed individually for the users.

All these subjects, mentioned above give us evidence that the society needs a standard in cartographic visualization of nature risk and disasters. This standard should be national or international and used by all institutions and organizations involved in the process of reducing and minimizing damages and saving human lives.

## 3 Nature risks and disasters represented in the maps

Nature risks and disasters are presented on the maps using different kinds of visualization, in different scales and territories: from maps of the world to the largest-scaled maps of the cities and their districts [4].

There are two main trends of development of such studies. In both cartography and maps play important role. First trend deals with nature risks and disasters investigated mainly by ISDR or IRDR and this paper highlights cartographical support of it. Second one is closely linked with wider environmental and ecological approaches [14], [23].

### 3.1 Classification

In the mapping process, the all phenomena, processes and objects of interests should be classified. But "definitions and categorisation of disasters vary according to geosectors, the geographical and social settings in which they are located" [20]. For example the last authors classified natural disasters in two categories: major (earthquake, flood, drought, cyclone) and minor (heat wave, cold wave, landslide, avalanche, tornadoes hailstorm). Other authors give classification of disasters as: 1. Natural, 2. Fire, 3. Water 4. Animate creatures [http://www.telmedpak.com]. In Table 1 the classification is done by the authors and made on the

base of the UN report and cartographic principles of object and phenomena classification. It is useful also for capture and storage hierarchy database for disasters.

**Table 1.** Classification of natural hazards and disasters [16]

| **Natural hazards and risks** | **Disasters** | **Characteristics** |
|---|---|---|
| 1000.Geological | **1010. earthquake,**<br><br>1020.volcanic eruption<br>1030. landslide<br>1040. erosion | **1011 magnitude,**<br>**1012 structure location,**<br>**1013 date,**<br>**1014 built area**<br>**1015 construction** |
| 2000. Hydrometeoro-logical | 2010.landslide<br>2020. erosion<br>2030. hurricane,<br>2040. tornado,<br>2050. storm,<br>2060. flood,<br>2070. high water,<br>2080. wind-driven water,<br>2090. tidal wave,<br>2100. drought,<br>2110 hailstorm<br>2120 blizzard,<br>2130 avalanche<br>2140 wild-land fire | *intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing* |
| 3000. Biological and social | 3010 famine,<br>3020 pestilence,<br>3030 fire,<br>3040 oil spills<br>3050 explosion,<br>3060 building collapse,<br>3070 transportation wreck,<br>3080 erosion<br>……<br>3200 other situation | *intensity, frequency, duration, area of extent, speed of onset, spatial dispersion and temporal spacing* |

### 3.2 Mapping

We can find many maps in the theme "nature hazards, risks and disasters". From cartographic point of view there are not any standard and order in object and phenomena visualization.

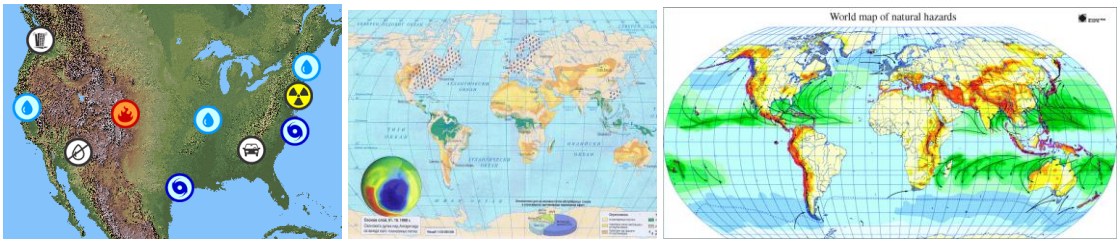



**Fig. 2.** Different kinds of cartographic visualization of nature hazards, risks and disasters, from left to write: [5] [21]

The maps on Figure 2 shows affected area by disasters. The cartographers are used point (pictorial), line and area symbols. The color systems are also different. The users could direct attention in map legend and understand the map contents. But if we use the same presentation to visualize these phenomena on mobile or computer screen in critical situation, it will be very difficult to direct user's attention to legend. Because of this we need standardization of visualization: color, symbol system and cartographic way of presentations.

### 3.3 Symbol system

The utilization and standardization of symbol system for mapping nature hazards, risks and disasters need a detailed research in the international level. It could start by classification of represented objects and phenomena and clarify the color system presentation. Many authors and organizations propose standards for symbols systems represented nature hazards and risk processes, as well as disasters. Some of them are proposed for national standards or they are used in different branches of science and practice (see Figure 3).

First symbol system has very wide text explanations in the legend and the second two are based on symbols for emergency situations. The second group of symbols [9] on Figure 3 is proposed for American National Standard (ANS). In other research about the same symbols, the result is clear: "22 of the 28 symbols tested did not achieve the 85 percent comprehension level necessary to meet the standard" [1]. The third group is the most understandable and practically used but still not accepted as national standard [8].

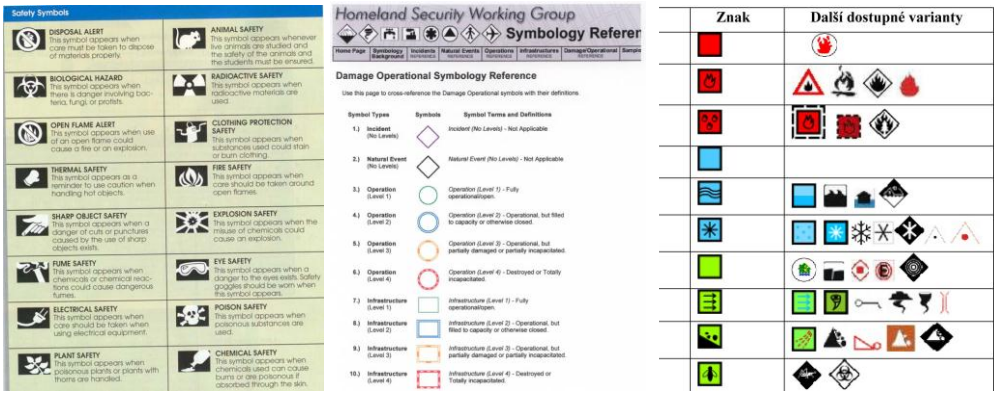



**Fig. 3.** Proposals for symbol system standards in hazards mapping ([http://science.valleyheights.org/safety.jpg], [9], [8])

The cartographic symbols should have clear and short definition to be used in a map legend. The next very important characteristic of them is to be situated on a map and the last one is that they should give quality and quantity information about represented object, phenomena or process to users.

The steps in symbols creating for these maps are distinguished as follows:

a) gathering information about an object (quality and quantity characteristics, images, textures);
b) analyzing information and collecting data about each object;
c) designing symbols and then applying computer graphics techniques;
d) visualizing symbols in the virtual or paper environment;
e) obtaining synthesized information about object.

The created symbols should respond on following conditions:

- easy for reading and understandable;
- simply graphic construction;
- association with presented phenomena, process, object;
- color system presentation in CMYK or RGM
- independency of software system.

Recommendations given by J. van den Worm could be added: "All proposed symbols have to be **platform and software independent**. This is one of the reasons that animation and the use of transparency (despite its

advantages for the display of area related risks) have not been applied" [28]. Other authors as John Kostelnick at all give special requirements to symbol system, created for risk maps.

Symbols should:

- cross cultural barriers as much as possible;
- relate to each other in a hierarchical or tiered structure;
- be based on common cartographic standards and perceptual research;
- display effectively in both low- and high-resolution computer displays [17].

| Emergency | Type of Alarm levels |
|---|---|
| Green | No alarm |
| Yellow | Vigilance |
| Orange | Pre-Alarm |
| Red | Alarm |

**Fig. 4**. An example of risk variations visualization, UN ISDR Secretariat [12]

Such designed symbol system, according all above rules and requirements, should be also responded to area mapping, scale, map dimensions and way of visualization, as well as user's requirements.

### 3.4 Colors

Color standardization could be defined using computer definitions of colors for paper presentations in CMYK color system and for screen presentation in RGB color system.

One example of this is shown here. United Nations ISDR Secretariat publishes many books and information brochures to intend teachers' and students' attention "what to do in case of an emergency". Figure 4 shows an emergency table. The four colors correspond to the four risk variations, minimal, low, moderate, or high, defined by the General Clinical Research Center (GCRC). They are widely used and should be also defined as a map standard in visualization of risks and disaster processes.

Working with paper and screen visualized cartographic products we could propose the standard colors. They are defined in Table 2.

Using the same logic in color presentation we could define color presentation of different main disasters for map of the world or some region.

**Table 2.** Computer generated colors for risks variations presentation: a proposal for a standards

| Colors/ Color systems | RGB – screen | | | CMYK - paper | | | |
|---|---|---|---|---|---|---|---|
| Green | R = 0 | G = 153 | B = 61 | C = .90. | M = 0 | Y = 100 | K = 0 |
| Yellow | R = 255 | G = 245 | B = 30 | C = .0. | M = 0 | Y = 100 | K = 0 |
| Orange | R = 231 | G = 120 | B = 23 | C = .0. | M = 60 | Y = 100 | K = 0 |
| Red | R = 218 | G = 37 | B = 29 | C = .0. | M = 100 | Y = 90 | K = 0 |

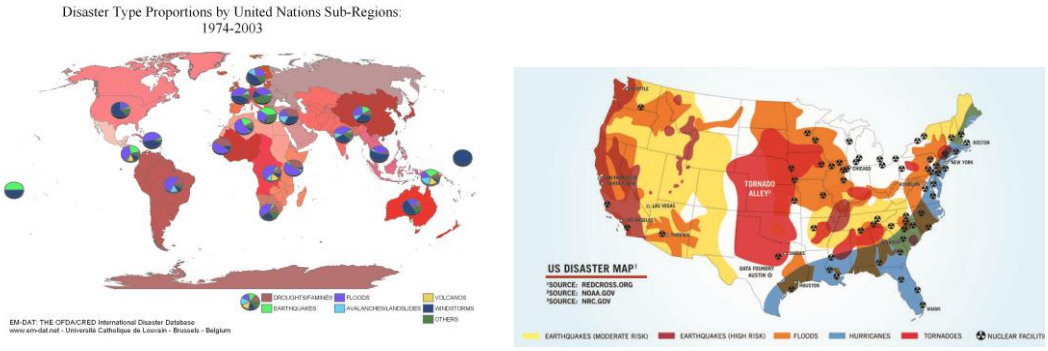



**Fig. 5** Main disasters presented by colors and diagrams on map of the world and map of USA [3]

On Figure 5 the main disasters (draughts, earthquakes, floods, volcanoes, windstorms, avalanches and others) are presented on a map of the world, e.g. they are grouped by Sub-Regions, defined by UN. The same

diagrams can show situations in the world or regions by country or in a country by districts. It is visible that the same disasters are represented on the map of USA by different colors.

Color definitions could help not only cartographers and map-makers but also users when they will get such cartographic information by mobile phone, screen equipments, paper versions of visualization of computer generated ubiquitous maps.

The proposed colors could be seen in Table 3. They are high saturated because the diagrams should be well visible on the map background. The colors related to areas are defined to be used as area symbols.

**Table 3.** Computer generated colors for disasters presentation in cartographic products

| **Disasters/ Color systems** | **RGB - screen** | | | **CMYK - paper** | | | |
|---|---|---|---|---|---|---|---|
| Draught / yellow | R=255 | G=250 | B=60 | C= 0 | M= 0 | Y=80 | K= 0 |
| Earthquake / green | R= 0 | G=155 | B=80 | C=90 | M= 0 | Y=90 | K= 0 |
| Flood / blue-violet | R=90 | G=90 | B=160 | C=70 | M=70 | Y= 0 | K= 0 |
| Volcano/red-violet | R=220 | G=35 | B=45 | C= 0 | M=100 | Y=90 | K= 0 |
| Windstorm/ blue | R=35 | G=41 | B=122 | C=100 | M=90 | Y= 0 | K= 0 |
| Avalanche/light blue | R= 0 | G=125 | B=195 | C=100 | M=20 | Y= 0 | K= 0 |
| | | | | | | | |
| draught - area | R=255 | G=250 | B=150 | C= 0 | M= 0 | Y= 40 | K= 0 |
| earthquake – area | R=100 | G=185 | B=95 | C=50 | M= 0 | Y= 80 | K= 0 |
| flood – area | R=140 | G=130 | B=180 | C=40 | M=40 | Y= 0 | K= 0 |
| volcano- area | R=230 | G=110 | B=105 | C= 0 | M=65 | Y=50 | K= 0 |
| windstorm – area | R=160 | G=170 | B=200 | C= 30 | M=20 | Y= 0 | K= 0 |
| avalanche – area | R=90 | G=190 | B=240 | C= 50 | M= 0 | Y= 0 | K= 0 |

Standardization in coloring for symbol systems and maps is a long-time process which could continue in many directions. The work here is only a first step and show the principle steps of the processing. Every color system could be improved to be more clear and readable for users. The human vision also could be studied in the direction of how people react of different colors in emergency situations.

### 3.5. Standardization

OGS (Open Geospatial Standards) declare that by using OGS we can "improve efficiency and effectiveness of users in all phases of emergency and disaster activities communities through changes and extensions to OpenGIS specifications which result in interoperable geospatial products and other information consumables that can be shared across these communities"[10].

Some of example topics are:

- Addressing a range of events, from small to large scale.
- Involving limited or denied communications environments.
- Limited "time to deploy" inherent in Emergency and Disaster event operations.
- Trans-border events, such as nuclear accidents and pollutant dispersion, involving international and a variety of national institutions.
- Assessment of institutional policy and practices as drivers for standards assessment, development, testing, validation and demonstration.
- Consideration of changing technology and social trends, such as the impact of social networking, crowd sourcing and other mass market trends [10].

Other International proposals from standardization are coming from International Organization for Standardization (ISO). "ISO/IEC 24762:2008, Information technology – Security techniques – Guidelines

for information and communications technology disaster recovery services aims to offer guidance on the information and communications technologies and services necessary for disaster recovery (ICT DR) as part of business continuity management. With this guidance, the standard supports the operation of an information security management system (ISMS) by addressing the information security and availability aspects of business continuity management in time of crisis" [19].

To find right decision about what standards will be used in a separate country or region is also political and economical question. ISO prepared a lot of information in ISO *Focus+* magazine to crisis management. It is connected to crises like earthquakes, tornadoes, tsunamis, etc. [24].

According to the World Standards Cooperation (WSC) all kind of disasters: earthquakes, hurricanes, floods, etc. account for many people. International Standards offer widely accepted and recognized solutions to prevent and respond to these threats. The role that standards can play in preventing or mitigating such human and material losses is increasingly recognized and their use is rising as a consequence. The WSC is established in 2001 by the International Electrotechnical Commission (IEC), ISO and the International Telecommunication Union (ITU) [29].

## 4 Conclusion remarks and directions for future work

The tasks of all organizations caring for nature risks and disasters are to reduce them and - when they occur – ensure safety of human lives. The ICA and many cartographers work in this field of mapping phenomena connected with nature risks and disasters. Showing the way how to draw and read the maps, they are included in the processes of standardization. The way for data capture, collection, classification and visualization is proposed and many different ways for management with cartographically presented data are known.

All efforts could be direct to the international standardization process: it could be started from data standards in some aspects:

- data classification;
- data content;
- **data symbology or presentation;**
- data transfer;
- data usability [7].

According to the same authors process of standards design could be consider in the following directions:

- general (specific) data transfer procedures;
- existing data access procedures;
- **classification methodology;**
- data collection;
- storage procedures;
- presentation standards;
- data analyzing procedures;
- data integration;
- quality control and quality assurance.

In the report we proposed a methodology of a standard in two of above pointed directions: symbol system and color representation and the second one - data classification in nature risks and disasters mapping. The researches could be continuing in International Commission of standardization of different International organizations. Specialists in different branches of geo-science are needed to achieve final results of presented problems.

## References

1. Akella M. K.: First Responders and Crisis Map Symbols: Clarifying Communication, Cartography and Geographic Information Science, Vol. 36, No. 1, (2009), 19-28

2. American Red Cross: http://www.seattleredcross.org/disaster/definition.htm, available on 2. 01. (2013)

3. Austin Risk Assessment: TEXAS 1, Austin, TX 78744, https://www.datafoundry.com/resources/data-sheets/austin-risk-assessment/, available on 2. 01. (2013)

4. Bandrova T., Konecny M.: Mapping of Nature Risks and Disasters for Educational Purposes. In: Conference Collection of Papers, Volume II, VIth International Scientific Conference, Modern Management of Mine Producing, Geology and Environmental Protection. SGEM 2006. Bulgaria (2006) 127-134

5. Bandrova T.: Atlas on Geography and Economics, Grade9., DataMap-Europe Ltd., Bulgaria ISBN: 978-954-8717-96-0 (2008) pp.80

6. Bandrova T., Konecny M., Rusnakova M.: Research of Students' Cartographical Knowledge in Early Warning and Crisis Management. In Geographic Information and Cartography for Risk and Crisis Management. Lecture Notes in Geoinformatics and Cartography. ISSN 1863-2246, ISBN 978-3-642-03441-1 Springer Heidelberg Dordrecht London New York, 2010, pp. 361-378.

7. Batuk F. et al.: Developing of Turkey's Disaster Management Standards for E-Government, Commission IV, WG IV, http://www.isprs.org/istanbul2004/comm4/papers/339.pdf, (2004)

8. Brezinova S. et al.: Tvorba Kartograficke Infrastrukturu. In: Dynamicka Geovizualizace v krizovem management, ed. Konecny M. et al, Masaryk University, Brno, Czech Republic, ISBN: 978-80-210-5858-3 (2011) 235-287

9. Dymon U.J., Mbobi, E.K.: Preparing an ANSI Standard for Emergency and Hazard Mapping Symbology, http://www.cartesia.org/geodoc/icc2005/pdf/oral/TEMA29/Session%201/UTE%20DYMON.pdf, ICC (2005)

10. Emergency & Disaster Management DWG, http://www.opengeospatial.org/projects/groups/edmdwg, available on 5/01/ (2013)

11.Federal Foreign Office: Training Package on Natural Hazards and Early Warning for Training of Trainers' in Kenya, Printing: UNON, Publishing Services Section, Nairobi, ISO 14001: (2004) pp.88

12. Gaudru H.: Volcano Daily. UN/ ISDR, Geneva, (2002) pp.20

13. Hyogo Framework for Action (HFA), UNISDR, http://www.unisdr.org/hfa

14. Kasimov N.S. et al.Tematiceskoje i atlasnoje kartografirovanije:sovremennoje sostojanije i perspektivy. In Russian. (Thematic and Atlas Mapping: the-state-of the-art and perspectives). Geodezija i kartografija, No 11, (2012) 40-47

15. Konecny M. et al.: Cartography and Geoinformatics in Early Warning and Crises Management. ICA Poster for United Nations EW III Conference in Bonn. (2006)

16. Konecny M., T. Bandrova. Proposal for a Standard in Cartographic Visualisation of Natural Risks and Disasters. SMF/UPIMap 2006, Proceedings of the Joint Symposium of Seoul Metropolitan Fora & Second International Workshop on Ubiquitous, Pervasive and Internet Mapping. pp.157-164, Seoul, South Korea, October 23-25, 2006

17. Kostelnick J. et al.: A Cartographic Study of IMSMA Symbology: Reviewing Its Value for operations, http://www.gichd.ch/fileadmin/pdf/IMSMA/summer_workshop/Kostelnick_et_al.pdf, (2006)

18. Kubíček P. Staněk K.: Dynamic Visualization in Emergency Management. CD Proceedings of I-st International Conference on Cartography and GIS, (2006)

19. Managing crises with new ISO/IEC standard for IT disaster recovery, http://www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1118, 6 March (2008)

20. Parasuraman S., Unnikrishnan P. V.: Disaster response in India: An Overview, http://www.punjabilok.com/india_disaster_rep/introduction/overview.htm, (2006)

21. Royal Society Publishing. Natural disasters and the challenge of extreme events: risk management from an insurance perspective, Smolka A Phil. Trans. R. Soc. A 2006;364:2147-2165 http://rsta.royalsocietypublishing.org/content/364/1845/2147/F2.expansion.html (2006)

22. Stanek K. Konecny M. and Friedmannova L.: An adaptive cartographic visualization for support of the crisis management. In: XXIII International Cartographic Conference. Moscow: Roskartographija, on CD-ROM, 9 pp. ISSN 2071-9388. (2007)

23. Tikunov V.S., Kasimov N.S., Kotova T.V. Atlasnoje ekologiceskoje kartografirovanije Rossiji. In Russian. (Atlas Environmental Mapping of Russia) Sovremennaj geograficeskaja kartografija, Moskva, Data+, (2012 )133-145

24. Tranchard S.: ISO's magazine focuses on standards and crisis management, http://www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1565, 16 May (2012)

25. United Nations International Strategy for Disaster Reduction (UN/ISDR) Central Asia Dushanbe, Tajikistan, Disaster Risk Reduction 20 Examples of Good Practice from Central Asia. www.unisdr.org

26. UNISDR: Terminology on DRR, http://www.unisdr.org/we/inform/terminology. available on 3. 01. (2013)

27. UNISDR: Secretariat International Environment House II. Risk Reduction Methods: Disaster Reduction Handbook for Foundation Phase Learners, Grades 1-3 www.unisdr.org available on 2. 01. (2013)
28. Van den Worm J.: Cartographic Visualization Aspects of the web-based Dutch National Risk Map, http://gis.esri.com/library/userconf/proc03/p0802.pdf, (2006)
29. World Standards Cooperation: http://www.iso.org/sites/WSC/wsd.html. available on 3. 01. (2013)
30. Yonahton B., Judith A., Zachary A.: Safari's Encounter with Floods. UN/ISDR AFRICA Educational Series, Vol. 1, Issue 2, March, (2004)

- empty page inserted -

# "Virtual Public Arenas" of Environmental Information and Communication

María Angela Torres Kremers
P.O.B. 20 05 48
Communication Researcher
13515 Berlin, Germany
office@maria-angela-torres.net

**Abstract.** Environmental Observatories are usually Citizens' or Governmental initiatives to make information on environmental aspects continuously available in the Internet and disseminating it. From a communication point of view, particularly from an interactionist one, they become new 'arenas' of the public sphere. That means that actors involved in the generation and dissemination of this information discuss, select, define, frame, dramatize, package and present it to the public. From this point of view these socio-technical and scientific processes that lie behind environmental observatories, can be approach and reflect to understand how did environmental problem definitions arise and which problems and implications emerge in the context of digital environmental information and communication processes related. This paper will feature some of them from the results of an analysis of two samples: the Environmental Observatory of Bogota and the Observatory of the European Environmental Agency.

**Keywords.** Virtual public arenas, Digital Environmental Observatories, Information, Communication

## 1 Introduction

Open Access of data for Awareness and Participation are key concepts addressed in Principle 10 of the Rio Declaration (1992) denoting the need of information concerning the Environment and for what is it needed. The roles of communicators, as those who hold information and can make it available, is addressed in this declaration to the public authorities. For whom? The public, which should be encourage and mobilized towards participation (UN 1992a).

As a working plan, Agenda 21 shows with more details in its Chapter 40 "Information for Decision Making" the scope of this 'Need Situation' of environmental information, referring more exactly the role of Decision Makers and the function of information to meet broader objectives (UN 1992b, 350).

A slight view on the way this dynamic sees lets guess a linear and unidirectional information and communication process, even more a "two step flow of communication" model. It is a typical model with a very narrow view of participation, that -from the point of view of this article- doesn't fit the needs of participation in the Environmental Task, because of the low level of involvement and interaction in these processes.

Dramatic Changes in information and communication dynamics since the last two decades were brought about particularly by the Internet. This has led to the proposal of renewed concepts and practices of public participation and information sharing. Alike, virtual social networks are getting gradually a central position on the definition, formulation and management of environmental problems. Thus, participation became key element of information collection, analysis, and use for decisions and actions.

## 2 The Virtual Arenas

From a symbolic interactionist point of view, social problems are described as products of a process of collective definition, and therefore competing for social attention (Hilgarthner, Bosk, 1988 citing Blumer, 1971). From this view, the relevance that environmental problems gain against other problems in the public sphere is product of a process of collective definition.

Such kind of dynamic occurs particularly in 'public arenas', like the government institutions, the Media, political organizations, NGOs, research community, private foundations, and others. "It is in these institutions that social problems are discussed, selected, defined, framed, dramatized, packaged and presented to the public" (Hilgartner, Bosk. 1988, p. 59).

Internet as Media, in which this and others actors inform and communicate constitutes definitely a 'public arena' in the sense of Hilgartner and Bosk (1988). One may say that environmental social and institutional actors that arise in the digital space of Internet provide 'virtual public arenas', where environmental problems are being discussed, selected, defined, framed, dramatized, packaged and presented to the public. The "symbolic character" of theses interactions in a digital space is emphasize here explicitly.

But in the Internet the concept and reality of the 'public' as the one that passively observed and received information, has changed dramatically and is somewhat diffuse now. The concept of 'Mass Self-communication' (where people build their own system of mass-communication) as proposed by Castells for the networked society, makes clear important features of the type of communication that is generated by individuals involved in the dynamic of the Internet World : (Castells 2009, 55)

a) It can potentially reach a global audience
b) Its production is self generated
c) The potential receivers are self-directed
d) The retrieval of contents is also self-selected.

These features describe from the point of view of the individuals, as so called "ProdUsers" (Produsage.org, 2007), how they can involve themselves and participate in the definition and formulation of environmental problems. From the point of view of the traditional communicators, it describes how much inclusion as well as participation and mobilization opportunities (tools and structures) they offer in online communication sites such as 'virtual arenas'.

| Public Virtual Arenas |
|---|
| Inclusion |
| Participation |
| Mobilization |

To which extend do these new 'virtual arenas' become effective parts of the public sphere, where the formulation and definition of social problems have a broader social impact? As Raupp (2011, 9) concludes referring Beck (2010) and Bohmann (2004, 140), "online communication itself does not generate a network public sphere", and "the internet becomes a public sphere only through agents who engage in reflexive and democratic activity"..

Nevertheless, as Friedland, Hove and Rojas (2006) argue with respect to the communicative power of the networked public sphere, "the new networked media system radically, even exponentially, increases the

possibilities for reflexivity at every level of society" (Friedland, et.al. 2006, 24). And they consider these possibilities "increase with each generation [of society]" (Friedland, et.al. 2006, 24).

Thus in the networked media system arise the following important aspects to discuss about Environmental Observatories as public virtual arenas and its potential in the definition and formulation of environmental problems: Reflexivity, (should we speak of levels of reflexivity? -1 of the internal operators of it and 2. of the contributors), Democratic Activity, Management of Contributions, and Participation.

| ENVIRONMENTAL OBSERVATORIES AS PUBLIC VIRTUAL ARENAS |
|---|
| Reflexivity |
| Democratic Activity |
| Management of Contributions |
| Participation |

## 3 Environmental Observatories as Virtual Arenas

In this study I argue that Environmental Observatories can be seen as 'virtual public arenas' in the sense of Hilgartner and Bosk (1988), in which environmental problems, in the sense of social problems, are being discussed, selected, defined, framed, dramatized, packaged and presented to the public. But it is relevant to make clear as Friedland et.al (2006) did, that digital networks of communication have to be distinguished from social networks.

Descriptions of this kind of environmental communication spaces may not only help to support this point of view, but approach an interface of scientific based information and the communication framed by it. That is communication about the environment, the public involvement in this particular area, the different appropriation forms of this information (that is how the source and its resources lead to construct new knowledge and integrate it in the common schemas), its exchange and in particular cases its improvement through feedback.

| Elements of environmental Communication Space |
|---|
| Communication about the Environment |
| Public Involvement |
| Appropriation Forms of Information |
| Exchange of Information |
| Improvement by Feedback |

The following definition of Manuel José Amaya, from the Environmental Observatory of Bogota highlights the informational function of these "digital arena": "it is a 'virtual space' which enables citizens to know about the environmental situation and the environmental quality in the corresponding region" (OAB, 2012). The definition of the European Environmental Agency about Eye on Earth (EoE), the Environmental Observatory of this regional Agency, stresses the cooperative and creative process: it "is a 'social data website' for creating and sharing environmental information" (EEA, 2011).

Behind the informational, sharing and creative components described in these definitions, there are in the sense of Hilgartner and Bosk (1988) selection, definition, frame, dramatization and discussion processes that may be done in a regular way or not, in formal or informal spaces, to make environmental information available for the public and compete toward its attention.

| Processes in Environmental Observatories |
|---|
| Selection |
| Definition |
| Frame |
| Dramatization |
| Discussion |

Environmental Observatories as 'virtual arenas' may be managed from diverse social actors, like governmental institutions, NGOs, Academic Centres, communities, Guilds and from the private sector. This social actors can be described as Communicators in a traditional communication process.

In the sense of the interactionist point of view, these spaces or institutional environments as 'virtual arenas' of the public sphere became relevant in processes of collective definition of Environmental Problems. They compete for attention not only in the broader scope of Social Problems, but between them, because of the particular qualities of uncertainty of Environmental Issues (data [intrinsic] and effects [extrinsic]).

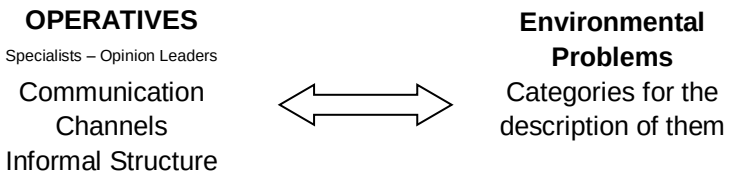
"Feedback among the different arenas is a central characteristic of the process through which social problems are developed" (Hilgartner, Bosk, 1988, 67). As the same authors explain, the complex set of linkages between the arenas foster propagation of their activities throughout the others. This can explain form a different point of view, processes of agenda setting, in which some problems dominates in many arenas of public discourse. The attention and relevance given to problems in public arenas is amplified or dampened as function of the feedback between them.

Critical in this situation is that in controversial areas of sometimes very opposing opinions, like those in environmental problems, "competing groups often struggle to impose definitions of a problem and, hence to influence policy. (...) "Which interpretation of reality comes to dominate public discourse has profound implications for the future of the social problem, for the interest groups involved, and for policy" (Hilgartner, Bosk, 1988, 58). In this case one can imagine the relevance that Environmental Observatories may acquire in the collective definition of Environmental Problems.

### 3.1 The 'Operatives'

In Hilgartner and Bosks view there is another important point related to the "arenas". They stressed the role of "operatives" as the specialists in particular problem areas in the institutional arenas. They form communities centred in these particular problem areas, have communication channels that crisscross the different institutional arenas, through which they scrutinize, influence or stimulate each other. These let describe not only a passive and reactive attention of the operatives in each institutional arena, but also an active one, with powerful synergistic effects. Indeed, they shape an informal organizational structure that ties the arenas of public discourse and correspond to the cultural problem structure represented in the system of categories for describing social problems (Hilgartner and Bosk, 1988, pp 67).

In this sense, 'Operatives' describe the role of the specialists in the collective definition of Environmental Problems. Their communication channels and the informal organizational structure that they shape, let explain how Environmental Problems are described in the cultural problem structure (the categories for describing social problems) of their societies public sphere.




In Environmental Observatories as E-Government efforts to provide information for decision-makers, there are sets of data, compiled scientific and technically, that describe important features of environmental situations. Their information and definition as environmental problems occur in the same virtual arena particularly by their operatives. For example, in Environmental Observatories as technical instances, it is their operatives that define - from a scientific or administrative point of experience, best practice, and view- what levels of contamination are harmful for the average individual). It competes with other environmental problem definitions of other institutional arenas (may be an Environmental NGO or a community) or supports them.

But how does participation of the public, which is stimulated by the use of several interactive tools in the networked public sphere, affects the process of collective definition of Environmental Problems as social problems? To which extend can the externally involved public in this arenas be defined as 'external operatives'? What are the implications, problems and perspectives of such considerations?

## 4 Environmental Observatories Information and Communication

To answer the questions posed in 3.1, Environmental Observatories of Governmental Institutions provide on one side the opportunity to characterize the informational efforts of governments in the sense of the Agenda 21. On the other side, they provide virtual space for the collective definition of Environmental Problems as 'virtual arenas' of the public sphere in which they are imbedded. The range of this space depends on the available tools in it and the way these are networked in the Internet. For example the Environmental Observatory of Bogota provide their users with the possibility of feedback. But there is neither a link to any social media (for example twitter) nor a blog or something in this sense. Actually contributions of the users are controlled and afterwards published or not. In Eye on Earth, there are links to a blog moderated by the EEA and there are links to Facebook, Twitter, You Tube and others. Reasons to these differences are not only in the concept that each institution has of the role of the Observatory, but also on management decisions and last but not least on financial and technological resources.

In a descriptive analysis of these two E-Government Environmental Observatories, the Environmental Observatory of the city of Bogota, Colombia (OAB), and 'Eye on Earth' (EoE) the Environmental Observatory of the European Environmental Agency, two matrices of analysis were developed. Table 1 and 3. The following explains how were they developed.

The first describes the scope of Information available, the other is related to the range of public participation in the sense of WEB 2.0 applications tools.

In the sense of Hilgartner and Bosk (1988),

1. the formal characteristics and contend definition of the information available in the Environmental Observatories, describe how 'operatives' of these arenas select, frame and define Environmental Problems. This aspect allowed to discuss to which extend the public is sufficient and adequately provided with information to be involved in the process of collective definition of Environmental Problems.
2. The patterns of interaction as forms of participation available in these 'virtual arenas' provide initial clarity to which range new 'actors' in the role of external 'operatives' of the Environmental Observatories in this case, are seen as involved in the process of collective definition of Environmental Problems in these 'virtual arenas'.

### 4.1 Information and Open Access

Form and content of Information are the broad categories used to describe initially what is available and in which format is this provide in the Websites of these two Observatories. Table 1. below shows:

a) The range of Themes as content accessible in each of the cases

b) The range in which Environment is framed and defined

c) The form in which Data and Information are made available

To which extent are these sets of available Information sufficient to define, understand, reflex, discuss and act around environmental problems? An answer to this question requires to consider aspects related to the information and communication goals of the main actors, the'operatives', their Institutions or Organisations as well as the goals of 'the public'. The Royal Society describes this central aspect: "openness to the public must be audience-sensitive" (Royal Society, 2012, 39).

The general goal of communication actors is to reach a level of mutual understanding, rapport. The socio-technical interaction before and after information is made available is of relevance in all phases of the process. But there is a special goal in communication processes. It is what actors, pursue particularly: to make aware, to promote action, to mobilize people, to improve processes of decision making, etc. Situations, contexts, action, as well as distinguishing social actors with different intensions and interests, are key aspects here, particularly when information is to support decision makers.

**Table 1** Form and Content of Environmental Information in the two Observatories, OAB and EEA

| CATE-GORIES | | **OAB** (Environmental Observatory of Bogotá in Spanisch, OAB) | **EEA** (European Environmental Agency) | |
|---|---|---|---|---|
| | | | **EEA** | **EoE** (Eye on Earth) |
| **Form** | Alfanumeric Data Data as Graphics, Special Distributions, Statistical Analysis (interactive) | X | X | 3 Watches |
| | Georeferenced (maps and interactive maps) | X | X | Watches |
| | Analysed information: Documents, Articles, Publications | Only related to Localities | X | 0 |
| | Multimedia | Only related to News, Events | X | 0 |
| | News Service | X | X | 0 |
| | *Watches* | 0 | 0 | X |
| **Content** | The Resources | Water, Air, Soil (Public Spaces), Fauna, Green Zones/Trees | | Water Watch<br>Air Watch<br>Noise Watch<br>**Nature Watch*** |
| | Themes | Control Env. Quality, Ecosystems, Env. Education and Part. Corp.Env. Management, Sustainable Mobility, Planification and Ecourbanism, Rurality<br>**Special: Health in the City*** | What? Env. Issues*<br>Why? Sectors + Activities<br>Where? (only coasts, seas, specific regions, urban environment)<br>Across Issues + Sectors | |
| | Georeferenced | City/ Local | X | Interactive |
| | Environmental Indicators | 436 | 231 (depends on each Topic) | |
| | | | * Air Pollution, Biodiversity, Climate Change, Env.+Health, Land use, Natural Ressourses, Noise, Soil, Waste, and Material Resources, Water, Various others. | *Invasive Species in Europe |

Note: Env.= Environment/tal;
*Watches:* Name of the interactive tools for users to observe and value themselves, depending on the way these allows it.

**Open Access.** As the Royal Society expresses the disclosure of data "requires a *more intelligent openness*, one where data are effectively communicated".(Royal Society, 2012, 14). Four 'fundamental requirements' need data to fulfil to be effective: (Royal Society, 2012, pp14)

| Fundamental Requirements of Data to be Effective |
|---|
| **Accessible**<br>(readily to be found) |
| **Intelligible**<br>(that others understand it. Takes care of what the different users need) |
| **Assessable**<br>(Allows its assessment or judgment from the public) |
| **Usable**<br>(it should be able to be use and reuse) |

**Information Structure**: Other key aspects that must be considered, particularly when targeting different levels of "social actors" and "decision makers", are related to the information structure. Data and information have to make sense in a complex of Situation –Context –Action. As Kremers' 'Primary Components of Full Information Models' in Table 2 (below) specifies, the 'pragmatic component' of information available supports the potential action alternatives in a Multilevel Decision environment.

**Table 2**. Primary Components / Semiotic Structure of Full Information Models (Kremers, 2005, 11)

| Facts and Contexts | Communication | Cooperation |
|---|---|---|
| **Structure** | **Interaction** | **Behaviour** |
| **Syntax** | **Semantics** | **Pragmatics** |

In risk situations the pragmatic component of information and data sets became a high relevant component. Risk situations and contexts of action have to be reflected in order to provide information for alternative actions. Of course, not all information and communication process is intended to lead to action. But as we refer above, there is always a purpose.

### 4.2 Participation and WEB 2.0 principles

As stated above, Castells concept of 'Mass Self-Communication' refers to decisionmaking as well as to action patterns of individuals in the networked society. This kind of communication involves these actors in the process of generation and production of information and communication. The corresponding patterns of interaction as forms of participation in the observatories provide clearness with regard to the extent to which the public or audiences of these environmental digital media can be considered also as 'external operatives' in the process of problem definition.

In this paper participation is understood in a very broad view, in the sense of ways to influence problems definitions as well as decision processes and this view comprehends:

a) The right to be informed

b) The right to share (and produce) information

c) The right to hear and see it

Table Nr. 3 shows a scope of aspects related to participation that were analysed in the two Observatories under investigation in this study. They serve as examples for the reflection on their social role. These also show communication as interaction patterns in a digital or virtual arena, that may be related with those typical to characterize features and factors of communication actions. , and are:

- Involvement: formal (regular and with intended effects; informal, not regular, may have influence.
- Restrictions: scope or limits in the definition of themes, topics, issues, as well as Target-Groups of information, information sets made available but for particular groups, Intranets or registered, etc.
- Levels of interactivity: high, middle or low alternatives to interact in information production or publication / dissemination.
- Feedback: which can be previously structured by the 'operatives' of the institutional arena or not.
- Filters: as moderators or not in the interaction spaces (like Gatekeepers).
- Flow of Communication: oneway, two-way, multiple sources and ways of communication (symmetric or asymmetric), Two Step Flow.
- Tools and applications: the corresponding technical virtual 'object' that realizes the above features of interaction and communication in these 'virtual arenas'.

**Table 3.** Citizens Participation in Environmental Observatories

| | CITIZENS PARTICIPATION IN ENVIRONMENTAL OBSERVATORIES | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Participation as involvement in information generation** | **Participation - Scope / Limits** | **Interactivity in the Information Production and Publication** | **Feedback Previuously structured** | **Filter** | **Flow of Communication** | **Tools and Applications** |
| **PARTICIPATION** AS A RIGHT TO BE INFORMED, TO SHARE (and produce) INFORMATION AND THE HEARING RIGHT, ALL TOGETHER AS WAYS TO INFLUENCE DECISION PROCESSES. (From the institutional level: Delegation and participation of power) | Informal involvement, (not regular - may have influence) | No restrictions | High Level | Not Structured | No | Multiple sources *Decision on ProdUser) | Web 2.0 (Facebook, Twitter, YouTube *ArcGis) |
| | | Theme and Target-Group restriction | Middle Level | Not Structured | Moderated | One / multiple source(s), Two-Step Flow and multiple ways | Blog, Forum |
| | | Theme restriction | | Semi – Structured | Moderated | Multiple Sources, Two-Step * Multiple Ways | Ratings, Comments |
| | | Target Group restriction | Low Level | | Moderated | Two-way, one step | Chat, Email (inquieries and comments). |
| | Formal Involvement | Theme and Group Restriction | High Level | Structured | Moderated | Two-Step-Flow* / Two-way | Given by researchers |
| | | Theme restriction | | Structured | Mediated | Multiple Sources, One-way | Smartphones appl. |
| | Informal . Right to be Informed | Theme, space limit, Target Group restrictions | No | No feedback possible | X | One-way | Just Given Information |

In this paper we propose that the more participation there is, the more involvement there is from the public and therefore the emergence of 'external operatives' increases correspondingly. Depending on the applications and tools available, participation in the definition of the Environment 'informed' in it and in the social definition of environmental problems is not only enabled but also discussed, framed, dramatized, packaged and presented to others public virtual arenas (also to different Observatories) of the networked public sphere.

### 4.2.1 WEB 2.0.

The principles of the WEB 2.0 concept of Tim O'Reilly are important in this context. They describe the way "self mass communication" is possible with the latest technological communication improvements. O'Reilly used the term " 'the architecture of participation', to explain the nature of systems that are designed for user contribution" (O'Reilly 2004). He pictured these systems from the perspective of the developers, and acknowledges that the web, "took the idea of participation to a new level, because it opened that participation not just to software developers but to all users of the system" (O'Reilly 2004).

From the point of view of this study only some of the WEB 2.0 principles referred to by O`Reilly are relevant: These principles are directly associated with: a) communication as sharing of meaning, b) communication between two or more users, c) not one-way communication. Further, these principles are associated with tools and applications that "support and strengthen the practices of autonomy, including user-produced content"(Castells 2009, 129).

The following principles and its appropriate tools will be evaluated as components implemented in the public observation systems investigated in this study:

1. The Web as a platform: Information is accessible in many ways and formats, as a service. The system works as "an enabler between the user and his or her online experience" (O'Reilly, 2005) In practice this means a) searching, b) finding, c) accessing and d) transmission of data in different modes or formats required by citizens.

2. Harnessing Collective Intelligence: The collaborative principle is implemented but principally with the collaboration of the users interactions by means of hyperlinks, tags, bookmarks and also through their possibility of contributing to content creation (adding, editing, etc.), Wikis.

3. Blogging and the Wisdom of Crowd: The knowledge and links of users become information that is made accessible and helpful for others. Here the practical component addressed are Blogs (also as Forums), RSS, Twitter, Facebook, YouTube and Flickr and others, or their corresponding protocols of communication.

These principles refer to the most well-known tools and applications accessible in Internet Information Services that support citizenship participation and collaboration.

### 4.2.2. ProdUsage.

The character of the collaborative component that is implied in the interactions enabled by some of the tools and applications in the Internet can be better understood in relation with the typical market point of view: "ProdUsers engage not in a traditional form of content production, but are instead involved in *produsage* – the collaborative and continuous building and extending of existing content in pursuit of further improvement" (ProdUsage, 2007) As the authors of the concept of ProdUsage argue about the information economy, there are no more distinctions between producers and consumers. The 'products' are no longer "discrete complete packages", and they actually are not "producing" because their interactions are based on

preconditions and principles that don't have anything to do with the typical industrial model. (ProdUsage, 2007a). The passive audience, or passive consumer, no longer exists in the Web. Some are more interested on their issues, but "some of them [are] participating more strongly in ways which are inherently constructive and productive of social networks and communal content." (ProdUsage, 2007a). Examples of this kind of participation or interaction are also available in the *Watches* of the Observatory of the European Environmental Agency, Eye on Earth. ProdUsage has preconditions:

| Pre-conditions of ProdUsage |
|---|
| Probabilistic not directed |
| Problem solving |
| Equipotentiality not hierarchy |
| Granular not composite |
| Shared not owned |

In: ProdUsage, 2007

#### 4.2.3 Citizens Science:

As the Royal Society describes, "there is a small, but increasingly numerous body of engaged "citizen scientists" that wish to dig deeply into de scientific data relating a particular issue. They are increasingly powerful 'digital voice'" (Royal Society, 2012, 39). There are many examples of this kind of involvement and participation in the construction and definition of our Environment and Environmental Problems. In the analysed Observatories, the approach to such a kind of digitally public involvement in the "arena" is in the 'Nature *Watch*' in Eye on Earth, where citizens collaborate in the observation of invasive species in the region.

## 5 Further Questions, Problems and Perspectives

In chapters 3 and 4 we depicted a broad view of the role of Environmental Observatories as "virtual arenas" in the public sphere. From an interactionist view some qualities were explained that 'interactions' of 'ProdUsers' may have in the Internet. This was done based on a previous analysis of two cases of virtual spaces about the environment. Their particular condition was its governmental origin, defined by the principles of E-Government Open Access efforts in the sense of the information and participation incitements and challenges expressed in the Principle 10 of the Rio Declaration and the Cap. 40 of Agenda 21 as well as in the strategic principles of E-Government declared by the European Union.

Nevertheless there is a need to research and develop further evaluation instruments that let assess the range to which the challenge of participation and its increasingly information need is being met not only by the governmental institutions, but by the NGOs, private economical sectors, academics, scientific organisations, as well as by ad-hoc communities. There is a particular need to investigate these conditions in developing and emerging countries, e.g. in Latin America. The Internet access there is not so broadly developed as in industrialized countries, but as the report of 'Big Data' from the United Nations expected, the growing rate of usage of these technological instruments is growing comparatively faster than in other regions.

In this broad point of view of "virtual arenas" that observes situations, contexts, social actors as 'operatives', their networks of interactions and the patterns of interactions, there are further questions and aspects to study:

- The problems of restrictions and carrying capacities of the public social institutions in the sense of Hilgartner and Bosk, (1988) and particularly in the virtual environment of the networked public sphere. The institutional arenas as well as their 'operatives' have a capacity to manage a scope of themes, because of different conditions and their working contexts. How does the public as ProdUser in networked arenas realize to manage his own information necessities?
- There is also the problem of making available adequate information, what is the carrying capacity of the different groups involved: institutional arenas and the ProdUsers?
- Is there a need to reconcile, distinguish or supplement the five preconditions of ProdUsage with market points of view, but also with science as well as R&D principles of work? The addressed problem is that of higher participation levels in relation to the reliability (trustworthyness, administratively collected vs. privately collected) and accuracy of data.
- In the sense of the interactionist point of view: how can participation and collaboration be promoted with fewer limits and restrictions (those typical in digital information systems) to enrich information sets, and at the same time assure/improve the use quality of information?
- And last but not least, how to manage and reflect on apparent or real differences of the interactionist point of view of collective definition of Social Problems with the Scientific Principles of Work? Further, is it possible to explain the role of other forms of knowledge different to the scientific one in the collective construction of ours views of the Environment? Citizens Science is one approach, but with scientific orientation and restrictions. The open research approach of Nunaliit, an open access atlas framework developed in the Carleton University, Otawa Canada is a good example of what is ment with this question: an indigenous mapping and knowledge research project that enables to tell stories and highlight relationships between different forms of information from different sources (GCRC, 2012).

**BIBLIOGRAPHY**

1. Castells, Manuel (2009): Communication Power. Oxford University Press.
2. Friedland, Lewis A., Hove Thomas, Rojas Hernando. (2006): The Networked Public Sphere. In Javnost. The public. Vol 13 (2006), No. 4, pp 5-26..
3. European Environmental Agency, EEA (2011): Eye on Earth Watches.. EEA Briefing. September 2011.
4. GCRC (2012). Nunaliit Atlas Framework. In: http://nunaliit.org/
5. Glathe, Caroline (2010). Kommunikation und Nachhaltigkeit in Fernsehen und Web 2.0.
6. Hilgartner, Stepthen. Bosk, Charles L. (1988): Rise and Fall of Social Problems: A Public Arenas Model. In The American Journal of Sociology, Vol 94, No. 1 (Jul., 1988), 53-78.
7. Kremers, Horst (2005). Generalization and Semiotics: The Way to Consistent Multilevel Decisions. In: Diskussionsbeiträge zur Kartosemiotik und zur Theorie der Kartographie. Vol.8 (2005) pp. 7-13.
8. Observatorio Ambiental de Bogota, OAB (2009): Personal Communication of Manuel José Amaya, Environmental Agency of Bogota. http://oab.ambientebogota.gov.co/sobreelobservatorio.shtml (26.06.2012).
9. O'Reilly, Tim (2004): The Architecture of Participation. O?Reilly Network. http://www.oreillynet.com/lpt/a/5994 (26.06.2012).
10. ProdUsage. Org (2007): ProdUsage: A working Definition. In: http://produsage.org (02.01.2013).

Produsage. Org (2007a). Key principles. In http://produsage.org (02.01.2013).

11. Raupp, Juliana (2011). Organizational Communication in a Networked Public Sphere. In SCM. Studies in Communication on Media. In (http://www.scm.nomos,de/index.php?id=3119&L=1 ) (12.10.2012)
12. The Royal Society (2012). Science as an open enterprise. The Royal Society Science Policy Centre report 02/2012.
13. United Nations (1992a): The Rio Declaration on Environment and Development.
14. United Nations (1992b): Earth Summit Agenda 21 The United Nations Programme of Rio.
15. World Economic Forum (2012). Big Data, Big Impact. New Possibilities for International Development.

- empty page inserted -

# Why weren't people warned? Assessing Pre-Crisis Media Coverage Using Principles of Effective Risk Communication

Patricia M. Kennedy, J.D., Ph.D.

Associate Professor, Department of Communication Studies, 321 Monroe Hall,
East Stroudsburg University of Pennsylvania,
East Stroudsburg, PA USA 18301; E:
pkennedy@esu.edu

## Abstract

This paper reviews findings from decades of risk communication research to show the development of a concept termed "risk-alerting" information. The paper then describes the concept's application to media coverage of a single crisis case -- the tragic contamination of the public water supply in Walkerton, Ontario, Canada in May 2000 by a lethal strain of E. Coli bacteria from agricultural run-off. In spite of post-crisis claims that the contamination was "preventable and predictable," quantitative analyses of local, regional, national and international newspaper content revealed very little pre-crisis coverage likely to alert relevant publics to systemic interactions of environmental, public health and politically created threats to water safety. By contrast, voluminous post-crisis coverage emphasized and detailed not only the transboundary and interdisciplinary nature of the hazards, but the probability of harm to clearly defined target groups. The author applies a multi-factored model for increasing the effectiveness of risk communications.

**Keywords:** risk communication, risk-alerting information, environmental risk, public health risk, politically created risk, Canadian crisis case.

## 1 Introduction

More than one scholar has suggested that, as the offspring of those with reflexes fast enough to avoid, for example, being eaten by saber-toothed tigers, we experience a reflexive fixation on "events" as part of our evolutionary surveillance "hard-wiring." [1, p. 21, 2, 3] Theoretician Peter Senge, who writes about systems thinking and learning organizations, additionally suggests such reflexive attention to fast-moving events may have become a dysfunctional trait because the nature of the threats we currently face has changed – with many of the most serious of the slow-moving, systemic variety, where cause is likely to be very distant in time and space from effect, and where cause and effect are complicated by other intervening, slow-moving relationships that are "too large" (or too small) for us to directly experience or to "see" without explicit retraining. [1, pp. 22-24]. Recent extremes and changes in climate and the rapid, transboundary and international spread of dangerous viruses and bacteria not only confirm this thinking, but also point to the difficulty of predicting the likelihood of harm from gradually changing environmental conditions and from accidental, unplanned and/or unanticipated consequences of technological "advances" -- many of which are "unprecedented in terms of spatial and temporal reach, their potential catastrophic effects and their invisibility". [4, p. 8] The magnitude, invisibility and potential interactive impacts of such environmental, technological, and biological systems have made the process of searching the known to make sense of and protect against the dangers of the unknown more difficult, especially for the individual. [1, p. 22, 5, pp. 5-10]

Consider, for example, the unintended consequences of technological advances in transportation exemplified by just two transboundary instances of disease transmission -- that of Sudden Acute Respiratory Syndrome (SARS) from China in 2003 and that of *E. Coli* 0104:H4 from Germany in 2011. According to the World Health Organization, contaminated, but largely symptom-free individuals carried SARS thousands of miles in a few hours from China to more than 25 other countries infecting others along the way and on arrival with this invisible, contagious, and potentially deadly "bug." [6] During the outbreak in Germany, the virulent bacterium, reportedly carried on bean sprouts and seeds, infected nearly 4000 people in 16 countries and killed 49. [7] It is the thesis of this paper that when dealing with modern complex, transboundary risks such as these, it is increasingly important for communicators to share, as is occurring at this conference, what is being learned about when, where and how best to provide "risk alerting" information – that is, information most likely warn potentially impacted individuals to "watch out!"

This paper focuses primarily this question: RQ1) What factors have been found most effective to successful risk communications? Then, to limited extent, the paper reports on this question: RQ2 In what ways did pre-crisis and post-crisis media coverage of a single crisis case – the Walkerton, Ontario, Canada *E. Coli* contamination of May, 2000 – display the factors identified as most likely to result in effective risk communication? [1]

## 2 Literature Review

Research in the many disciplines interested in risk communication reveals an absence of uniform agreement on the definitions of many common terms. Among these are some many would consider essential: *risk communication, risk, risk assessment and management.* As part of this review, the author proposes the adoption of common definitions. In addition, a constructed term, *risk alerting information,* will feature in the study reported here.

### 2.1 Risk, risk perception, risk judgment

Astonishingly, there is little consensus on the meaning of "risk." Even when the search for conceptual consistency is limited to studies where, as in this paper, risk is examined primarily in a media context, lack of agreement on when a story or communication is "about risk" is hypothesized as a variable leading to "diverse conclusions" that have "hampered coherent theoretical development in the fields of media and of risk." [8, p. 57] The author proposes that a definition of "risk" should integrate elements offered by several recognized experts in risk-related fields [9, p.4], and be considered to mean *an organization or individual's technical and cultural assessment of the probability that variations in exposure to a specific hazard will result in negative consequences of varying severity to identifiable individuals or groups.*[2]

In discussing risk some scholars argue that the term risk *perception* should be replaced with risk *judgment* -- as a way of emphasizing not only that active information processing is involved, [10-13] but also that understandings (or judgments) about risk are the outcomes of social, cultural and psychological influences that are both long-term and complex. [see 14, 15] Information processing refers to the "amount of attention paid to a message that one happens to encounter" [16, p. 190]. In decades of study of risk perception/judgment several key areas of general agreement have emerged, these five "bottom line" propositions have been summarized as follows: *Risk means different things to different people; people tend to ignore or discount discrete, familiar, voluntary, and low probability risks; feelings of control and opportunities for participation tend to make risk more acceptable; people evaluate risk as members of a community; and, trust is an important influence on risk perception.* [17, p. 173]

### 2.2 Risk communication

Although risk communication has been broadly described as "any public or private communication that informs individuals about the existence, nature, form, severity, or acceptability of risks" [18], early risk communication efforts were largely "top-down, one-way communication(s) that attempt(ed) to bring public beliefs into line with expert views." [19] Underlying such unidirectional processes has been a patronizing assumption -- *if we just tell them what we know, they'll agree with us.* One-way efforts to communicate risk -- except under conditions of immediate and dire threat -- are generally considered destined for failure. [20, 21], [22, p. 301] Modern public relations theory portrays risk communication as "an interactive process of exchange of information and opinion among individuals, groups and institutions" that "involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions and reactions to risk messages or to legal and institutional arrangements for risk management." [23, p. 21] Although some still consider it "heretical to assert that industry, government, activist groups, and the media (the principal risk communicators) should perhaps talk less and listen more" [24], a definition that promotes risk communication as a partnership, has been applauded by many scholars [see 25, p. 343], [see 26], with some describing the partnership stage of risk communication as indicative of a "new level of maturity." [18, p. 169] The author proposes "risk communication" be understood to mean:

[1] The content analysis described for this paper is small portion of a larger multiple-method case study.

[2] The hazards of interest in this study are those environmental conditions, bacteriological threats to public health, and political risk assessment and risk management decisions the Walkerton Inquiry Commissioner and post-crisis news coverage identified as causally related to the contamination, and briefly described in Section 3 and 4.1 of this paper. A detailed list will be provided upon request.

*Traditionally, any public or private communication that informs individuals about the existence, nature, form, severity, or acceptability of risks. Increasingly, an interactive process of exchange of information and opinion among individuals, groups and institutions which involves multiple messages about the nature of risk and other messages, not strictly about risk, that express concerns, opinions and reactions to risk messages or to legal and institutional arrangements for risk assessment or risk management.*

### 2.3 Risk assessment, analysis and management

In lay parlance, "assessing the risks" generally refers to intuitive "guestimates" of probability and severity of harm, and, as noted above, risk assessment may be used as a synonym for "risk perception" and/or "risk judgment" [10, 11]. Risk *assessment* has been described as "a scientific process that characterizes a risk and assesses the probability of occurrence and outcomes." [27, p. 6] It is also referred to as numerical calculation based on estimates of a hazard's potential to produce adverse effects on humans, animals, plants, or other environmental or public health resources at varying levels of exposure. [28, p. 18] Uncertainty plays in the process, since "by its very nature" any risk *assessment* requires "scientific inference to bridge the gaps because, to reach conclusions in the face of incomplete information, we have to make the best judgments we can come up with." [29, p. 169]

Risk *management,* which generally begins (or ought to begin) with some level of risk assessment or analysis, has been described as a "political, value-based process of deciding when, how and to what degree to control or reduce health and environmental harm." [17, p. 171] Some, however, charge that many analyses relied on for making risk management decisions are "atheoretical, ad hoc" and "hit or miss" responses that treat each disaster as unique [30, pp. 253-254]. Although there is systemic variation, the procedures by which risk management decisions are made often require public hearings where a non-expert's tendency to define risk "with a broader set of dimensions than the set used by experts" makes conflicts over "definitional issues regarding risk and the relative value of economic, health and environmental outcomes" visible [31, p. 120] in ways and places likely to attract media attention. [32]

Differences or uncertainty in answers to scientific and economic questions, as well as prior beliefs and values, "can manifest their influence through the initial framing and conceptualization of a risk problem." [31, p. 121] Judgments of risk are rarely limited to assessments of physical processes, more frequently responding to social, cultural and psychological influences. [33, p. 76] Some argue that conflicts over how risks will be managed are rarely mere "debates about risk statistics," and "may not even be about risks." [15, p. 231] When risk concerns are a "surrogate for other social or ideological concerns" or are used to "provide a rationale for actions taken on other grounds," communication about risk is simply irrelevant to the discussion" (p. 231).

The author proposes that definitions of risk *assessment* and risk *management* take these debates into account. When applied to experts, risk *assessment* should be seen as *numerical calculations based on estimates of a hazard's potential to produce adverse effects on humans, animals, plants, or other environmental or public health resources at on varying levels of exposure -- where it can be determined, the probability times the severity of harm.* When applied to non-experts, risk *assessment* should be considered *synonymous with risk perception and/or risk judgment.*

Risk *management* should be treated as: *a value-based process that is often, but not exclusively political, for deciding when, how and to what degree to control or reduce potential health and environmental harms.*

### 2.4 What constitutes a successful risk communication outcome?

Perhaps the most important challenge to assessing the likelihood communications will effectively convey the nature of a hazard and the probability of its harm to the intended population is the absence of agreement on what constitutes a successful outcome. At a national (U.S.) symposium on risk communication, the professional communicators assembled were asked to consider this dilemma; should the goal of risk communication be "an informed citizenry, a compliant citizenry, an *alert* citizenry, or an empowered citizenry," or "better decisions, fairer decisions, more consistent decisions, or, in the throes of environmental gridlock, any decisions at all?" [34] Some consider a risk communication successful "only to the extent that it *raises* the level of understanding of relevant issues or actions and *satisfies* those involved that they are adequately informed within the limits of available knowledge." [23, p. 21] Although many agree that risk communications should at minimum be educational, especially on issues of public health where individualized precautionary measures may be needed [35-38], others see risk communications as essential to fostering democracy, empowering public participation [34, 36, 39-43], and improving the quality of political decision-making. [39, 41-51]

In summary, then, depending on specific goals of the risk communicator, risk communications may be considered successful to the extent that they: 1) identify unknown/difficult/controversial risk aspects, 2) advance or change knowledge and attitudes regarding hazards and risk-taking, 3) modify the risk-related behaviors of people exposed to hazards, 4) promote community participation in hazard mitigation, 5) facilitate cooperation and joint conflict resolution regarding controversial risks, and 6) develop disaster preparedness and emergency management. [52, p. 2, Table 1]

### 2.5 Risk-alerting information (RAI)

A concept central to the content analysis described in this paper is "risk-alerting" information. Communications are considered to contain risk-alerting information when …

> *The communication would be recognized by the receivers as an alert, that is, of an increased need for watchfulness to the possibility of harmful exposure to an identifiable hazard -- before the harm occurred to them or someone they cared about. Risk-alerting information is the kind that warns reasonably prudent persons that additional information seeking may be needed to assess the degree to which a situation presents dangers or risks requiring watchfulness, vigilance, behavioral change or protection of some sort.*

#### 2.6.1 Focusing on message and receiver

Although there are many factors with potential relevance to different goals of risk communication, for the purposes of this content analysis, those focused on *message* characteristics and those focused on *receiver* characteristics are reviewed.

#### 2.6.1.a. Exposure via channel

A necessary (but not sufficient) element of the risk communication process is that the risk message reach the receiver. A risk message is more likely be received when it is delivered through mediated or interpersonal channels that members of a target population depend on or attend to for information of types contained in the message. [see 53, 54-59, 60, pp. 262-262, 61, pp. 374-375] Media dependency theory posits that individuals will rely more on various media as society becomes more complex. [62] From the perspective of the message sender, the more channels that are used to convey a risk message, the more likely it is to reach the target. [61]

#### 2.6.1.b. Frequency

Risk messages have more impact when they are delivered frequently and in volume. [see 20, p. 241, 27, p. 84, 63-65] Not only has it been established that repetition makes messages more easily accessible from memory [66, 67]; [68], but agenda-setting studies identify frequency and volume as factors that tend to move risk-related topics higher in importance on both public and government agendas. [see 69, 70, 71]

Some argue that it is the amount of coverage, not its substance or format, that increases the public's perception of some hazards as risky -- even more risky than experts have assessed or than the media have reported [72, ¶ 8]. The generally low attention paid to the details of media stories leaves audience members with impressions formed from scanning headlines, photographs and images, captions and the beginning of stories, a process that results in an "availability heuristic" providing a mental shortcut to enhanced perceptions of risk (¶ 8). "As quantity declines," says Mazur, "so do audience worries" (¶ 8).

Studies of "schema" theory also suggest that frequent exposure to information about a risk or various aspects of that risk may increase audience members' ability to recall information about the risk and infer additional information about it. For example, in an experiment that tested recall and inference after exposure to either consistent or inconsistent information on forest fires (good or bad for the environment) and population growth (good or bad for society), researchers reported two different significant impacts: subjects receiving consistent information were most willing to apply the facts learned about one risk to another somewhat related risk, while those receiving inconsistent information demonstrated better factual recall. [73, p. 156]

#### 2.6.1.c. Recency

It long been recognized that the more recently an individual is "primed" with categorical information, the more likely it is that a cognitive connection will be made between the priming information and subsequently encountered stimuli [68]. Priming has been described as the process by which the "presentation of one stimulus, or prime, alters subjects' perceptions of a second target stimulus," [74, p. 725] and a process

of "activating an association between an item highlighted in a framed[3] text and an audience's thinking about a related concept." [67, p. 27] Unless the priming content is personally or culturally resonant [67, p. 6], the more time that passes between the prime and the presentation of related stimuli, the less likely it is that the prime will impose cognitions onto the subsequent information. [68, p. 68] However, when priming engages emotional responses, it can shape not only perceptions of an abstract future, but also perceptions of a past that differ from what actually occurred. [75]

**2.6.1.d. Framing**

Once characterized as a "niche method," framing is once again emerging as a topic of controversial scholarly interest. [76, ¶. 3, citing numerous others, 77]. Scholars treat framing in conceptually different and sometimes incompatible ways [76, 78, 79]. These differences focus most sharply on the degree to which the term "frame" (or "framing") should be considered "an unconsciously used conceptual scaffold," as opposed to a "consciously adopted" interpretation of culturally accepted or disputed social reality [76, ¶¶. 5-8]. While granting that framing "has been vulnerable to criticism as an imprecise catchall that means slightly different things to each researcher employing it," [80, p. 5], a standard definition of framing has been proposed, to wit: *selecting and highlighting some facets of events or issues, and making connections between them so as to promote a particular interpretation, evaluation, and/or solution*" (p. 5)

A critique of disparate theoretical and methodological approaches to framing research, provides what the author considers to be "shared assumptions" on framing: 1) that frames are "patterns of interpretations through which people classify information in order to handle it efficiently, 2) that "framing emphasizes specific aspects of reality," and, 3) that "specific attributions, evaluations or decisions are assigned to recipients." [79, p. 402] "Schema" and "script" were described as sometimes used interchangeably with frame (pp. 403-404).

Framing matters in risk communication because individuals may be *less* likely to interpret risk information in a personally alerting manner, *less* equipped to engage in political deliberation regarding risks, *less* likely to recognize or understand the underlying causes of problems, and *more* likely to place responsibility for the creation of potential harms on the actions of other individuals, when a risk story has been framed *procedurally* (i.e., in an event-oriented manner) rather than *substantively* (i.e., in ways that define effects or conditions as problematic, identify causes, convey moral judgments, or endorse remedies or solutions. [67] Others have used slightly different descriptors, but with similar meanings, *episodic* (event-oriented) and *thematic* (issue-oriented). [81], [82] *Episodically* framed coverage focuses on specific events; *thematically* framed coverage is broader in scope, including policy debates, historical background, or consequences connected with various actions (p. 371). More specifically, news stories are considered to have an episodic frame when they depict "public issues in terms of concrete instances or specific events -- a homeless person, an unemployed worker, a victim of racial discrimination, the bombing of an airliner, an attempted murder." [82, p. 369] In contrast, news stories are considered to have a thematic frame when public issues, even if spurred by some current event, are placed "in some general or abstract context" such as, reports on reductions in government welfare expenditures, changes in the nature of employment opportunities, the social or political grievances of groups undertaking terrorist activity, changes in affirmative action policy, or the backlog in the criminal justice system (p. 369).

Media routines and practices, sadly, make it more likely that risk information will be framed episodically (or procedurally), rather than thematically (or substantively). Audiences exposed to episodically or substantively framed risk coverage will be *less* likely to interpret risk information in a personally alerting manner, *less* equipped to engage in political deliberation regarding risks, *less* likely to recognize or understand the underlying causes of problems, and *more* likely to place responsibility for the creation of potential harms on the actions of individuals, rather than a political, social or cultural system.

**2.6.1.e. Perceived relevance.**

While there appears to be substantial agreement that the meanings individuals draw from risk messages are most strongly influenced by the perceived relevance of those messages, the determinants of perceived relevance are not fully understood [20, p. 196]. In support of this claim, in addition to reference to relevant studies, Slovic offers a hypothetical example particularly apt to this study: "What a resident of the West Coast" infers about her own "risk from cancer from polluted groundwater upon receiving risk estimates for

[3] Definitions of framing and recent relevant theoretical perspectives are discussed in the section below.

residents of the East Coast" is unclear [20, p. 195].

Recent research, however, provides some guidance on the kinds of information people say they need in order to determine the relevance of a new risk. For example, researchers found most participants in their study of responses to previously unknown risks did not want to be "bothered too much with information about risks and spend their time worrying about them" unless "it was really necessary" [83, p. 772] -- in other words, unless high levels of personal relevance could be established. To evaluate whether the risk was personally relevant, these participants said they were most interested in knowing how exposure takes place, what the risk means, how severe the consequences of the risk might be, what the probability was that exposure would occur, whether there was anything they could personally do to avoid or mitigate risk, and, if a risk could not personally controlled, what official agencies could do or were doing to reduce the risk. [83, pp. 769-773]

Not only do people need substantive knowledge of what a hazard is and how it works to fill gaps in their understanding and determine its relevance [84], they also need a conceptual framework to organize facts in a risk story. [85] People consider risk messages more effective when they provide accurate, contextual information [see 27, 38, 63, 84-86], and when the causes of a hazard are described clearly. [see 87, 88, 89].

Although the temporal relationship between perceptions of personal relevance, problem recognition, and personal or professional involvement appear unclear [90], there seems little doubt that they are closely intertwined.

**2.6.1.f. Involvement.**

Involvement, defined as "the extent to which a person perceives a connection between himself (sic) and a situation" [91, p. 11], is a recognized predictor of whether a person is more likely to passively process information or actively seek it. Research suggests that "A person purposely seeks information that has utility for him (sic) in deciding what to do in a situation. The information seeking occurs when the perceived level of involvement is high. In contrast, a person does not look for and generally does not need information he (sic) processes. He (sic) may take it in, however, as a means of passing time -- such as reading a magazine while waiting for an appointment or watching television when there is nothing else to do." [91, p. 11]

When the message recipient's level of involvement is high, risk messages have been found to increase knowledge, information processing, understanding and willingness to engage in additional risk information seeking behaviors [25, 91-97]. A few examples --Those who were more actively interested in an environmental issue ("hot issue publics") knew more about such issues and were more likely to engage in active information seeking. [91] Participants in focus groups presented with hypothetical news stories about terrorist threats to food were more likely to recognize risks and pay more attention to information about them when levels of perceived involvement increased [98]. Perceived involvement increased when risks were viewed as geographically close, threatening to someone with similar racial or socio-economic characteristics, or someone with similar behavioral patterns that increased vulnerability to the hazard. These findings clarify the importance of including features in risk messages that increase "social identification" -- that is, the "process in which people come to feel that other human beings are much 'the same' as they are."[99] Participants in one study were more likely to perceive heightened risk from tick bites when the risk communications showed victims with racial characteristics similar to the participants.[96] In another study, young female participants who read hypothetical news stories about the risks of carjacking were more likely than males who read the same stories to experience increased levels of concern, a finding that suggested women -- perhaps, perceiving themselves more likely to be victims of such events -- became more psychologically involved. [97]

**2.6.1.g. Proximity.**

Messages that describe nearby risks tend to raise awareness, increase understanding and recall as well as information seeking behavior [93, 98, 100, 101].

**2.6.1.h. Severity.**

Even if a potential harm is of low probability, people are more likely to pay attention to information about it when they believe the probability of specific harm is high. [see 95, 102, 103, 104] When the likely victims of a hazard are children or future generations, and the probable harms inspire great fear, are irreversible, or are severe, people are more likely to pay attention. [20]

**2.6.1.i. Source credibility.**

Risk messages are more effective when they come from sources considered credible by the target population [15, 20, 63, 104-109]. The challenge for the message sender is that assessments of the reliability of a source's statements about a risk vary, depending not merely on the words in the message, but also on the receiver's knowledge of the source, the source's past behaviors, past trustworthiness, judgmental tendencies and the social and informational context in which the source's opinions were formed and disseminated [see 54, 95, 106, 109-116]. Variation among these factors explains, for example, why people generally *trust* medical professionals to safely administer radiation and chemicals (X-rays and prescriptions), but *distrust* officials of government and industry to administer radiation and chemicals (nuclear power, pesticides, industrial chemicals) [106, p. 317, citing others], (environmental risks in Appalachia. [109] Perceptions of the credibility of government and business leaders and the media as sources for risk information varied with the type and severity of risk.

Accuracy and trust are linked in the risk perception formula. A source's past statements of risk probability -- later proven to be inaccurate or inadequate -- decreased trust in that source's subsequent statements. [86, 111] Perceptions of trustworthiness are based on knowledge and expertise as well as conclusions about how well a risk information source complies with expectations of honesty, openness, commitment, competence, caring, and predictability behaviors. [108, 114, 117] People are more likely to trust a risk information source when the causes are described clearly, [87-89] and in ways that match their own experiences. [118-120]

However, studies have also shown that when an individual lacks personal knowledge of a risk, s/he will rely on "social trust," that is the attitude the person holds toward the organization issuing the message. [121] Social trust allows quick judgments about the validity of risk messages through the application of cognitively miserly "social decision rules." [94, 122] In such instances, people may be more likely to rely on government sources. [122]

Although source diversity appears to increase credibility in risk stories [123], diversity alone is not sufficient. When low trust sources criticize high trust sources, for example, the low trust sources' credibility remains low; however, the credibility of risk information provided by a low trust source can be enhanced when a high trust source supports the position taken by the low trust source. [124] It is not clear which sources will be assessed as high or low in trust. Participants in a longitudinal, panel design field study exposed to opposition from a leading advocacy organization were unwilling to symbolically adopt irradiated food -- even when provided with information demonstrating that the FDA, AMA and ADA supported the process as a safe one. [112]

**2.7. Summary**

The answers to RQ1 (*What factors have been found most effective to successful risk communications?*), at least in a media context, can be summarized as follows: Decades of research suggest that, in designing messages, risk communicators need to consider that target of any risk communication will be more likely to be alerted to specific risks when the target…

1. monitors "channels" through which messages about risk of the relevant type are transmitted
2. pays attention to messages about the risk type
3. receives the messages frequently
4. receives the messages recently
5. receives risk information in a format with thematic elements that allows her/him to learn necessary information (how exposure takes place, what the risk means, the probability that injury will occur, the severity of the consequences, what is being done about the risk by others and what the receiver can do),
6. recognizes the hazardous conditions as potentially relevant (is personally or professionally involved, cares about the risk subject or those likely to be harmed, considers the hazardous condition geographically proximate, sees those potentially impacted as similar to her/himself)
7. believes the probability of specific harm is high
8. believes the specific harm will be severe
9. sees physical evidence that matches the warning
10. has had previous experience with a similar hazard where harm resulted
11. receives the information from a source of proven or perceived trust for this type of information
12. believes constraints on responding to a warning or seeking additional information are low.

## 3 The outbreak site: Walkerton, Ontario, Canada, May 2000

Walkerton (now part of Brockton), with a population 4800 in 2000, is a rural town in the cattle country of Bruce County, a two-hour drive west from Toronto. Heavy rains had been falling for most of the month of May leading to serious and obvious flooding. Less obvious though, were the invisible dangers the flood waters were carrying to Walkerton -- May's rains washed a powerful and poisonous bacteria, the *0157:H7* strain of *E. coli*, from cow manure spread on nearby pastures into a poorly sited shallow well that fed Walkerton's negligently maintained public water system.

*E. Coli* is the common name for *escherichia coli*, a generally harmless bacterium that aids digestion in human and animal intestines. Although most strains of *E. Coli* are benign, and even helpful, some variants can cause severe health problems. One of the dangerous versions, the *E. Coli 0157:H7* strain, was first identified in 1982 after its presence in ground meat caused a widespread outbreak of severe food poisoning. [125] The symptoms of what is frequently called the "hamburger disease" include bloody diarrhea, kidney malfunction, and a variety of illnesses particularly dangerous to the very young, the very old and those with compromised immune systems. [126], [61]

Subsequently reported media investigations [127], and a heavily publicized provincial Inquiry into the causes of the Walkerton outbreak [60] would uncover a fatal interaction of systems: the region's porous underground hydrogeological conditions, combined with incremental and relatively inaccessible acts by water plant staff, and poorly reasoned risk assessment and risk management decisions by those controlling local and provincial governments had drastically increased the probability that Walkerton's public water would be vulnerable when this lethal, strain of *E. Coli* was carried into the system by heavy rain. Ordinarily, an invasion of *E. coli*, even the deadly *0157:H7* variation, into a public water system would not cause severe health problems because the chlorination levels required in public drinking water would kill the bacteria (pp. 3-5). Unfortunately, Walkerton's water was not being properly chlorinated (pp. 3-5, 13-14). Evidence uncovered by investigative journalists [127] and findings from the Public Inquiry revealed that for more than twenty years, and continuing up to the crisis in May of 2000, the operators of the system reduced chlorine levels below required levels and then falsified the records to conceal what they were doing (pp. 3-5, 13-14). Over the years, *E. Coli* had been repeatedly found to be present in laboratory tests of Walkerton's supposedly "treated" water supply (pp. 13-31). Although the presence of *E. Coli* is ordinarily an indicator that the water system is compromised by contaminants (pp. 7, 18), it does not always constitute a serious danger to human health (pp. 48-49). On the rare occasions when adverse test results caught the attention of the provincial and county government ministries responsible for watching over the public water, Walkerton's local plant operators insisted that everything was being attended to, that the results were anomalies and that the water was being properly chlorinated in accordance with provincial guidelines (p. 19). These assurances turned out to be false (pp. 15-19).

At the time of the Walkerton outbreak, although the responsibility for providing clean water rested at the primarily at the municipal level, the job of setting and enforcing drinking water standards was still at the provincial level ( p. 23). The province had established "objectives" that suppliers of public drinking water "ought" to meet (p. 33). These "Ontario Drinking Water Objectives" described a system that sounded reassuringly strict – but, in practice were not. On Sunday May 21, 2000, during the long Victoria holiday weekend, some Walkerton residents finally received a formal warning of the danger. The alert came in the form of a "boil water" advisory issued via local radio stations at the direction of Dr. Murray McQuigge, the medical officer of health for the Bruce-Grey-Owen Sound region (p. 10). By the time the boil-water advisory was disseminated, however, the water that had been contaminated for over a week, had reached thousands of residents and visitors, many of whom, already painfully ill with cramps and bloody diarrhea from the contaminated tap water, were overwhelming the region's hospitals (pp. 7-12).

Ultimately, more than 2300 would be infected. Some of these, especially children and the elderly, would suffer kidney failure requiring long-term access to dialysis. Seven would die in excruciating pain.

News of the poisoning brought hordes of reporters to rural Walkerton, where the media were quick to characterize the Walkerton contamination, not only as "the worst outbreak of *E. Coli* in Canada"[128], but also, in unsettling terms that caught my attention, as a tragedy that was both "preventable and predictable" [129]. Within days, front-page headlines were posing such questions as, "Why weren't people warned?" [130]. Either explicit or implicit was the assumption that there had been no warning of impending danger. Inquiry evidence confirmed that the first official warning was the boil water advisory on May 21 [60, pp. 7-12]. Although no evidence was collected to determine whether any of those at risk recognized how existing environmental and bacterial conditions interacting with provincial acts and local omissions increased the likelihood of contamination to the water supply, a survey conducted by Health Canada shortly after the

outbreak found that only 56% of the residents using Walkerton's water heard about the advisory on the day it was broadcast, 18% reported they did not learn of the danger until the next day, and 8% indicated ignorance until May 23 (p. 262).

## 4 Methods

RQ2: *In what ways did pre-crisis and post-crisis media coverage of a single crisis case – the Walkerton, Ontario, Canada E. Coli contamination of May, 2000 – display the factors identified as most likely to result in effective risk communication?*

Data to answer this question were obtained using the research design methods described below. Table 1 displays the operationalization of the concepts identified above as most likely to result in effective risk communication.

### 4.1 Defining the Walkerton "case"

The Walkerton "case," as defined for this content analysis, was a chronologically and geographically focused examination of news coverage of risk information about three categories of hazard -- environmental conditions, bacteriological threats to public health, and political risk assessments and risk management decisions -- all causally relevant to the Walkerton *E. Coli* contamination of May, 2000.

***Media coverage of hazardous environmental conditions*.** The Walkerton region's soils are porous and limestone rich. Such hydrogeological conditions, that permit easy transmission of contaminated groundwater to aquifers feeding public and private wells, are not unique to this region. Consequently, newspaper coverage from parts of the world where similar environmental risk conditions were reported was included in the case.

***Media coverage of bacteriological threats to public health***. Since the early 1980s, the 0157:H7 strain of *E. Coli* bacteria had been found in sites all over the world, most frequently in places contaminated by the feces of animals, especially cattle. This strain's presence on cattle farms of the Walkerton region was confirmed by university studies conducted years before the outbreak. Because there are no known geographic boundaries for this bacteriological threat to public health, print coverage from parts of the world where the dangers of *E. coli*, especially when transmitted through water, was included in the case.

***Media coverage of political risk assessments and risk management decisions*.** Negligence, errors in judgment based on inadequate training or uncertain information, and attempts to balance conflicting values are not unique to the Walkerton geographic region. However, because the risks resulting from political assessments, decisions, acts, and omissions of interest were those of elected or appointed officials with responsibility for the safety of local tap water in the province of Ontario and the Walkerton region, only newspaper coverage from the province was included in the case.

### 4.2 Variables of interest -- "Risk-alerting" information

Of particular importance was the concept of "risk-alerting" (RAI) information. A measure of the likelihood a risk will be recognized (risk recognition). Information was considered to be "risk-*alerting*" when analysis suggested that a reasonable audience member would recognize the information as containing a message to "watch out" or pay attention to the probability of harm from the hazard described. Each news item was coded for the presence or absence of these nine risk information variables: Risk information source (s): (1) Government and (2) non-government; Primary reason for inclusion of information as newsworthy: (3) Episodic or thematic; Risk recognition or recognizability level: (4) Risk-alerting, (5) risk-calming, and (6) risk-uncertain information; Risk severity indicators (7) bacterial strain identification (*E. coli* 0157:H7) and potential outcomes: (8) sickness and/or (9) death.

In addition, as shown on Table 1, data were also collected to assess other factors likely to increase the success of risk communications, including the news item's date, news organization's geographic location, country of occurrence, and category of risk topic.

**Table 1.** Concepts from previous research shown to increase likelihood of effective risk communications operationalized as variables for data collection of international, national, regional and local news sources

| Concept | Operationalized how? |
|---|---|
| **Attention**<br>Comes through a media channel a receiver attends to directly or indirectly (through two-step flow) | ▪ News organization (outlet)<br>▪ Country of news source (outlet)<br>▪ Number of news items by risk topic/category |
| **Frequency**<br>More likely to be received and will have more impact if delivered frequently | ▪ Date of news item<br>▪ Number of news items by risk topic/category |
| **Recency**<br>Has more impact if received recently | ▪ Date of news item |
| **Perceived relevance/Involvement**<br>Has more impact if perceived as relevant and necessary | ▪ Country of news outlet<br>▪ Location of hazardous occurrence<br>▪ Number of news items by risk topic/category<br>▪ Date of news item<br>▪ Risk severity indicators<br>• bacterial strain identification (*E. coli* 0157)<br>• potential outcomes sickness, and death. |
| **Proximity**<br>Perceived relevant if receiver is involved (hazard is perceived as physically, emotionally, socially or culturally "nearby.") | ▪ Location of hazardous occurrence<br>▪ News organization (outlet)<br>▪ Country of news outlet<br>▪ Similarity of victims |
| **Severity**<br>Has more impact if message explains how exposure takes place, what the risk means, the probability that exposure will occur, the severity of consequences, the effectiveness of others' efforts to reduce risk, and what the receiver can do to reduce risk. | ▪ Risk severity indicators<br>• bacterial strain identification (*E. coli* 0157)<br>• potential outcomes sickness, and death.<br>▪ Location of hazardous occurrence<br>▪ Primary reason for inclusion of information as newsworthy<br>▪ Episodic or thematic<br>▪ Risk recognition/recognizability level<br>▪ Risk-alerting<br>▪ Risk-calming<br>▪ Risk-uncertain information |
| **Source credibility**<br>Has more impact if source is credible to receiver on risk topics. | ▪ News organization (outlet)<br>▪ Risk information source<br>▪ Government and non-government |
| **News frame**<br>Receivers are *less likely* to recognize alert, to engage in political action, to recognize or understand causes, *and more likely* to place responsibility for the creation of potential harms on the actions of other individuals, when a risk story has been framed rather than episodically/ procedurally, rather than thematically/systematically | ▪ Risk recognition/recognizability level<br>▪ Risk-alerting<br>▪ Risk-calming<br>▪ Risk-uncertain information<br>▪ Primary reason for inclusion of information as newsworthy<br>▪ Episodic or thematic |

### 4.3 Media source selection, coding protocols and reliability

The primary review of pre-crisis news content was focused on a six and one-half year period before the outbreak running from January 1, 1994 to May 20, 2000. Initially, two searches of electronic media were conducted.

First, a search of regional, national and international news sources in Syracuse University's version of Lexis-Nexis (the L-N searches) in the four major electronic databases of the "News" section of Lexis-Nexis' Academic Universe: *General News* (Major Papers), *World News* (North/South America News Sources, European News Sources, Asia/Pacific News Sources and Middle East/Africa Sources), *U.S. News* (Midwest, Northeast, Western and Southeast Regional New Sources). These L-N search data were collected in two stages: 1) The L-N "well water/*E. coli"* search in all four databases for news items linking environmental risks with public health risks, described hereafter as the "well water/*E. coli"* searches, and 2) The L-N "political impacts" search limited to Canadian sources for news items linking public health and environmental risks with politically created risks. For this search a variety of terms were used in combination, seven based on government names and seven based on public health or environment (e.g., premier Harris w/s water).

Second, a manual search was conducted in the local library's microfilm collection of Walkerton's only local newspaper, *The Walkerton Herald Times* (the WHT search). Serving the Walkerton area since 1861, *The Walkerton Herald-Times* was, at the time of this study, a typical tabloid-format community newspaper, published 52 weeks a year on Wednesdays. With the manual search, every page of the WHT was examined for the 330 weeks reviewed for this study. Issues ranged in size from 8 to 32 pages, with a mean of 17.6, and a mode of 16 pages.

News items from the WHT search were not indexed in any known electronic database. Bound originals were filed in the newspaper's small office. Microfilmed copies for most years back to 1861 were archived in the Walkerton branch of the Bruce County Library System. Consequently, selecting content from the *Herald-Times* was performed the old-fashioned way -- by examining every page on a library microfilm reader, then using the photocopy feature to capture relevant pages. The data collection strategy was broad -- all articles, commentaries, photographs, stories, advertisements and letters to the editor including any information related to any of the three hazard categories (environmental, public health, political) were to be collected. Briefly, though, a news item was collected if it contained: 1) any mention of the region's hydrogeology, soils, wells, groundwater or other water sources or activities that threatened them ("wells" on the coding sheet); 2) any mention about the specific bacteria (*E. coli* 0157:H7) or any reference to pollution by any harmful contaminants; or 3) any reference to governmental decisions that might impact water quality, any mention of the PUC (Public Utilities Commission) or any of its staff, any mention of local government involvement with water systems, any mention of provincial or local government budget cuts, or governmental restructuring that impacted on government services -- especially drinking water safety. Consequently, close attention was directed to any coverage of public meetings or government activities and to letters to the editor offering opinions about government.

Two graduate students living in the Walkerton area were trained for the review. The first assistant conducted a manual search of all 5800 pages from 330 weekly issues. The second assistant, who was directed to make her search without consulting her predecessor, reviewed a random selection of 33 weekly issues (representing 10%) of those reviewed by the first assistant. Following these directions, the second researcher identified the same content (or lack thereof) as the first; she found no new articles that had not already been found - a result indicating 100% agreement for selection.

**Table 2.** Intercoder reliability calculations for nine dichotomously-coded risk information variables for by search results showing coefficient of reliability (CR) and Cohen's Kappa (CK)[A] for two coders

| | *Lexis-Nexis* "Well water + *E. coli*" searches (n = 42) [B] | | *Lexis-Nexis* "political impacts" searches (N = 39) [C] | | *Walkerton Herald-Times* (N = 85) [C] | |
|---|---|---|---|---|---|---|
| | CR | CK | CR | CK | CR | CK |
| **Risk information source?** | | | | | | |
| Government? | .98 | .86 | .98 | .86 | .98 | .90 |
| Non-government? | .95 | .83 | .95 | .83 | .94 | .86 |
| **Newsworthy reason?** | | | | | | |
| Episodic (event-driven) as compared to thematic | .91 | .77 | .90 | .73 | .91 | .82 |
| **Risk recognition level?** | | | | | | |
| Alerting | .98 | .86 | .95 | .81 | .94 | .86 |
| Calming | .91 | .77 | 1.00 | .89 | .97 | .90 |
| Uncertain | .93 | .79 | .92 | .78 | .89 | .78 |
| **Risk severity language?** | | | | | | |
| Bacteria can kill | 1.00 | .90 | 1.00 | .88 | 1.00 | .95 |
| Bacteria can sicken | .98 | .86 | 1.00 | .88 | .96 | .89 |
| Strain name/bacteria | 1.00 | .90 | 1.00 | .88 | 1.00 | .95 |

Notes.

[A] Cohen's kappa is recommended when, as here, there are only two coders, the data were collected at the nominal level (0/1), the sample is small, and, when one value (1 or 0, depending on variable and search) dominated when the coders agreed

[B] Based on a random sample of slightly over 20% of 201 news items (n = 42). For all nine variables (378 decisions per coder), the Scott's pi calculation was .86.

[C] Intercoder reliability calculations were performed on the census of news items coded, not a sample.

Copies of all L-N "hits" and all WHT pages containing the terms sought were copied and retained. All data were entered into SPSS for analysis. The news item was the unit of analysis.

**Intercoder reliability.** Following the L-N coding directions, a trained research assistant assigned dichotomous (no = 0/ yes = 1) choices for the presence or absence of the nine risk information variables described above. A second coder, working from the same coding instructions, made independent coding decisions on the same nine variables for a random selection of just over 20% of the news items (N = 201) from the *E. coli*/well water searches (n = 42). The intercoder reliability calculations for each of the nine variables for the L-N and WHT coding are shown on Table 2.

## 5 Results and discussion

### 5.1 The Lexis-Nexis "well water/*E. coli*" risk search findings.

Although the "well water/*E. coli*" risk search was conducted in electronic databases containing international and Canadian news sources, only 201 news items were found in the 78-month period before Walkerton. Of these, 95% (n =191) came from non-Canadian sources. Of these 201 news items, nearly three-quarters (74.1%; n = 149) were reported in media sources in the United States. The remaining 20.9% (n = 42) came from news media in other countries, primarily Japan (n = 37).

Only 5% (n = 10) came from Canadian news media. Of these, 3 reported on children's direct and secondary exposures to *E. Coli* 0157: H7, believed to have come from animals at a petting zoo in London, Ontario -- 100 miles from Walkerton; 2 focused on events more than two thousand miles from Walkerton in Calgary, Alberta; 5 were thematic and transboundary, that is, they did not report on any particular localized event, focusing instead on identifying a wide variety of vectors for *E. Coli* transmission, including cattle manure, groundwater, water from private and "treated" municipal wells, chlorinated swimming pools, hamburger, unpasteurized apple juice, radish sprouts, lettuce, and more -- exposure to which was believed to increase the risks of *E. Coli* contamination. Three news stories offered Canadian statistics for *E. coli*-related illnesses (ranging annually from 1000 to 3000 *reported* cases, with somewhere between 16,000 and 300,000 additional cases believed to be *unreported,* depending on the year, and news source). These informative pieces also referred to specific geographic locations where dangerous *E. Coli* had been found (e.g., Ottawa, Guelph, and Sarnia in Ontario, Calgary in Alberta, Japan, Argentina, and a variety of communities in the United States), as well as to generalized locales (e.g., rural areas, cattle farming regions, dairy farms, petting zoos, and fairs) where *E. Coli* had caused serious illness or death.

The simple answers from the data found from the L-N searches are these: 1) Almost all of the risk conditions that led to the Walkerton outbreak were described in local, regional, national or international news media. 2) Very little information about the lethal nature of *E. Coli* transmitted through water vectors was found in regional, national, or international news media. 3) Of the small amount of information that was uncovered, the risk related conditions: a) were rarely published in media disseminated in Walkerton, b) were rarely presented in ways that would allow area residents to recognize that the risk conditions described elsewhere were similar to their own, c) were often presented in confusing ways where important details were omitted, d) sometimes included inaccurate or misleading information, and e) frequently used the term "hamburger disease" to define *E. Coli* poisoning, emphasizing food, rather than water as a common transmission vector.

### 5.2 The Lexis-Nexis "political impacts" findings.

The "political impacts/politically created risks" searches were conducted in databases containing the Canadian news sources. Only 39 unique news items were found in the 78-month period before Walkerton. Of this small number, all but two (from *The Calgary Herald*) were either from news sources based in Ontario, such as *The Toronto Star* or *The Guelph Mercury*, or from wire services theoretically covering "all" of Canada, such as *Canadian Press*. Of the very few news items that addressed political impacts on provincial water quality, many of the messages from government officials were ambiguous, inconsistent, risk-calming, or incorrect.

### 5.3. *The Walkerton Herald-Times* findings

In the 78 months before the outbreak, *The Walkerton Herald-Times* published only 85 news items (news stories, commentaries, editorials, photographs, stories, advertisements or letters to the editor) arguably related to any of the threats to the quality of local water. The vast majority (82.1%, n = 271) of the 330 weekly issues contained no pages with news items matching any of the basic search criteria. Of the 85 items reviewed, 42.3% (n = 36) were assigned to political risk assessment and risk management, 32.9% (n = 28) to public health, and 24.7% (n = 21) to the environmental risk category. News items in this category reported on possible threats to water quality in three different ways: those posed by a proposed limestone quarry, general information about wells and groundwater, and threats from commercial water taking.

From a quantitative perspective, *The Walkerton Herald-Times* published very little risk information addressing any of the three risk topics (environmental conditions, water-borne bacterial threats to public health, or political risk assessment and management decisions). Of this very small number, fewer than half contained information coded as alerting. Event-driven news items outweighed those with information-driven content. Government did not dominate as a source of risk alerting information. Not a single news item included 0157's strain name or mentioned the potentially severe or deadly consequences of exposure. Only one story even used the term, *E. coli*..

## 6 Conclusions

There was little to suggest, from the data examined for this quantitative content analysis, that a reasonably prudent member of the Walkerton community would have appreciated and understood the threats posed to the public water system before the contamination crisis.

Why? Few of the news organizations where even the smallest amount of risk alerting information appeared were Canadian, making it unlikely a member of the Walkerton community, especially in those early days of Internet access between 1994 and 2000, would monitor any of the channels through which messages about Walkerton-type risks were transmitted. Although prudent persons would be likely to pay attention to messages clearly suggesting their water was at risk, no such clear messages were found in the media reviewed before the crisis.

The risk messages reviewed were neither frequent, not recent. Risk information was rarely presented in a format with thematic elements that would have allowed anyone to learn the kinds of information people say is necessary (i.e, how exposure takes place, what the risk means, the probability that injury will occur, the severity of the consequences, what is being done about the risk by others and what the receiver can do).

There was little that would permit a community member to recognize even one of the hazardous conditions as potentially relevant – and certainly few would see the interaction of risks. Most of the risk events reported were not geographically close, although a few Canadian stories focused on harms to children.

There was little to suggest that the probability of specific harm was high, although anyone who read the symptoms of 0157:h7 contamination would believe the harm will be severe. None of the stories described physical evidence likely to have been experienced by the Walkerton community. In fact, although evidence submitted at the Walkerton Inquiry confirmed *E. Coli* bacteria were found in the water on several occasions, there were no pre-crisis reports of harm.

A mere content analysis offers no way to assess community member's attitudes toward the credibility of the news sources, nor were there data that would allow an assessment of belief about constraints on responding to a warning.

But, it seems quite clear that, if the media reviewed were the only sources for risk information of the type involved in the contamination, there is little likelihood that anyone would have been warned.

## References

1. Senge, P.M., *The fifth discipline: The art and practice of the learning organization*. 1990, New York, NY: Currency Doubleday.
2. Shoemaker, P.J., *Hardwired for the news: Using biological and cultural evolution to explain surveillance function.* Journal of Communication, 1996. 46(3): p. 32-47.
3. Lilienfeld, R. and W. Rathje, *How did we get like this*, in *Use less stuff: Environmental solutions for who we really are*. 1998, Fawcett Books: New York.

4. Cottle, S., *Ulrich Beck, 'Risk Society' and the media: A catastrophic view.* European Journal of Communication, 1998. 13 (1): p. 5-32.
5. Howard, G.S., *Ecological psychology: Creating a more earth-friendly human nature*. 1997, Notre Dame, Indiana: University of Notre Dame Press.
6. *Global alert and response: Cumulative number of reported probable cases of SARS from: 1 Nov 2002 To: 4 July 2003*. 2003 [cited 2012 12/26/2012]; Available from: http://www.who.int/csr/sars/country/2003_07_04/en/.
7. *Outbreaks of E. coli O104:H4 infection: update 26*. 2011 [cited 2012 12/26]; Available from: http://www.euro.who.int/en/where-we-work/member-states/germany/sections/news/2011/06/outbreaks-of-e.-coli-o104h4-infection-update-26.
8. Kitzinger, J., *Researching risk and the media.* Health, Risk & Society, 1999. 1(1): p. 55-69.
9. Ropiek, D. and G. Gray, *Risk: A practical guide for deciding what's really safe and what's really dangerous in the world around you*. 2002, Boston: Houghton Mifflin Company.
10. Trumbo, C.W. *Risk perception in community context: Evaluating the psychometric paradigm and its relationship to risk amplification and reported communication channel usefulness*. in *Association for Education in Journalism and Mass Communication - Annual Conference*. 1995. Washington, DC.
11. Trumbo, C.W., *Communication channels and risk information: A cost-utility model.* Science Communication, 1998. 20(2): p. 190-203.
12. Riffe, D., *Media use affects perceptions of environmental hazards.* Newspaper Research Journal, 2006. 27(3): p. 101-113.
13. Coleman, C.-L., *The influence of mass media and interpersonal communication on socity and personal risk judgments.* Communication Research, 1993. 20: p. 611-628.
14. Thompson, P.B. and W. Dean *Competing conceptions of risk*. Risk, 1996. 7, 361-eoa.
15. Slovic, P., *Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield.* Risk Analysis, 1999. 19(4): p. 689-701.
16. Slater, M.D., et al., *Information processing and situational theory: A cognitive response analysis.* Journal of Public Relations Research, 1992. 4(4): p. 189-203.
17. O'Leary, R., et al., *Managing for the environment: Understanding the legal, organizational and policy challenges*. 1999, San Francisco, Ca: Jossey-Bass Publishers.
18. O'Leary, R., et al., *Working with stakeholders to produce environmental values: Communicating risk*, in *Managing for the Environment: Understanding the Legal, Organizational and Policy Challenges*. 1999, Jossey-Bass Publishers: San Francisco, CA. p. 164-191.
19. Plough, A. and S. Krimsky, *The emergence of risk communication studies: Social and political context.* Science, Technology & Human Values, 1987. 12(3): p. 4-10.
20. Slovic, P., *The perception of risk*. 2002, London: Earthscan Publications, Ltd.
21. Renn, O., *Premises of risk communication: Results of two participatory experiments*, in *Communicating Risks to the Public: International Perspectives*, R. Kasperson and P. Stallen, Editors. 1991, Kluwer: Amsterdam & New York. p. 175-218.
22. Rowan, K.E., *Goals, obstacles, and strategies in risk communication: A problem-solving approach to improving communication about risks.* Journal of Applied Communication Research, 1991. November: p. 300-329.
23. National Academy of Sciences Research Council, *Improving risk communication*, 1989: Washington, DC.
24. Sandman, P.M., *Risk communication*, in *Encyclopedia of the Environment*, R.A. Eblen and W.R. Eblen, Editors. 1994, Houghton-Mifflin: Boston, MA. p. 620-623.

25. Heath, R.L. and C. Gay, *Risk communication: Involvement, uncertainty and control's effect on information scanning and monitoring by expert stakeholders.* Management Communication Quarterly, 1997. 10 (3): p. 342-372.
26. Chartier, J. and S. Gabler, *Risk communication and government: Theory and application for the Canadian Food Inspection Agency*, 2001, Canadian Food Inspection Agency: Ottawa, Ontario, Canada.
27. Lundgren, R.e. and A.H. McMakin, *Risk communication: A handbook for communicating environmental, safety and health risks*. 1998, Columbus, Ohio: Battelle Press.
28. Montague, P. *What questions to ask experts about risk assessments*. in *Environmental Risk Reporting: The Science and the Coverage*. 1991. Lehigh University, Bethlehem, PA.
29. Dumanoski, D., W.H. Farland, and S. Krimsky, *Science in the public arena: A panel discussion*, in *Communicating Uncertainty: Media Coverage of New and Controversial Science*, S.M. Friedman, S. Dunwoody, and C.L. Rogers, Editors. 1999, LEA: Mahwah, NJ. p. 167-178.
30. Woo, D.M. and K.J. Vincente, *Sociotechnical systems, risk management, and public health: Comparing the North Battleford and Walkerton outbreaks.* Reliability Engineering and System Safety, 2003. 80: p. 253-269.
31. Vaughan, E. and M. Seifert, *Variability in the framing of risk issues.* Journal of Social Issues, 1992. 48(4).
32. Fishman, M., *Manufacturing the news*. 1st paperback printing ed. 1988: University of Texas Press.
33. McComas, K.A., *Defining moments in risk communication research: 1996-2005.* Journal of Health Communication, 2006. 11: p. 75-91.
34. Chess, C., et al., *Results of a national symposium on risk communication: Next steps for government agencies.* Risk Analysis, 1995. 15(2): p. 115-125.
35. Schwartz, L.M. and S. Woloshin, *News media coverage of screening mammography for women in their 40s and tamoxifen for primary prevention of breast cancer.* JAMA, 2002. 287(23): p. 3136-3142.
36. Brody, J.E., *Communicating cancer risk in print journalism.* Journal of the National Cancer Institute Monographs, 1999. 25.
37. Fisher, A., *Risk communication challenges.* Risk Analysis, 1991. 11: p. 173-179.
38. Weinstein, N., et al., *Experimental evidence for stages of health behavior change: The precaution adoption process model applied to home radon testing.* Health Psychology, 1998. 17(5).
39. Rossow, M.D. and S. Dunwoody, *Inclusion of "useful" detail in newspaper coverage of a high-level nuclear waste siting controversy.* Journalism Quarterly, 1991. 68: p. 87-100.
40. Bioca, M., *Risk communication and the precautionary principle.* European Journal of Oncology, 2005. 11: p. 261-266.
41. McComas, K.A., *Theory and practice of public meetings.* Communication Theory, 2001. 11(1): p. 36-55.
42. McComas, K.A., *Citizen satisfaction with public meetings used for risk communication.* Journal of Applied Communication Research, 2003. 31(2): p. 164-184.
43. Nicodemus, D., *Mobilizing information: Local news and the formation of a viable political community.* Political Communication, 2004. 21: p. 161-176.
44. Tichenor, P.J., G.A. Donohue, and C.N. Olien, *Community conflict & the press*. 1980, Beverly Hills & London: Sage.
45. French, B.C., *More effective citizen participation in environmental decision-making.* The University of Toledo Law Review, 1993. 24 (Winter): p. 389-423.
46. Kasperson, R., *Six propositions on public participation and their relevance for risk communication.* Risk Analysis, 1986. 6: p. 275-281.

47. Kuhn, S., *Expanding public participation is essential to environmental justice and the democratic decision-making process.* Ecology Law Quarterly, 1999. 25 (4): p. 647-64.

48. Löfstedt, R., J. Linnerooth-Bayer, and G. Sjöstedt, eds. *Transboundary risk management*. 2001, Earthscan Publications, Ltd.

49. Perkins, D.D., B.B. Brown, and R.B. Taylor, *The ecology of empowerment: Predicting participation in community organizations.* Journal of Social Issues, 1996. 52(1): p. 85-110.

50. Rich, R.C., et al., *Citizen participation and empowerment: The case of local environmental hazards.* American Journal of Community Psychology, 1995. 23(5): p. 657-676.

51. Tauxe, C.S., *Marginalizing public participation in local planning.* Journal of the American Planning Association, 1995. 61(4): p. 471-481.

52. Rohrmann, B., *A socio-psychological model for analyzing risk communication processes.* Australian Journal of Communication, 2000. 2000-2: p. 1-14.

53. Scherer, C., *Communication, scientific information and risk management: A case study*. Community Development, 1999. 6(3).

54. Wakefield, S.E.L. and S.J. Elliott, *Constructing the news: The role of local newspapers in environmental risk communication.* The Professional Geographer, 2003. 55(2): p. 216-226.

55. Sinden, P.G. *Risk communication effects: A comparison of information sources and audiences*. in *Paper presented at the Annual Metting of the American Sociological Association*. 1995. Washington, D.C.

56. Morton, T.A. and J.M. Duck, *Mass and interpersonal influences on perceptions of risk to self and others.* Communication Research, 2001. 28(5): p. 602-626.

57. Pollard, W.E., *Public perception of information sources concerning bioterrorism before and after anthrax attacks.* Journal of Health Communication, 2003. 8(1): p. 93-103.

58. Williams, B.L., et al., *Frequency of use and perceived credibility of information sources and variations of socioeconomic factors among Savannah River stakeholders.* Risk, 2000. 11(1): p. 69-92.

59. Chipman, H., et al., *Audience responses to a risk communication messsage in four media formats.* Journal of Nutrition Education, 1996. 28(3): p. 133-140.

60. O'Connor, D.R., *Report of the Walkerton Inquiry: Part One: The events of May 2000 and related issues*, 2002, Ontario Ministry of the Attorney General: Queen's Printer for Ontario: Toronto, Ontario, Canada.

61. O'Connor, D.R., *Report of the Walkerton Inquiry: Part Two: A strategy for safe drinking water*, 2002, Ontario Ministry of the Attorney General: Toronto, Ontario, Canada.

62. Lowery, W., *Media dependency during a large-scale social disruption: The case of September 11.* Mass Communicaiton & Society, 2004. 7(3): p. 339-357.

63. Gutteling, J.M., *A field experiment in communicating a new risk: Effects of the source and a message containing explicit conclusions.* Basic & Applied Social Psychology, 1993. 14(3): p. 295-316.

64. Riffe, D., *Frequent media users see high environmental risks.* Newspaper Research Journal, 2006. 27(1): p. 48-57.

65. Combs, B. and P. Slovic, *Newspaper coverage of causes of death.* Journalism Quarterly, 1979. 56: p. 837-843.

66. Eagly, A.H. and S. Chaiken, *The Psychology of Attitudes*. 1993, Fort Worth, TX: Harcourt Brace College Publishers.

67. Entman, R.M., *Projections of power: Framing news, public opinion and U.S. foreign policy*. Studies in communication, media and public opinion, ed. S. Herbst and B.I. Page. 2004, Chicago & London: University of Chicago Press.

68. Higgins, E.T., J.T. Bargh, and W.J. Lombardi, *Nature of priming effects on categorization.* Journal of Experimental Psychology: Learning, Memory and Cognition, 1985. 11: p. 59-69.

69. Protess, D.L., et al., *The impact of investigative reporting on public opinion and policymaking: Targeting toxic waste.* Public Opinion Quarterly, 1987. 51: p. 166-185.

70. Iyengar, S., M.D. Peters, and D.R. Kinder, *Experimental demonstrations of the "not-so minimal" consequences of television news programs*, in *Political psychology: Classic and contemporary readings*, N.J. Kressel, Editor. 1993, Paragon House: New York, NY.

71. Atwater, T., *Reader interest in environmental news.* Newspaper Research Journal, 1988. 10(1): p. 31-38.

72. Mazur, A. *Technical risk in the mass media*. 1994 [cited 2003 August 13]; Available from: http://www.fplc.edu/RISK/vol5/summer/mazur.htm.

73. Wicks, R.H. and D.G. Drew, *Learning from news: Effects of message consistency and medium on recall and inference making.* Journalism Quarterly, 1991. 68(1/2): p. 155-164.

74. Murphy, S. and R.B. Zajonc, *Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures.* Journal of Personality and Social Psychology, 1993. 64(5): p. 723-739.

75. Fischoff, B., et al., *Evolving judgments of terror risks: Foresight, hindsight, and emotion.* Journal of Experimental Psychology Applied, 2005. 11(2): p. 124-139.

76. Koenig, T., *Routinizing frame analysis through the use of CAQDAS*, in *RC 33: Sixth International Conference on Social Science Methodology*2004: Amsterdam.

77. Dahinden, U., *Framing: A decade of research experience* in *International Communication Association - Annual Conference*, 2005: New York, New York.

78. Fisher, K. *Locating frames in the discursive universe*. Sociological Research Online, 1997. 2.

79. Scheufele, B., *Framing-effects approach: A theoretical and methodological critique.* Communications, 2004. 29: p. 401-428.

80. Entman, R.M., *Framing: Toward clarification of a fractured paradigm.* Journal of Communication, 1993. 43(4): p. 51-58.

81. Iyengar, S., *Is anyone responsible? How television frames political issues*. 1991, Chicago: University of Chicago Press.

82. Iyengar, S. and A. Simon, *News coverage of the Gulf crisis and public opinion.* Communication Research, 1993. 20(3): p. 365-383.

83. Lion, R., R.M. Meertens, and I. Bot, *Priorities in information desire about unknown risks.* Risk Analysis, 2002(22): p. 4.

84. Bostrom, A., B. Fischhoff, and M.G. Morgan, *Characterizing mental models of hazardous processes: A methodology and an application to radon.* Journal of Social Issues, 1992. 48(4).

85. Fischhoff, B., *Reporting on environmental and health risks.* The Quill, 1996. 83(6): p. 43-47.

86. Friedman, S.M. *The media, risk assessment and numbers: They don't add up*. 1994 [cited 2003 August 18]; Available from: http:/www.piercelaw.edu/risk/vol5/summer/friedman.htm.

87. Bell, A., *Climate of opinion: Public and media discourse on the global environment.* Discourse & Society, 1994. 5(1): p. 33-64.

88. Coleman, R., *The effects of news stories that put crime and violence into context: The public health model of reporting.* Journal of Public Health Communication, 2002. 7(5): p. 410-406.

89. Yaros, R.A. *Communicating complex news: Structuring stories to enhance public engagement*. in *Association for Education in Journalism and Mass Communication*. 2005. San Antonio, TX.

90. Johnson, B.B., *Testing and expanding a model of cognitive processing of risk information.* Risk Analysis, 2005. 25(3): p. 631-650.

91. Grunig, J.E., *Communication behaviors and attitudes of environmental publics: Two studies.* Journalism Monographs, 1983. 81: p. 1-47.

92. Johnson, B. and A.H. Eagly, *Effects of involvement on persuasion: A meta-analysis.* Psychological Bulletin, 1989. 106(2): p. 290-314.

93. Aldoory, L. and M.A. Van Dyke, *The roles of perceived "shared" involvement and information overload in understanding how audiences make meaning of news about bioterrorism.* Journalism and Mass Communication Quarterly, 2006. 83(2): p. 346-362.

94. Grantham, S. and T. Irani. *An ounce of prevention: The role of critical thinking and message frames in addressing low-involvement environmental risks*. in *Association for Educators in Journalism and Mass Communication - Annual Conference*. 2004. Toronto.

95. Heath, R.L., S. Seshadri, and J. Lee, *Risk communication: A two-community analysis of proximity, dread, trust, involvement, uncertainty, openness/accessibility and knowledge on support/opposition toward chemical companies.* Journal of Public Relations Research, 1998. 10(1): p. 35-56.

96. Gibson, R. *Reading between the photographic: The influence of incidental pictorial information on issue perception.* in *Association for Education in Journalism and Mass Communication Annual Conference*. 1999. New Orleans, LA.

97. Berger, C.R., *Processing quantitative data about risk and threat in news reports.* Journal of Communication, 1998. 48(3): p. 87-106.

98. Aldoory, L., *Making health communications meaningful for women: Factors that influence involvement.* Journal of Public Relations Research, 2001. 13(2): p. 163-186.

99. de Swann, A., *Widening circles of identification: Emotional concerns in sociogenetic perspective.* Theory, Culture & Society, 1995. 12: p. 25-39.

100. Donnelly, L., *Proximity, not story format, improves news awareness among readers.* Newspaper Research Journal, 2005. 26(1): p. 59-65.

101. Major, A.M., *Environmental concern and situational communication theory: Implications for communcating with environmental publics.* Journal of Public Relations Research, 1993. 5(4): p. 251-268.

102. Weinstein, N. and P.M. Sandman, *Some criteria for evaluating risk messages.* Risk Analysis, 1993. 13(1): p. 103-114.

103. Griffin, R., et al. *Testing the robustness of a risk information processing model*. in *Association for Educators in Journalism and Mass Communication - Annual Conference*. 2004. Toronto.

104. Sandman, P.M., et al., *Agency communication, community outrage and perception of risk: Three simulation experiments.* Risk Analysis, 1993. 13: p. 585, et seq.

105. Slovic, P., *Trust, emotion, sex, politics and science: Surveying the risk-assessment battlefield*, in *Environment, Ethics and Behavior: The Psychology of Environmental Valuation and Degradation*, M.H. Bazerman, et al., Editors. 1997, The New Lexington Press: San Francisco, CA. p. 277-313.

106. Slovic, P., *Perceived risk, trust and democracy*, in *The perception of risk*, P. Slovic, Editor. 2002, Earthscan Publications: Sterling, VA. p. 316-326.

107. Logan, R.A. *Official sources, embedded perspective and news frameworks: How two Korean newspapers covered a public health crisis*. in *Association for Education in Journalism and Mass Communication Annual Conference*. 2001. Washington, D.C.

108. McCallum, D.B., S.L. Hammond, and V. Covello, *Communicating about environmental risks: How the public uses and perceives information sources.* Health Education Quarterly, 1991. 18(3): p. 349-361.

109. Riffe, D. and J.E. Knight. *Environmental threats, information sources and optimism bias: Environmental risk in Appalachia*. in *Association of Educators in Journalism and Mass Communication*. 2002. Miami, FL.

110. Fox, C.R. and J.R. Irwin, *The role of context in the communication of uncertain beliefs.* Basic and Applied Social Psychology, 1998. 20(1): p. 57-70.

111. Sandman, P.M. and J. Lanard. *Duct tape risk communication*. 2000 [cited 2003 August 13]; Available from: http:/www.psandman.com/col/ducttape.htm.

112. Sapp, S.G. and P.F. Korsching, *The social fabric and innovation diffusion: Symbolic adoption of food irradiation.* Rural Sociology, 2004. 69(3): p. 347-369.

113. Rosati, S. and A. Saba, *The perception of risks associated with food-related hazards and the perceived reliability of sources of information.* International Journal of Food Science and Technology, 2004. 39: p. 491-500.

114. Kasperson, R., D. Golding, and S. Tuler, *Social distrust as a factor in siting hazardous facilities and communicating risks.* Journal of Social Issues, 1992. 48(4).

115. Irani, T. and J. Sinclair. *Question of trust: The effects of knowledge and public accountability on risks and benefits*. in *Association for Education in Journalism and Mass Communication - Annual Conference*. 2003. Kansas City, KS.

116. Palenchar, M. and R.L. Heath, *Another part of the risk communication model: Analysis of communication process and message content.* Journal of Public Relations Research, 2002. 14(2): p. 127-158.

117. McCallum, D.B., V. Covello, and R.G. Peters, *The determinants of trust and credibility in environmental risk communication: An empirical study.* Risk Analysis, 1997. 17(1): p. 43-54.

118. Blanchard-Boehm, R.D., *Understanding public response to increased risk from natural hazards: Application of the hazards risk communication framework.* International Journal of Mass Emergencies and Disasters, 1998. 16(3): p. 247-278.

119. Blanchard-Boehm, R.D. and M.J. Cook, *Risk communication and public education in Edmonton, Alberta, Canada on the 10th anniversary of the "Black Friday" tornado.* International Research in Geographical and Environmental Education, 2004. 13(1): p. 38-54.

120. Weinstein, N. and P.M. Sandman, *Predicting homeowners' mitigation responses to radon test data.* Journal of Social Issues, 1992. 48(4).

121. Siegrist, M. and G. Cvetkovich, *Perceptions of hazards: The role of social trust and knowledge*. Risk Analysis, 2000. 20(5): p. 713-719.

122. Trumbo, C.W., *Heuristic-systematic information processing and risk judgment.* Risk Analysis, 1999. 19(3): p. 391-400.

123. Cozman, R., *Source diversity increases credibility of risk stories.* Newspaper Research Journal, 2006. 27(3): p. 8-21.

124. Löfstedt, R., *Science communication and the Swedish acrylamide "alarm".* Journal of Health Communication, 2003. 8: p. 407-432.

125. Tindal, C.R. and S.N. Tindal, *Local government in Canada*. 5th ed. 2000, Toronto, Ontario, Canada: Nelson.

126. *E.coli outbreak claims victims*, in *Examiner,* 2000: Peterborough, Ontario, Canada. p. A3.

127. Verma, S. and K. Donovan, *The Walkerton story: Bad policies, bad decisions, bad water: The anatomy of a preventable tragedy*, in *The Toronto Star,*2000: Toronto, Ontario, Canada.

128. Ash, S. and B. Burtt, *Bacteria attacks Walkerton: 160 cases confirmed, 13 hospitalized in 'worst outbreak' of E.coli in Canada* in *The Record*. 2000: Kitchener, Ontario, Canada. p. A1.

129. Nikiforuk, A., *An old and deadly enemy lays siege to Walkerton*, in *Toronto Star*2000: Toronto, Ontario, Canada. p. A25.

130. Aagaard, C., *Why weren't people warned of E. coli threat?*, in *The Kitchener- Waterloo Record.* 2000: Kitchener- Waterloo. p. A1.

- empty page inserted -

# Environmentalism through Creative Visual Communication

Darlene Farris-LaBar

East Stroudsburg University of Pennsylvania
Fine and Performing Art Building
200 Prospect St
East Stroudsburg, PA 18301, USA

darlenelabar@yahoo.com and dfarris@esu.edu

**Abstract.** Since the earliest of times, humans have been referencing their natural surroundings through various forms of visual communication. Today, artists are still actively engaging their communities about the environment. Through an investigation of environmental concerns such as water conservation, land management, and the protection of ecosystems, this presentation will display how contemporary art and design, about the environment, can be a tool to enhance data mapping and encourage more ethical and moral practices towards the respect and preservation of the earth.

**Keywords.** Biodiversity, Nature Protection, Environmental Sustainability, Water Conservation, Land Management, Protection of Ecosystems, Visual Communication, Creativity, Environmental Art, Design

## Introduction

Art can be used as a vehicle to support visual global communication and understanding of environmental matters while using data mapping techniques. This presentation contains a brief explanation of how artists use creativity to visually communicate the debates related to environmental issues. Topics will include water conservation, land management, and the protection of ecosystems. It demonstrates how art depicting the environment can influence public awareness of biodiversity and the necessity to protect the natural environment. Art provides a type of visual communication that can entertain, decorate and/or educate. Can art enhance the communicational end of data mapping and be used to infuse values and a better understanding on environmental protection and awareness?

Artists and Designers are integral components of a healthier planet. Artists communicate and express themselves through forms such as media, sculpture, painting, video, installation, graphic design, illustration, performance and photography. Designers provide practical solutions for creative and functional ways to live. These include products, graphic design, landscapes, architecture, and much more. Environmentally conscious artists and designers create work that requires scholarly research concerning the health of our natural surroundings and the vulnerability of species that influence our future existence. Their art is accomplished by combining science, aesthetics, and a variety of techniques into a reality that is modeled in ways that communicate environmental activism.

Environmental art and design is likely to transform the way people value the natural environment so they will also support its protection. Creative people can bring communities and the environment together. They can encourage more ethical and moral practices towards the respect and preservation of the earth. With this in mind, I propose that art can be a vital component of a mechanism to save our environment.

## Artist to Nature Relationships

I try to think back when the majority of the world was pristine. When humans were closer to the environment. There are many examples of visual imagery from the past that illustrate the intimate connection of artists to their surrounding environment.

Historically, art has not only been a way of documenting the landscape through representational painting or sculpture. It has been more about underlying factors that reveal how humans relate to nature. We can look back through history to understand more about how various cultures and attitudes changed over time. Evidence of the artist to nature relationship can be seen in various ancient cave paintings around the world. A cave painting dating back to over 40,000 years ago is located in the El Castillo cave and depicts animal figures. Little is known of why these visual communicators, who were surrounded by and subjected to forces of nature, represented such natural imagery. In other artifacts, theories have developed regarding ceremonies associated with the changing of seasons such as in the Stone Henge located in Salisbury Plain, England circa 2000 B.C.

While observing examples of art from ancient times, one can see how the past creators revealed a consistent respect and connection to their natural environment. Etruscan artists depicted a culture that celebrated and embraced nature, as evidenced by those in their wall paintings located in various tombs. Here, murals decorated the walls with dancers and musicians among the trees and birds. In 1000 AD Egyptians represented columns, holding up the high ceilings of temples, as giant papyrus plants. The papyrus plant was a valuable resource in Egypt, where it originated as the first form of paper, for people to use for written correspondence. Throughout other parts of the world such as China, scenes inspired by nature continued to be popular. Chinese artists painted Buddhist temples, set in misty mountains after rainstorms, with ink on silk fabric.

During the Renaissance Era, artists were combining new techniques and styles with contemporary knowledge of science. In 1482, Sandro Botticelli painted Primavera, also known as Allegory of Spring. The painting provided a different way of communicating the lush, fertile spirit of spring through the use of imagery. People existed, danced and mingled with the natural elements of their surroundings.

Nearly 300 hundred years after Botticelli Primavera, artists were creating paintings called “Outdoor Conversation Pieces”. These paintings were more portraits of wealthy people depicted in the foreground of the land they owned. Thomas Gainsborough is known for the portrait of Mr. and Mrs. Andrews (Fig. 1) and their vast estate nestled in the beautiful English Landscape with gold and green fertile fields. The couple proudly sits in the foreground of their property on about 1/3 of the painting. 2/3 of the painting is left for the audience to gaze deep into the landscape, across the rolling hills. Such a painting communicated the land use during that time.

**Fig. 1.** Thomas Gainsborough, Mr. and Mrs. Robert Andrews, Oil on Canvas 27.5 x 47 in, National Gallery, 1748

In the mid-1800's, an artist named, John Ruskin believed that all art should express a supportive role towards nature. In his painting, Fragment of the Alps (Fig. 2), the viewer gazes on the beautiful detail of an ordinary boulder. The colors and features of the rock are skillfully detailed and inspiring. Such rock fragments are distributed over the wondrous landscape of the Alps. [1]

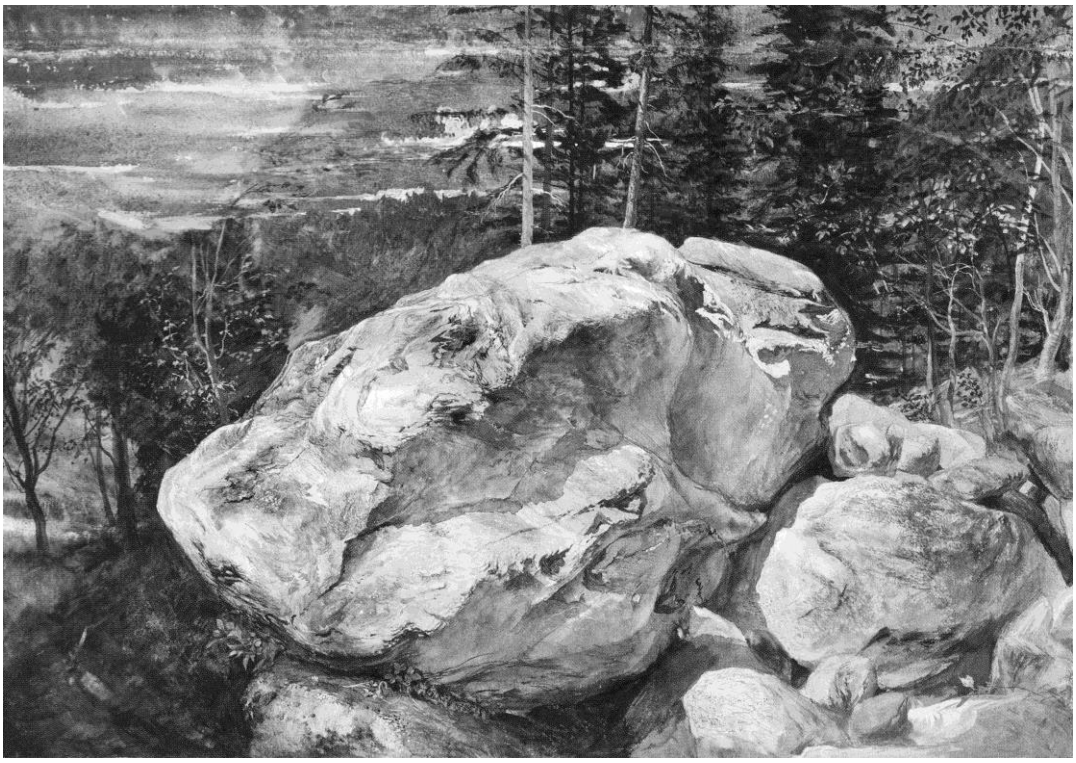


**Fig. 2.** John Ruskin, Fragment of the Alps, Water color opaque watercolor over pencil on paper, 13.2 x 19.4 in, Harvard Art Museum, Cambridge, MA, 1854-1856

## Contemporary Art about the Environment

Simply inspiring others to appreciate the natural environment through art still exists but today artists are also expressing alternative ideas and feelings about nature. Contemporary art about the environment can effectively combine social and natural history enabling the viewer to appreciate a healthy environment. Like, John Ruskin, artists have found themselves in a similar practice of the "artist as naturalist."

Many creative people have a unique ability to affect positive environmental change. This is crucial at a time when humans are imposing an overwhelming burden on the earth's air, water and food supply. The human population's insatiable hunger for natural resources such as oil, minerals, natural gas, and wood is leading to an unbalanced eco-system. The consequence of this quest is nothing less than disappearing species, undrinkable water and air that is no longer safe to breath while contributing to the accelerated warming of the planet. As people become more distant to our land, innovative techniques to bring communities and the environment together are needed. Artists' new ideas and abilities to make connections across various disciplines make the artist's role invaluable in solving a variety of environmental problems. Through collaboration and the guidance of experts in various fields of environmental study, artists can actively engage, enlighten, and educate their communities about their natural environment. [2]

Contemporary art about the environment today may stem back from the environmental art of the late 1960's. Work from Robert Smithson in 1968 was titled "Earth Works" and took place outdoors within the natural landscape. These series of works opposed conventional materials for art making by using the land as the medium. The earth was his canvas. Since the work's original meaning and presence was within the landscape, documentation through photography offered a virtual experience for the viewers who would walk through Smithson's art gallery exhibitions. [3]

In 1982, a female artist of the name Agnes Dennis established commentaries on human values and misplaced priorities regarding how society might be ignoring concerns about how we are managing sustainability on the planet. By focusing on world hunger, her work called "Wheatfield-A Confrontation" involved the planting of 1,000 pounds of wheat planted on a vacant two-acre lot in lower Manhattan. On behalf of "The International Art Show for the End of World Hunger" the harvested wheat eventually toured 28 cities around the world. The documentation of her work through photography still continues to inspire many artists 30 years later.

Digital media has also provided artists great opportunities to visually communicate their ideas. Chris Jordan works in great detail through the use of digital tools in order to create shocking images of the consumer culture. One of his works shows the land filled with two million plastic beverage bottles, which is equal to the number of plastic bottles that the US uses every five minutes. The combination of imagery with the data heightens the awareness of how much plastic is disposed of in society. [4]

Social change can be implemented through the enormous power of creativity in design. In such organizations like "Design Ignites Change", creative professionals and students have the opportunity to utilize a technique called design thinking and creativity to improve the lives of people and their communities. Various projects may include the designing of smart phone apps that help monitor better choices to reduce a person's carbon footprint; posters that help promote recycling or environment awareness; and various products that may use recycled materials or implement sustainable actions from its consumers. [5]

Artists and designers represent the most contemporary values of our times through their work. They evoke ideas not only from what they perceive but also from each other. Today the use of the Internet and social media has provided advanced windows into the world of social values and ideas. Our new age of acquiring information may promote the evolution of ideas instantaneously. Websites such as Inhabitat.com have become portals for creative people who hope to save the world through their creations. Inhabitat.com is "devoted to the future of design, tracking innovations in technology, encouraging practices and materials that are pushing architecture and home design towards a smarter and more sustainable future." Visual global communication can be accomplished through valuable online resource guides that promote current innovations in sustainability and environmental awareness. [6]

My work is designed to embody the result of extensive research and personal passion towards the environment. The forms I create are metaphorically composed of specific materials and media into art that

represents or challenges reality. Through environmental interaction and studying a variety of eco-systems such as vernal pools, marshlands, ponds, rivers, streams and suburban backyards I am inspired to create works that depict my visual interpretation of the unique characteristics of each of these eco-systems. Some distinguishing characteristics that have led to some of my creations are spring peeper frogs, honeybees, and fiddler crabs. Beyond biodiversity my work also highlights the significance of the non-living aspects of the environment such as water conservation and land management. During a critical point in time, with our planet precariously balanced on the verge of great environmental impairment, areas such as water conservation, land management, and the protection of ecosystems are vital to the continuation of all living things.

## Water Has No Boundaries

My most recent work comes in the form of a large-scale sculpture expressing the critical necessity for clean water. Appearing as a contorted fence lifting off the ground, "Water Has No Boundaries" (Fig. 3) is a sculpture that rolls across the floor like a flowing stream fragmented from the landscape. Inspired by the need for clean water the sculpture uses 900+ samples of water that were collected and preserved in glass bottles from 60 waterway locations from Eastern Pennsylvania. The sculpture appears to be floating even though the large amount of water makes it incredibly heavy. Each bottle is labeled and corresponds to a range of locations on a map to further reinforce that water has no boundaries. It conveys that all water is ever moving and can easily flow into another body of water. The sculpture raises the viewer's consciousness of the fragile connectivity of all bodies of water. The significance of this piece is that it demonstrates the crucial stakes of protecting even the smallest body of water. The value of water to all living things is well understood however the idea that all water is connected is often lost on many people. The hope is that this piece will give people pause the next time they encounter pollution on any body of water, from a large river to the smallest mountain stream. It is intended to impact the psyche of all who view it and make them aware that they are stakeholders who play a valuable role in protecting water regardless of its size or location.

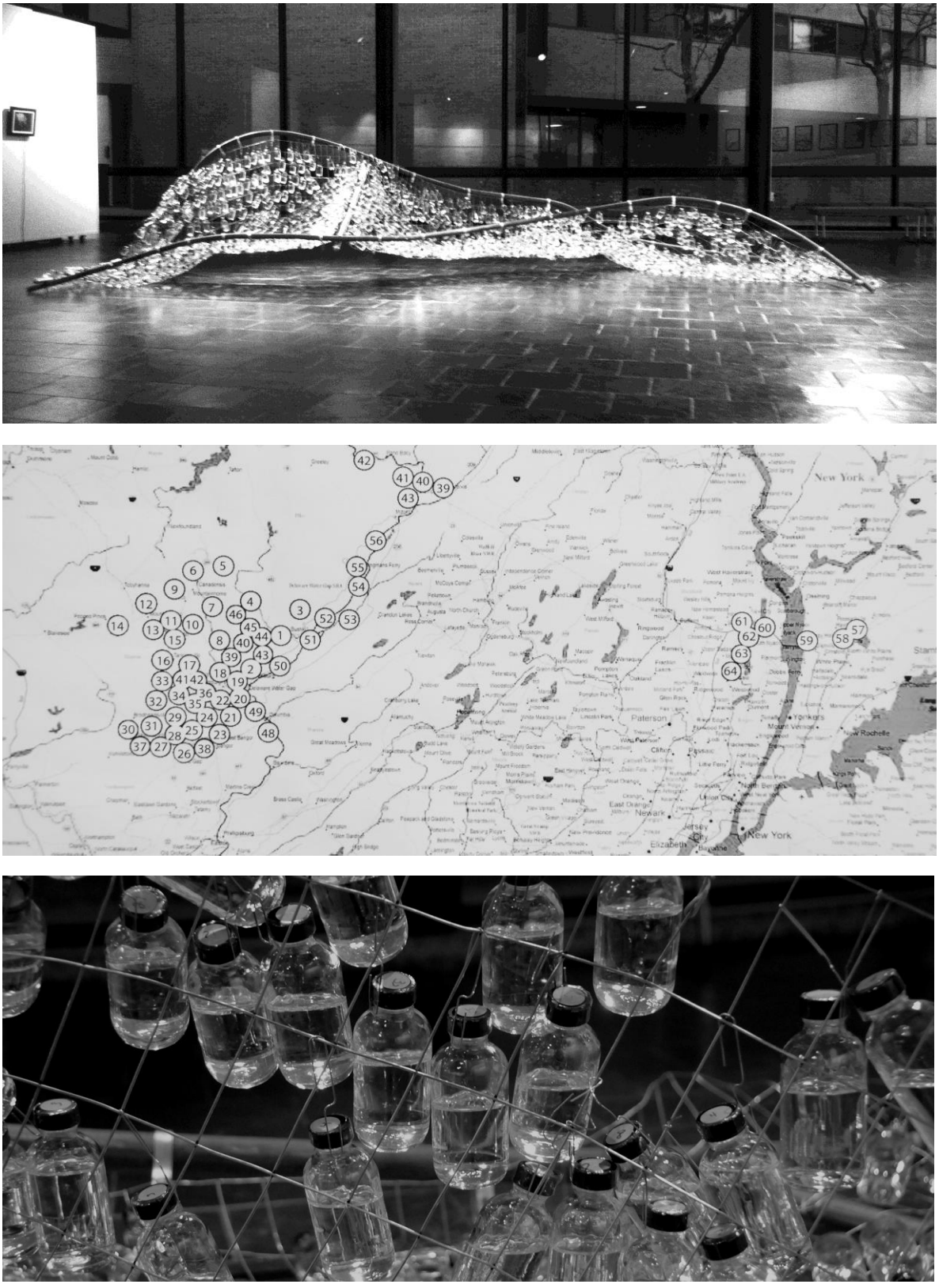



**Fig. 3** Darlene Farris-LaBar, Water Has No Boundaries, 900+ Glass shrink wrapped bottles filled with water from 60 various locations, fencing material, The map shows the various locations where the various samples came from. The detail image shows the bottles with the location numbers.

### Rhythms of a Whole

"Rhythms of a Whole," at Sykes Gallery, Millersville University of Pennsylvania was an environmental art installation that integrated sound, video, watercolor paintings and sculpture. This show was developed as the result of research outlining the importance of bees to the environment. The bee is a transport for the continuation of life for most plant species. Pollination is one of nature's best examples of the co-dependency that exists between different forms of life. As the bee collects nectar for its own posterity it gives continued life to the plants it visits. These plants provide a large part of the foundation of all living things. Without them as a food source and their oxygen creating respiration all living things would cease to exist.

The sculpture is constructed of simple brown paper bags that are used by most people as a way to package food for their children. The bags were chosen to create the honeycombs because they represent the food storage of the brood in a hive. In recent years there has been growing evidence of the deleterious effect of chemicals being transported back to the hive as the adults deliver the nectar needed to feed their young. The idea that the adult bee is unknowingly destroying its own youth as it attempts to provide life-sustaining nectar demonstrates a cruel irony. The brown bags, used to feed children, make a frightening connection to the harmful effects of chemicals on humans. Since bees are ever flying across boundaries hopefully this piece will promote an awareness and understanding of these small, vulnerable, very important creatures to the existence of all species. It is to create a sense of understanding that all people must consider the impact of pesticides.

## Symphony on Shallow Water

This exhibit called "Symphony on Shallow Water" (Fig 4) is an installation about vernal pools and the spring peeper frogs that inhabit these vulnerable bodies of water. Vernal pools are temporary oasis for amphibians that provide the required elements for the continuation of these species. At first glance they appear to be nothing more than a large puddle on the edge of the forest resulting from the spring thaw. However, upon closer observation it becomes evident that these pools are the breeding ground for much new life providing protection from natural predators such as fish. Due to rapid and often unchecked development, along with pollution, and the filling in of wetlands, these vernal pools are in great peril. Without vernal pools, spring would not have those harmonic sounds of the tiny spring peeper frogs. Even more distressing is the threat to numerous other amphibians and the resulting effect on the food chain if these species cease to exist. This exhibition was a compilation of sound, video, educational signage, watercolor studies and sculpture intended to entice the senses and communicate a better understanding of the immeasurable value of vernal pools as a habitat for many important species.

Additional work in this same show was designed to provide an understanding of life in a saltwater marsh. The focus of this work was the unique and entertaining fiddler crab. (Fig 5) The medium used for this show consisted of video and lenticular art. Movement was the inspiration to this work. The fiddler crab employs a unique rhythmic swaying motion during its mating ritual. The emphasis of this swaying is on the large bright yellow claw of the crab. Also emphasized is the sudden retreat back into their individual private dwellings in the sand. These movements can only be appreciated through the use of video, photography and lenticular art. The lenticular art was of particular significance. It allowed the viewers to interact with the crab by moving themselves back and forth in front of the piece. This simulated the traditional movement of the actual mating ritual.

**Fig. 4** Darlene Farris-LaBar, Symphony on Shallow Water, Sculpture composed of an old dock, the artists boots, marsh grass and video of tadpoles, sound composed of spring peeper frogs, watercolor paintings/illustrations and lenticular art also were included in the exhibition


**Fig. 5** Google Earth Map of Chincoteague Island used to reference the location where the study of Fiddler Crabs was performed.

**Mountains For Insects**

The sculpture called "Mountains for Insects" (Fig. 6) is a large-scale sculpture that represents land mass and territories. This sculpture is part of a series that represent a variety of forms found in the landscape. They are portable landscapes that can be placed in settings such as a city. The hundreds of flowerpots are pieced together like a blanket and placed over a landscape-like form. Each flowerpot maintains its own identity while acting as a part of a whole. It can be thought of as a land mass mosaic. It offers varying perspectives acting as a small hill for humans yet equaling a mountain for insects. People claim ownership of land often disregarding the value it has to other walks of life. A person may see such a small hill as somewhat insignificant yet it is capable of being a vast valuable land for smaller living creatures. The purpose of this piece is to encourage thought and discourse about the responsibility of land ownership.

**Fig. 6** Darlene Farris-LaBar, Portable Landscape, Mountains for Insects, 300+ flower pots sounds composed of bees and monks, video of bees, watercolor paintings/illustrations

## Conclusion

By providing an experience of the natural environment through visual communication it may be possible to create more stewards of that environment. This information, to often, is presented in a mundane fashion that loses the interest of the audience. Communicating environmental problems through art can stir up diverse responses from the audiences, or stimulate a profound connection or experience and accountability on a more personal level. By combining scientific research with visually stimulating imagery a new level of interest can be attained. The mind begins to formulate new pictures that it would have never been able to conjure up on its own before this experience. The imagery holds the imagination of the viewer allowing for the science to take hold in the long-term memory, thus leaving an indelible impression that the viewers will carry with them indefinitely.

I view my art as a way to provide this environmental imagery experience that will raise questions about the human relationship with the Earth. Its intention is to inspire creative thought and educate the public about alternative ways to communicate sustainability and environmental awareness. Today, more than ever, there is a need for newer tools of communication to address major environmental and sustainability problems. It is my desire that my work will become a catalyst for in depth conversation pertaining to protecting the natural

environment. Only through raising awareness and sparking discourse on this important topic can it be expected that people will start to make better decisions. It is my profound desire that my art may accomplish these goals.

## References

1. Parks, John. Masters: John Ruskin and His Influence on American Art. *Artist Daily*. Web. Oct 2007. http://www.artistdaily.com
2. Matilsky, Barbara. Fragile Ecologies: Contemporary Artists' Interpretations and Solutions (New York: Rizzoli International Publications, Inc, 1992)
3. Kastner, J., Wallis, B., Land and Environmental Art (London: Phaidon Press, 1998), 23
4. Mok, Kimberly. Top 5 Environmental Artists Shaking Up the Art World, *Tree Hugger*. Web. Feb 2009 http://www.treehugger.com
5. Randall, Mark. Design Ignites Change. Web. 2013. http://www.designigniteschange.com
6. Fehrenbacher, Jill. Inhabitat. Web. 2013. http://www.inhabitat.com

# ArcGIS Online as a Decision Support Tool for Community Development Projects in Imbabura - Ecuador

Iván Bedón

Pontificia Universidad Católica del Ecuador Sede - Ibarra
Av. Jorge Guzmán Rueda y Av. Aurelio Espinosa Pólit. Ciudadela "La Victoria",
Ibarra - Provincia de Imbabura - Ecuador

nibedon@pucesi.edu.ec

**Abstract.** This work started by a field study oriented towards the organizations of FOSPI. It was carried out in coordination with the Imbabura Corporation, in order to develop a technical diagnosis to determine the current status of such organizations in the areas of health, education, housing, population density, roads, floods, geological faults, protected forests, soil fertility, and climate for decision making in development projects with the support of a geoportal. The design and creation of the geoportal consist of two parts: the first refers to the creation and editing of data in ArcMap 10, the second involves with the settings in ArcGIS Online geoportal. The geoportal allows the manipulation and processing of online geographic information to visualize and analyze better the fundamental variables that directly affect certain projects.

## Keywords
Fospi, Federation of Social and Popular Organizations of Imbabura.

## 1 Data collection and editing

Once geographic data obtained through the portal IDE Imbabura Provincial Government [5]. The creation and editing of these data is performed through ArcGIS Desktop ArcMap 10 for which we take the following steps: we joined ArcMap to add and edit information on the maps, so this creates three layers are: Fospi, parishes and basemap (OpenStreetMap). Fospi layer, this layer consists of the geographic location, organization name, representative, address and telephone number of each of the associations belonging to the Federation. Parishes layer, this layer defines the boundaries of each of the parishes of the province of Imbabura. [1]. Basemap Layer, considering the overall environment for the base map as the background image more appropriate to show the different situations of each association, thinking about maximizing the resources provided by ArcGIS Online OpenStreetMap is considered by its wide reaching display level scales up very small compared to other online base maps. [4].

Fospi layer is created from a Feature Dataset with a coordinate system WGS 1984 Mercator Word local geodatabase in ArcMap, to maintain the same coordinate system in all geographic data, the same that is called as Associations and within This creates a point Feature Class who is called Fospi. Using ArcMap editor started creating sites by using the Feature Class points, where they settle each of the associations in the map of the province of Imbabura Ecuador, to finish creating these points recorded editing [3].The function of the base map, OpenStreetMap, is to allow greater accuracy in the location of the associations through support of its broad magnification level. Then export the layer information indicating the route Fospi which to save the information layer Fospi Associations shp format.

Once you have the data layer Fospi Associations, proceeds to compress the generated files in the. Zip thus has the first layer is ready to be used by this geoportal ArcGIs Online . Meanwhile, the downloaded information portal IDE Provincial Government, was distributed in layers georeferenced data most relevant for our purposes [2].

The edition of each layer starts to verify the information found in the database, whether data or fields that are not important for this research topic layer is removed, otherwise the data layer and fields are edited according to the nature of your information and the needs of this research. After finish editing all imported layers, we proceed to export the same, indicating the path where the file is saved. Shp containing the list to post information on ArcGIS Online [5], [6].


**Fig.1. Settings ArcGIS Online**

Once you save the file with a. Shp, are compressed in Zip for import properly formatted in ArcGIS Online. Edited layers were: housing, health, poverty, population, parishes, education, climate, protected forests, natural hazards.

## 2 Geoportal configuration in ArcGIS Online

The geoportal configuration is divided into five steps are:
a) Register
b) Select the base map
c) Creating and adding edited layers
d) Issue and change symbology
e) Generation of thematic maps

### 2.1 Register.

The registration was performed webwww.arcgis.com page, the advantage of the ArcGIS Online subscriptions are the facilities to publish data in ESRI's cloud and set up a website to manage content and users [4].

### 2.2 Selecting the Base Map

At the interface of ArcGIS Online, a map is created as a data layer in the flange (base map) for this research requires a base map that is semi-transparent to show the important geo data of the province where the associations Fospi , so it took into account the background map (Light Grey Canvas) as the basis for this geoportal [4].

### 2.3 Creating and adding layers

The layers are added from the stored compressed file, this process is repeated for each thematic layers in ArcMap edited. After the import of layers in ArcGIS Online, these layers can be managed from the Internet without needing to install any GIS software [4].

### 2.4 Editing and changing symbols

Editing and changing symbols is done to achieve a better understanding of the visual representation of georeferenced data [5].

### 2.5 Generation of Thematic Maps

The generation of thematic maps in ArcMap was performed for each of the edited layers. The finished map is saved with the same layer name for easy identification [5].

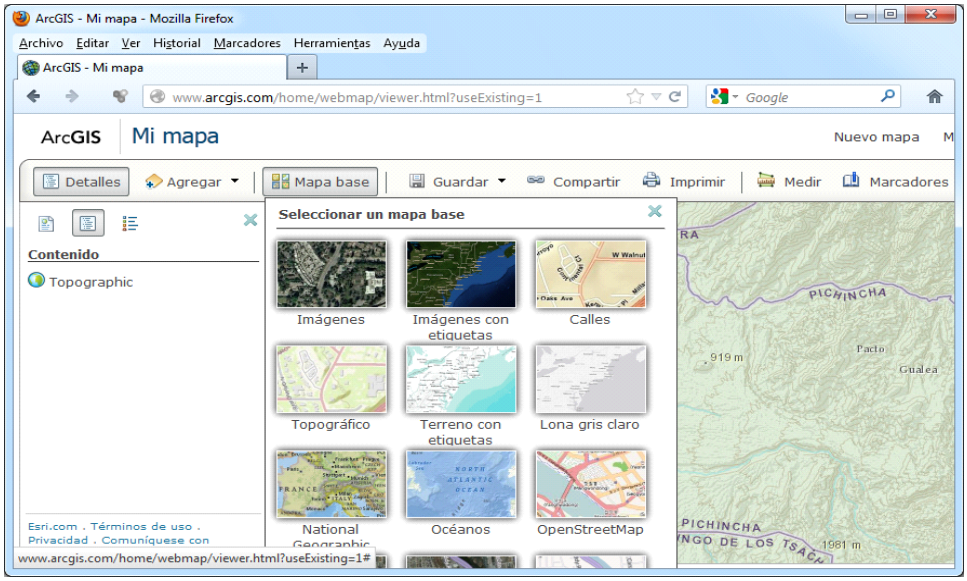



**Fig.2. Basemap ArcGIS Online**

The aspects evaluated associations Fospi in this project are: quality of health, quality of education, quality of housing, affected by floods, affected by faults, geological paths affected by, affectation protected forests affected by extreme weather swings, infertility affected by terrain, level of population density, level of self-management of projects [7].

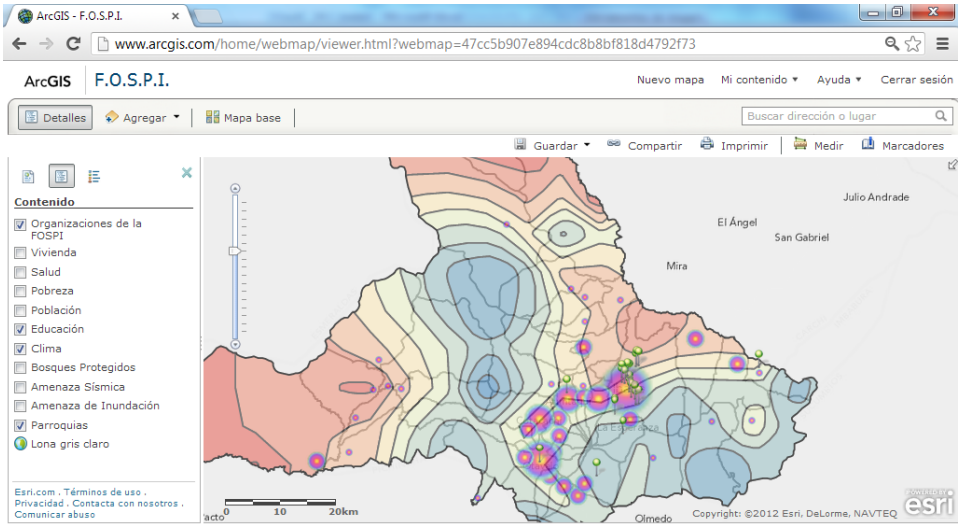



**Fig.3. Layers in ArcGIS Online**

## Conclusions

The cloud computing technology is useful in structure as geoportal solves the problem of having multiple servers and integrate through trained staff allowing interoperability with GIS.

The geoportal Fospi with ArcGIS Online, is a platform to which other interested parties can add value and new developments, expanding the availability and quality of information.

## Acknowledgment

This research is funded by the Imbabura Corporation and FOSPI.

## References

1. Alvarez, D. V. (15 de octubre de 2010). *Corporación Imbabura*. Recovered on March 27, 2012, from http://www.corporacionimbabura.edu.ec/index.php
2. Bedón, I. (2012). *Geoportal Fospi*. Ibarra.
3. Chappell, D. (Septiembre de 2010). *GIS in the cloud*. Recovered on July 29, 2012, from http://www.esri.com/library/whitepapers/pdfs/gis-in-the-cloud-chappell.pdf
4. Esri. (29 de Septiembre de 2012). *ArcGIS is Now Online*.
5. Esri. (27 de septiembre de 2012). *ArcGIS Resource Center*. Retrieved from http://resources.arcgis.com/es/help/getting-started/articles/026n0000000v000000.htm
6. GPI. (12 de julio de 2012). *IDE Provincial Geoportal Imbabura*. Retrieved on September 2, 2012, from http://186.46.93.70/geoportal_imbabura/?q=node/93
7. Fundació Universitat de Girona. (27 de mayo de 2012). *La plataforma de aprendizaje en SIG libre*. Retrieved on August 18, 2012, from http://www.sigte.udg.edu/formasig/index.php?page=curso-sig-cooperacion.

# International Environmental Dialogue in South America - Discussing Common Interests in Environmental Information and Communication -

# CEGeoIC2013 Bogota Conference Report

Horst Kremers[1], Alberto Susini[2], María Angela Torres Kremers[3]

[1]Chair, CODATA-Germany
P.O.B. 20 05 48
13515 Berlin, Germany
office@horst-kremers.de

[2]Alberto Susini
11, Chemin Petit-Montfleury
1290 Versoix, Switzerland
alberto.susini@geneva-link.ch

[3]Communication Scientist
P.O.B. 20 05 48
13515 Berlin, Germany
office@maria-angela-torres.net

## 1 Organizational Details

CEGeoIC2013 was organized by

CODATA-Germany, the German National Committee for the ICSU Committee on Data for Science and Technology

in cooperation with

National University of Colombia, Bogota
Human Sciences Faculty, Department of Geography

International Congress of Environmental Sciences, Colombia
Congreso de Ciencias y Tecnologías Ambientales, Colombia (CCyTA)

CODATA Taskgroup on
Preservation of and Access to Scientific and Technical Data in/for/with Developing Countries

International Cartographic Association
Commission on GIS and Sustainable Development

INTERCARTO / INTERGIS Conference Series

International Cartographic Association
Commission on Cartography in Early Warning and Crisis Management

This International and Interdisciplinary conference was sub-titled "Achieving Sustainability Goals through Knowledge Sharing" and was dedicated to scientific and technical methods of environmental information and communication. Special regard was given to the central role of Geoinformation.
The CEGeoIC conference provided a forum for the presentation of scientific papers illustrating the efforts of the research community, professional papers describing the cutting-edge methods employed by environmental

and geoinformation organizations and companies, furthering their national as well as international collaborative efforts to advance knowledge and techniques of environmental information and communication.

CEGeoIC2013, the International Conference on Geo- and Environmental Information and Communication, welcomed 55 participants form 15 countries.

The program of the international conference consisted of 12 sessions. Parallel to the English language international conference there were 3 workshops in Spanish language organized by PROSIS S.A. Bogota, main sponsor of the Conference, on the application of Geoinformation in the broader domain of environmental practical applications, intended for participants from Latin American technical and administrative organizations and public administrations. These workshops had a total of 150 participants.

## 2 The Opening Ceremony

In the Opening Ceremony, representatives of the four partner and guest organizations gave welcome addresses:

- Dr. José A. Lozano, General Secretary of the Colombian Academy of Physical and Natural Sciences, Bogota, Colombia
- Paulo Menezes, ICA Vice-President, Rio de Janeiro, Brazil
- Prof. Dr. LIU Chuang, CODATA Taskgroup on Open Data in/for/with Developing Countries, Beijing, PR China
- Prof. Vladimir S. Tikunov, ICA Commission on Sustainable Geoinformation, Moscow, Russia

## 3 Overview of the Program

The climate change in Colombia was foreseen to have as consequences, a rise of 0.8 C in the continent that will bring a warming in the tropical and seaside regions of the country. Other climatic variables will bring changes in precipitation, more cyclones, increased annual main rain, accelerated glacier retreat, lowering of lake levels and rise in the sea level. A local complex environmental management scenario forecasts a decrease in precipitation in the Pacific regions, over the Andean region and Caribbean regions. A rise in the annual precipitation is expected in the Cordillera, Magdalena and Cauca regions.

For the vegetal classification evolution, the forecast is of a diminution of the Andean and paramo vegetation and a rise of the dry ecosystems, which will lead to a rise of 6% of the national territory.

The presentation on the forming of the spatial data infrastructure in the arctic regions shows that this topic has achieved a high political priority inside the polar research field in Russia and Japan. Very different fragile zones adjacent to the arctic area are facing different sets of priorities discussed in Russia (social, natural and economic, due to gas and oil drilling). The preservation of the cultural heritage of national minorities and the lack of proper juridical management of local authorities, are also very important issues. However, interesting perspectives of local development came from a kind of ecotourism, involving the local cultures and visitors coming to study them. Forthcoming results of the new circumpolar Atlas of Arctic Regions will be linked to geoportals, standards of metadata and cartographical web-services. New developments of mathematical models are needed for evaluating criteria of a sustainable development of the region. It was also suggested to organize more international conferences near to the local people such as the Tchukotka.

In the case of the United Arab Emirates, the GIS approach of evaluating the coastal sensitivity is part of the national master plan. The rapid changes due to the economic development affected also the people culture ecosystem. The east coast is a very sensitive area. A strategy master plan was developed in order to have a

roadmap for future decision making processes. This approach was performed by the connection of spatial data and a growth probability map was createdfor the most likely situations.

The Salzburg mining urban mobility project,t based on the use of electric vehicles, was presented as an important project to reduce the major part of air pollution. Battery capacities, human movement patterns and energy consumption of vehicles were carefully analysed. This study shows that traffic flow and energy consumption follow a regular pattern which is predictable for future states of the road network linked to a reduced energy consumption.

An analysis of the vegetal region in Mexico's Usumacinta region used the Chomnitz forest transition theory. The study used polygons and Kernel's method for measuring the density per unit. The changes in the last twenty years were analysed, and showed that ecological, political and economic factors are all involved. Further studies will benefit from the involvement of indigenous people in a better forest management policy in the framework of global warming.

The Enid studies showed the need for local spatial and geographic information, in order to interact with the political authorities for a proper decision-making. The study area involved 25 communities, for which the spatial location and degree of connectivity in this community is determined. The farming system was considered relative to the technological and commercial aspects.

An agro-ICT backbone was also presented, together with future perspectives of developments in central and South America. This EU funded project, certified by the EU Joint Research Center (JRC), gives concrete indications to farmers via a planning documentation, energy nutrient balance, cost-profit margins, business plan, insurance data and thematic maps. This large EU project involves more than one thousand farmers in Germany, Austria and Slovakia.

Interesting and promising results of Geo 3D map models were presented with specific application results which can be immediately seen and understood by a large public. It was successfully used for the Guimaraes public participation during the consultation of a master plan. This kind of innovative instrument will help towards a better public involvement during complex procedures of long term urban planning.

In Chile, the production of accurate wind maps environmental information was also used successfully for optimizing decision making.

The successful implementation through Web 2.0 technologies, of a collaborative Geo-Citizen approach in Ecuador through the use of the Ushaidi platform on a voluntary basis was discussed with an accurate map of participants.

The Russian study of mapping memorial plants in the historical buildings of the Orthodox Church showed the importance of including the spiritual dimension inside the climate change and sustainability studies, these sensitive aspects of involving local and indigenous people relations to their trees was also noticed as very important by Colombian ecologists in the debate of the presentation.

## 4 The RISK Session

The risk session began with the presentation of the Brazilian oil spill mapping project. The oil spill calculation methodology was supported by the International maritime organization (IMO) and the first atlas was made in the Campos Basin Region along the Rio de Janeiro region. One of the main objectives was to identify the most sensitive coastal ecosystems. Strategic, tactical and operational maps were considered and a coastal sensitivity index was created. The project currently has 57 people working on it, and will finish in July 2013.

An innovative aspect of hazard analysis was also developed, taking a better account about the affected health of people and obtaining a better understanding of the psychological factors seen during and after a disaster.

Mental aspects of recoveries and also the inclusion of economic impacts inside disaster curves, will help for a better crisis management.

The managing of complex situations in disaster information is an extremely important issue that involves an optimal management of facts, context, syntax, semantics and pragmatic goals.

## 5 The Risk Panel Discussion

The Risk Panel Discussion showed that the deep religious feelings of indigenous people relative to tree vulnerability from must also be taken account. Cultural heritage management is an essential part of sustainability and post-disaster management that needs to be integrated in appropriate design tools. A closer link to nature and the benefits of plain common sense was also discussed in the panel. The link to past events such as flooding of the German Elbe river underlines the link with an appropriate prevention strategy for investment and prevision of technical and organizational security measures. Post disaster costs must be better assessed and normalized in order to allow a more efficient financial strategy for financing prevention goals. The ethical issues are part of this complex process and must not be forgotten. These issues, especially useful in developing countries, must be part of the Global Exchange Strategy discussed in the panel. The importance of the sharing of knowledge and experience (such as in the CODATA working groups) was discussed and identified as being crucial for developing countries. Improved forecasting methods for better taking account of the preventive actions and resources needed, are also important, as are precise exchanges on best practices. The knowledge management via digital newspaper analysis, combined with geographical analysis, will be interesting. Changing values of perception of risks with people from different cultures and stakeholders from developing countries was also part of the panel discussion. The Santa-Marta accident just before the conference, involving the Drummond company, in which 500 tons of coal were spilled in the coastal waters, and the ensuing complex conflict between environment and economic development, showed the importance of these topics as discussed during the meeting with the.

## 6 Risk and Environment Communication

The involvement people and their engagement in environmental and risk situations was the focus of this session of the Conference.

Art and artists have been a source of knowledge of how in ancient times man felt connected to nature and the environment. Contemporary art is now also expressing alternative points of view and perceptions about nature. This kind of art can help to show and transmit feelings of healthy environments, in contrast to the harmful actions against nature, and highlights the natural positive relations to it. Artistic involvement in the environmental issues linked to water pollution and risk perception was originally presented by different forms of sculpture and creation. This kind of art also included the sound dimension and helped people to better work for the environment with their different senses. Three dimensional field guides also helped in a better involvement of the public. How contemporary art related to the environment can improve data mapping was also an aspect discussed. Successful risk communication from the point of view of the people at risk relies on many factors, found by expert opinions and learned experiences. These aspects are related with the communication situation of people prior to, during and after risk events.

A case study about a small rural city in Canada (2000) showed how the complex interactions between systems linked to cultural paradigms of management, scarce and low quality (ineffective) media risk-alerting information and political habits, as well as other factors, can result in clearly harmful situations. In risk management not all is technical and scientific: culture is also a very important point of view management issues linked to the spreading of news and the role of the media were also discussed. Media information alone

in “risk-alerting” situations proved to be inadequate for the people in Walkerton, Canada when the E-Coli contamination of the water supplies occurred.

Participation, involvement and information as crucial activities in Environment were also a theme treated in this session, related to the digital information scenario available now. Digital Public Environmental Observatories used as Virtual Public Arenas and communication channels open a broad field of action, interaction and social construction. Despite the political relevance of open access of data on environmental issues as a democratic principle (Free-Flow of Information), and as factors of confidence and credibility, the access and availability of environmental information in services of public institutions are not just a necessity, or an example of e-governance practices. In addition, in the sense of WEB 2.0 developments, what is needed are sources and fields, “arenas” of the collective definition of environmental problems. Although online communication itself does not generate a network public sphere, the interaction in the Internet of agents (experts) engaged in democratic activity may be contributing to such a public sphere. In this sense some agents are more important than others. A comparative content analysis of information available (accessibility), participation tools and interaction showed how these aspects are expressed. A matrix of results of how governmental observatories contribute to the collective definition of Environmental issues was presented and discussed. Fundamental requirements of how data is be effective were cited (accessible, intelligible, assessable and usable).

## 7 Agro-Information

A series of contributions related to GIS methods and techniques in the Agro-Domain of applications were presented by Walter Mayer, of PROGIS Software, Villach, Austria. The Agro-Domain is characterized by directly relating the commercial and trade issues to the obvious consequences to environment. While internal issues of farming optimization decision support are key elements of success, the tools for combined reporting on regional or national level are essential for decision making and control of measures decided by government. The connection to weather and climate information - especially concerning heavy rainfall, drought, hail, biological and other risk situations – directly influences population and animal livestock in the consequences of disasters that arise in more or less repetitive timeframes.

## 8 Panel Discussion on Communication

A panel discussion on how journalists could in future deal with these issues in Colombia followed this presentation, with inputs and proposals for improving the media coverage of environmental and risk issues. Time and a review of previous issues, as well as expertise of journalists and heads of media and their focus on audiences and ratings, are the typical problems of public information and communication on environmental and risk issues. The discussion of social and public communication and information aspects of environmental issues between a scientifically informed group of experts found acceptance from the participants, but without effective communication, their work could not be effective. Joint discussions between communicators, journalists and scientist have to be promoted in these types of scientific conferences.

## 9 General Aspects, Outlook

The CEGeoIC2013 conference met very well its intention to offer a platform for information and communication on a broad international level and thus supported the discussions on further communication and cooperation in a straightforward way. The pleasant atmosphere and service from the hotel COSMOS100, as well as the visits to various tourist and cultural highlights in the city of Bogota were a great assistance to stimulating discussions between participants from all over the world.

The consequences of environmental information for our modern Information Society and its active role in collecting, assessing, and using environmental information have been highlighted in several presentations and discussions. Collaborative and productive users are to be expected on a much broader range of topics and regions. Public "Observatories" can supplement governmental environmental information systems and they are key techniques in situations where no systematic collection and publication of environmental information is yet provided.

A special post-conference meeting of the organizers with President Jaime Rodríguez-Lara and General Secretary Doctor José A. Lozano of the Colombian Academy of Physical and Natural Sciences gave the perspectives of broad and stimulating exchange between scientists, as well as mutual information and communication on strategically important aspects that arise from major international action fields (e.g. UN ISDR – International Strategy of Disaster Reduction, contracts of commerce between European Union and Latin American States etc.).

There was a general consent that CEGeoIC2013 gave a convincing highlight on the relevance of its topics and on the high quality of contributions that could be solicited for presentation and discussion of international science and technology achievements. The organizers were broadly encouraged to continue to realize similar events.

An open eNewslist **LatAmEIC** on Information and Communication on the Environment in Latin America and the Caribbean was installed to facilitate exchange on best practice, documents, events etc. in the English, Spanish and Portuguese languages. Contact Horst Kremers to join this eNewslist or send an eMail to join-LatAmEIC@kbx7.de

**The involvement and active participation of all social groups is a requirement for Sustainable Development. The role that Environmental Information and Communication play in order to develop ways to Sustainable Development Processes and Goals is essential as they empower public engagement through access and sharing of meaningful knowledge, opinions, decisions, plans and actions, about their nearest living environments.**

**Through the development of Information and Communication Technologies, environmental information and its communication have rapidly changed and assume huge challenges to approach broadly with effectiveness and precision the diverse environmental interests, issues and problems faced by major groups all over the world.**

## 10 Acknowledgements

We thank Dr. Mike Gerard for his assistance with the text.

We are especially grateful to Dra. Margarita Marino de Botero (Corporación CVVL, Bogota) for always giving essential and fruitful advice throughout all phases of the CEGeoIC2013 conference.

- empty page inserted -