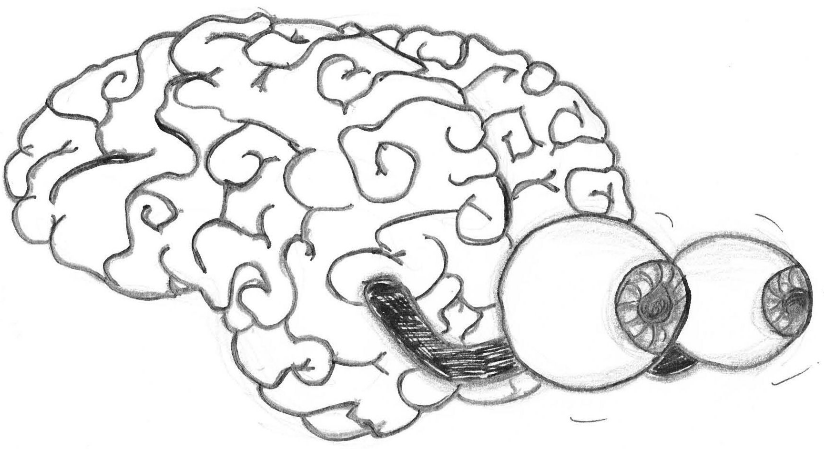
Chapter 7
Visualisation



It was eerie. I saw myself in that machine. I never thought my work would come to this.
Upon seeing a distorted image of his face, reflected on the inside cylindrical surface of the bore while inside an MRI (magnetic-resonance-imaging) machine—a device made possible by his early physical researches on nuclear magnetic resonance (1938).

Isidor Isaac Rabi

Quoted from conversation with the author, John S. Rigden, in *Rabi, Scientist and Citizen* (2000), xxii. Rabi was recalling having an MRI, in late 1987, a few months before his death. He had been awarded the Nobel Prize in 1944, for his discovery of the magnetic resonance method.

Although statisticians consider statistics as a very exciting subject, some could claim that it is one of the most complex to understand. Brainstorm for one minute and write down the first three things that come to mind when stats is mentioned.

Were numbers on the list?
Were tables on the list?
Were questionnaires on the list?

Were graphs on the list?
Were pictures/images on the list?
Were maps on the list?

All of the above should have been mentioned somewhere but we do have our dull moments! Do not worry if only one from the second group was mentioned, since very few people actually tag statistics with imagery. NO, it is not an endless list of figures and tables, it is also transposed into visual realities. In addition, most recent technologies such as the development of interactive content and wider access to spatial information systems has brought imagery to the populous.

This output is called Visualisation. Now there is Visualisation and Visualization!

Visualisation:
Visualisation with an S refers to the actual mental image that one can see within one's mind

Visualization:
Visualization with a Z refers to the process that occurs when one converts data into a graphic representation

Thus the **S** version refers to the image and the **Z** version refers to the process employed to get there.

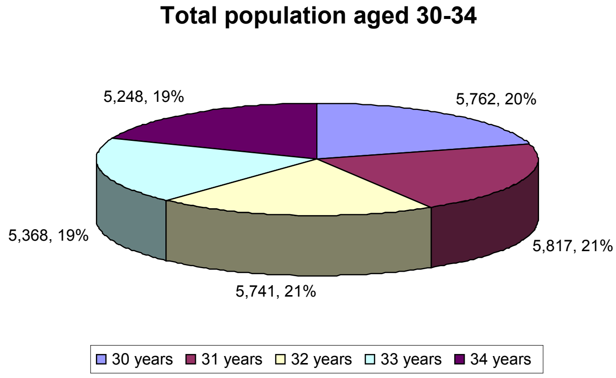
Whilst the final image is important for us to visualise data, the process is to get there is equally important. We shall discuss both in this chapter.

Whichever way one approaches visualization, the outcome is realistic enough to aid researchers in bringing to the fore a tool that renders their research easier to understand.
However this may not be easy to conceptualise for many people. Kindly review the following five visual categories that are linked to the data process. Try to identify them and then check the description below.

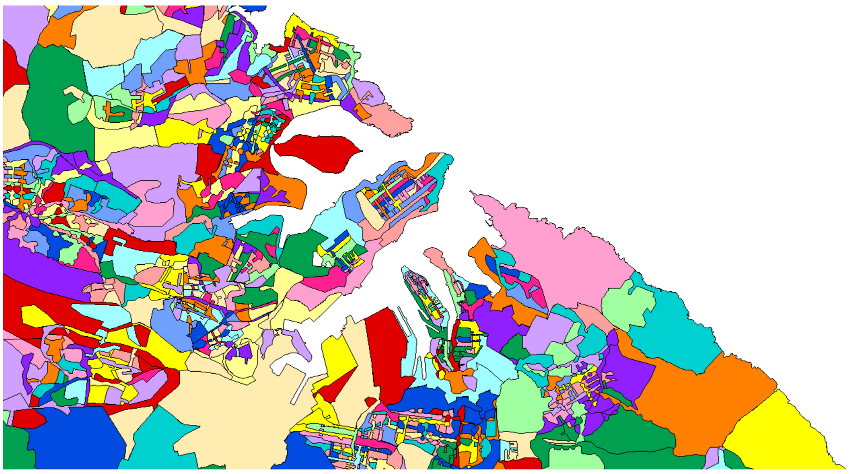
Category 1

Council	Eas_Code	NSO_Code	eas_code_for_route_	Eas_no	M_0_to_4	M_5_to_9	M_10_to_14
1	1	101	11	101	6	8	10
1	2	102	12	102	4	2	4
1	3	103	13	103	5	2	4
1	4	104	14	104	11	7	13
1	5	105	15	105	6	9	19
1	6	106	16	106	10	18	11
1	7	107	17	107	4	8	8
1	8	108	18	108	7	3	11
1	9	109	19	109	6	4	11
1	10	110	110	110	8	5	2
1	11	111	111	111	3	8	17
1	12	112	112	112	5	11	14
1	13	113	113	113	6	3	14
1	14	114	114	114	2	4	3
1	15	115	115	115	5	11	8
1	16	116	116	116	10	9	16
1	17	117	117	117	7	5	13
1	18	118	118	118	8	9	5
1	19	119	119	119	11	15	15
1	20	120	120	120	5	5	12
1	21	121	121	121	9	10	13
1	22	122	122	122	10	14	10
2	1	201	21	201	11	12	10
3	1	301	31	301	10	18	30
3	2	302	32	302	7	10	18
3	3	303	33	303	13	12	14
3	4	304	34	304	14	12	12
3	5	305	35	305	7	9	11
3	6	306	36	306	8	8	10
3	7	307	37	307	8	10	23
3	8	308	38	308	11	8	6
4	1	401	41	401	9	11	15
4	2	402	42	402	13	8	14
4	3	403	43	403	16	9	16

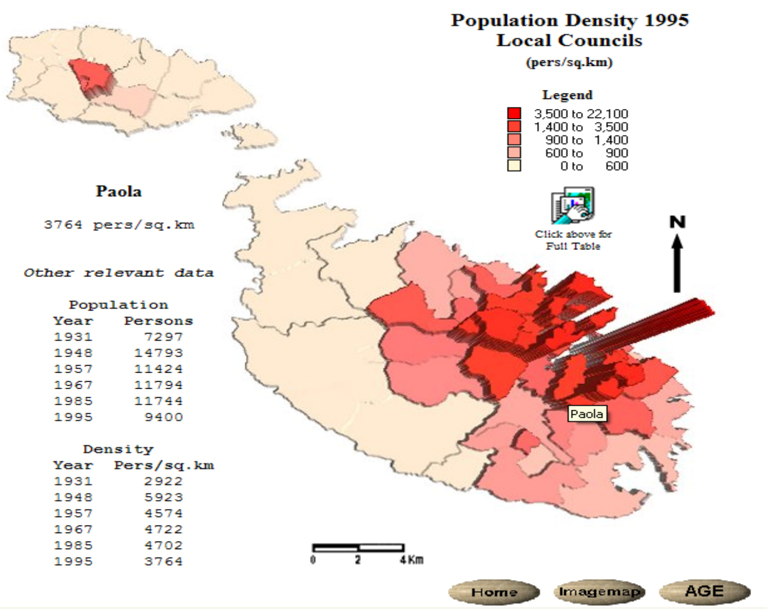
Category 2



Category 3



Category 4



Source: Formosa, (2000)
http://www.mepa.org.mt/Census/archive/age/Pop%20Density/popdens3D.htm

Category 5

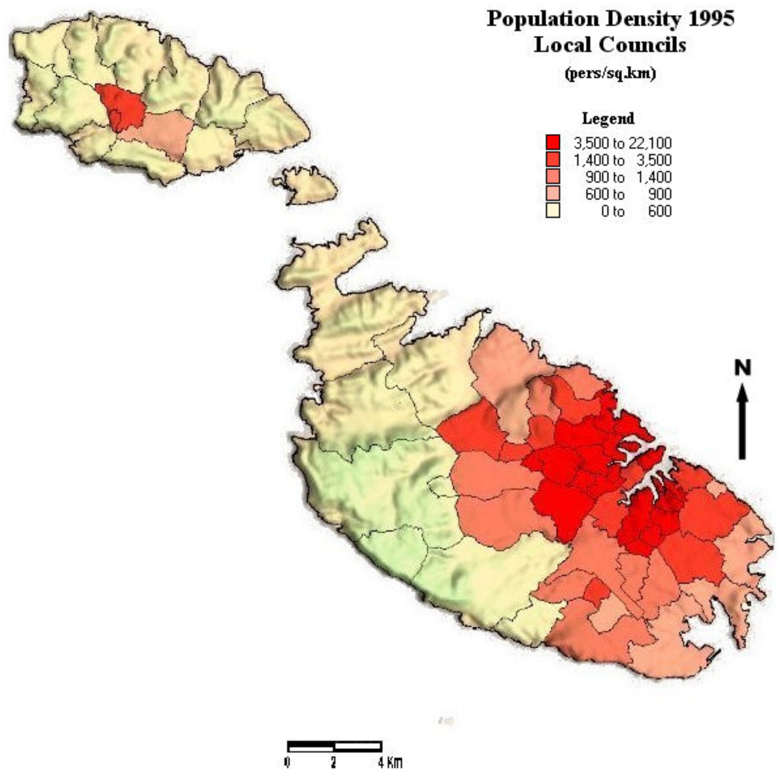
Source: MEPA

The five categories are easily discernible:

Category 1:	Table	Depicts actual data in cells
Category 2:	Chart	Depicts data analysis result in a simple form
Category 3:	Map	Depicts data on a map
Category 4:	3D Map	Interactive map
Category 5:	Photo	Depicts data in purely untainted visual format

Each category serves a specific purpose. One can read data off a table but needs to mentally visualize it in order to understand the relationships between the different attribute contents. The chart can be understood immediately but needs further information which would be contained within a table as there is no description of what the numbers and percentages are actually describing in relation to which population totals. The map is an interesting tool which requires a legend (Figure 7.1) to help readers to understand what those colour represent: is it population, area and if area, is it in kilometres squared, hectares, etc … ? The 3D interactive map takes data visualization to another level. Whilst the map may be difficult to understand, unless one has a tool to visualize it in 3D, the actual data is shown every time the mouse moves over one of the councils. The photo, on the other hand, depicts an image taken from a plane which shows urban development on the ground. It is interesting to note that one can read many items off a map from building types, to roof area, to number of cars to approximate time of days as based on shadowing analysis and a myriad of other data items. Thus, one must not make the mistake of assuming that a photo is a dead image: it speaks volumes.

Figure 7.1: An Example of a Legend



The short introduction given above shows that the eye can read diverse items off a data category. From a simple table to a complex 3D interactive tool, there is a veritable sea of information to be garnered from the use of one of the most vital human senses: sight.

However, visualisation does not stop here. This is only the beginning! The above are just five simple types of visual tools that can be used. An excellent research study by Lengler and Eppler (2007) resulted in the collection of a multitude of visualization methods which they adventurously called the Periodic Table of Visualization Methods. Their work, which is a very interesting case in their comprehensive structuring of visualization processing, was transposed into what is termed the Visual Literacy Project[1].

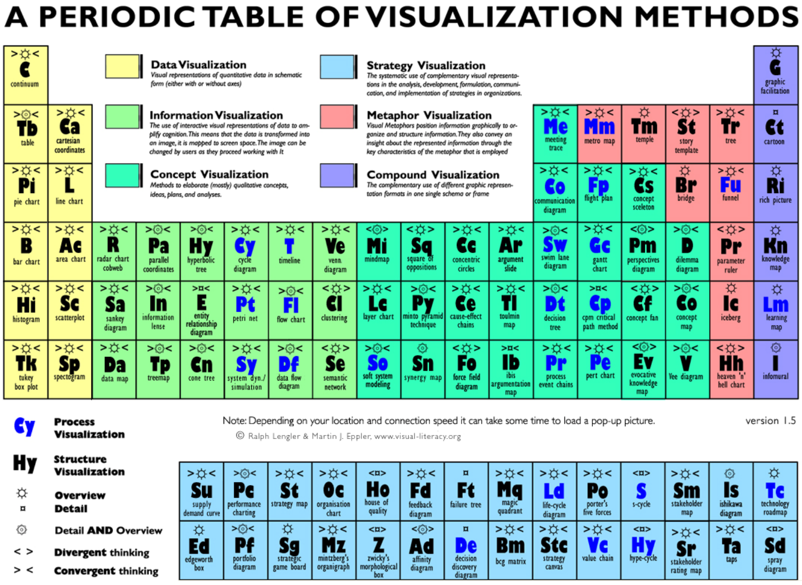
Lengler et al (2007) split the methods into six visualization categories based on what they called the Data, Information, Concept, Strategy, Metaphor and Compound approach (DICSMC).

Data Visualization	Data in schematic form
Information Visualization	Data transformed to an image
Concept Visualization	Qualitative approach
Strategy Visualization	Systematic approach
Metaphor Visualization	Structuring information
Compound Visualization	Combining different methods

This so-called DICSMC approach runs parallel to the DIKA one and structures each of its items towards the formulation of a final outcome; that of usage of the tools for implementation. The table also outlines whether the methods define processes or structure. Each of the ‘elements’ in the periodic table represents a visual tool which results in one of the most comprehensive tools available totalling a list of 100 methods. The table value-adds to the overall visualization concept as it identifies those ‘elements’ that focus on convergent or divergent thinking, which is an ideal way of expressing oneself away from traditional methods, especially where new concepts are being researched.

[1] http://www.visual-literacy.org/index.html

Figure 7.2: Periodic Table of Visualization Methods



Source: Lengler et al (2007)
http://www.visual-literacy.org/periodic_table/periodic_table.html

The reader is urged to review the tools identified in the table and partake to those highlighted in their specific area of specialisation. One of the tools covered in this book, (namely, the mind map), is listed as the concept visualization element MI.

Chapter 11 lists a number of books pertaining to the different disciplines, which publications serve as a focus for statistical tests as well as a pointer towards the methodological processing aspects that are endemic to that specific discipline. The rest of the chapter will cover the two categories of visualization most employed in research, those pertaining to graphing and mapping.

Graphing

Graphical representation through shapes is a way to summarise data through a visual medium. Graphs are vital to the understanding of data and how it is represented in non-tabular format.

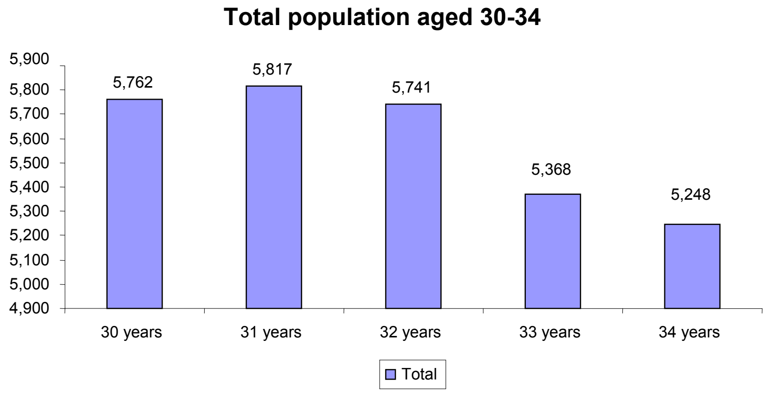
The formats mostly used include the following: Bar Charts, Pie Charts, Line Charts and Histograms.

- **Bar Charts**

Bar Charts are composed of bars separated by spaces

Ideal for displaying the distribution of variables measured at the nominal level.

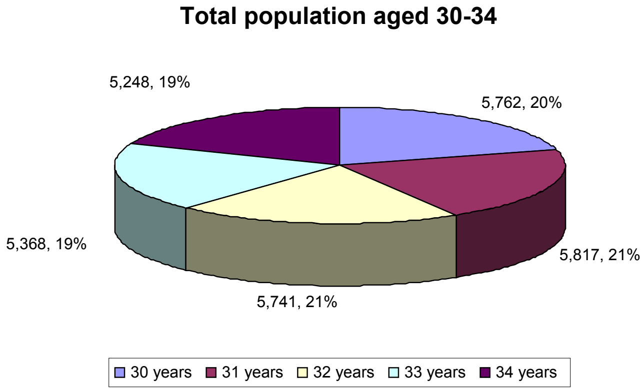
Figure 7.3: Bar Chart



- **Pie Charts**

Circles (Pies), as in the case of bar charts display their data in the form of slices. All the slices make up a cake or a pie!

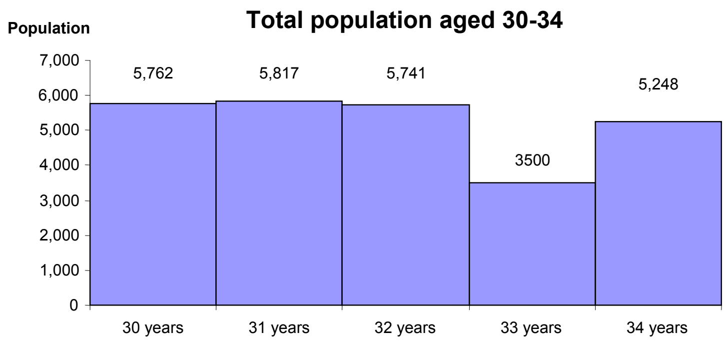
Figure 7.4: Pie Chart



- **Histogram**

Very similar to bar charts but depict a distinct difference. Adjacent bars used to display the distribution of quantitative variables. These variables vary along a continuum with no gaps.

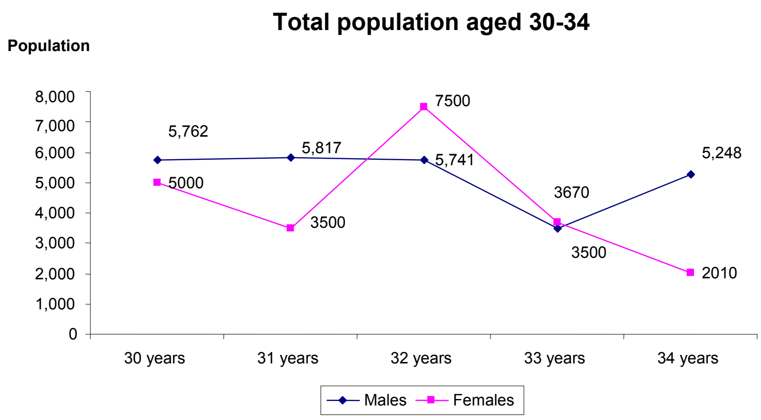
Figure 7.5: Histogram



- **Line Charts**

Line Charts are composed of lines along an axis. This type of chart allows multiple variables to be depicted in the same chart.

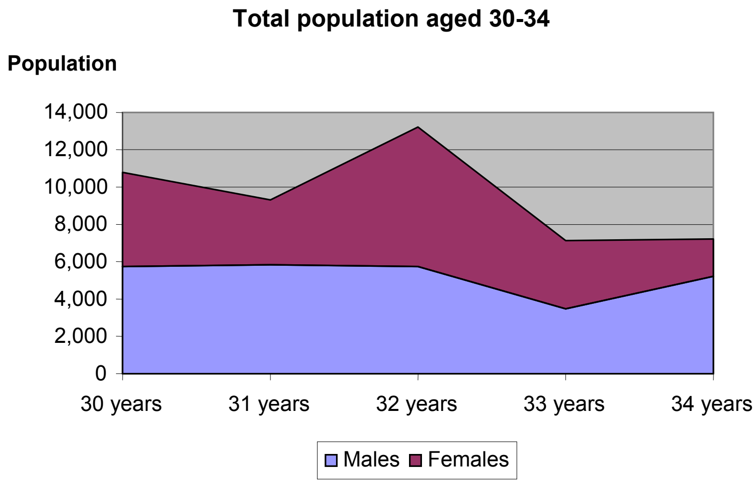
Figure 7.6: Line Chart



- **Area Charts**

Area Charts are ideally used for data that requires depiction of individual variables in relation to a total.

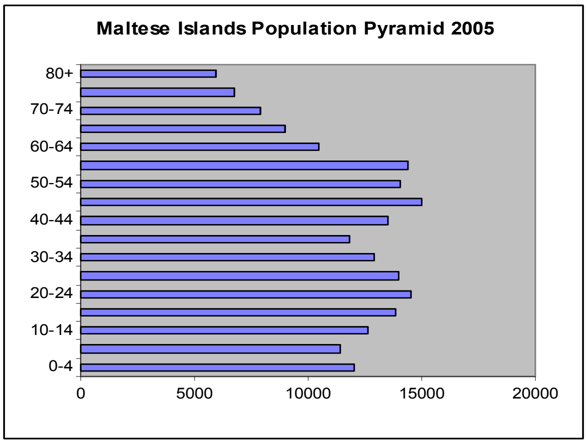
Figure 7.7: Area Chart



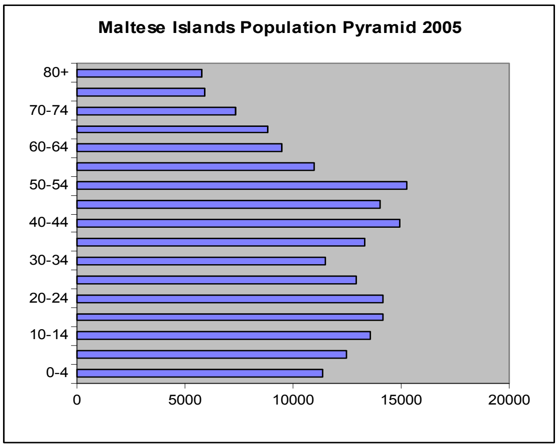
- **Composite Charts**

In statistical research, sometimes composite charts help one to better understand a situation. Let us consider the case of what is termed as a population pyramid. This is essentially a Bar Chart that has been inverted to form horizontal bars.

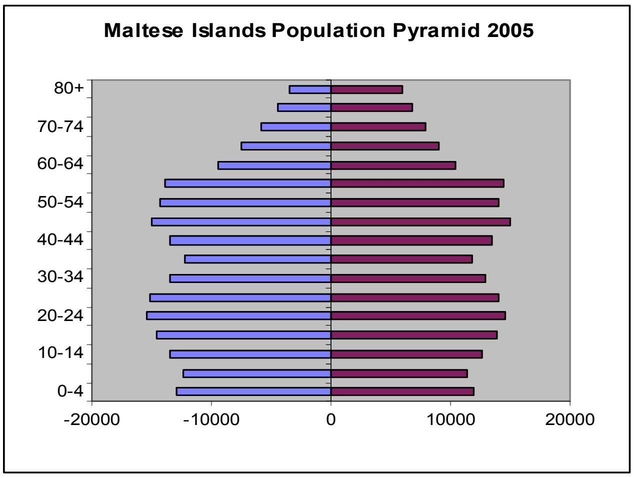
1. The following chart depicts the Maltese Female population in 2005 by age cohort.



2. Another chart depicts the Male population in 2005 by age cohorts.



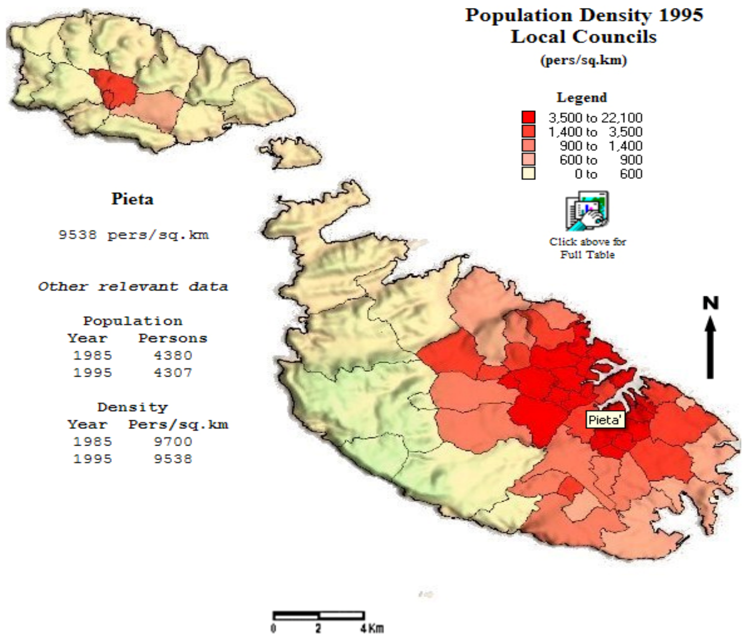
3. It is best if both are combined in order to be compared against each other. The population pyramid always depicts males on the left and females on the right. One can immediately state that the population is growing older as more people move into the higher age groups and that their are more females at the higher age groups compared to the males.



This tool has been developed in static imagemap format (Formosa, 2000) and in interactive format for the Maltese Islands (SAGIS for NSO Malta, 2009).

Static Imagemap Format

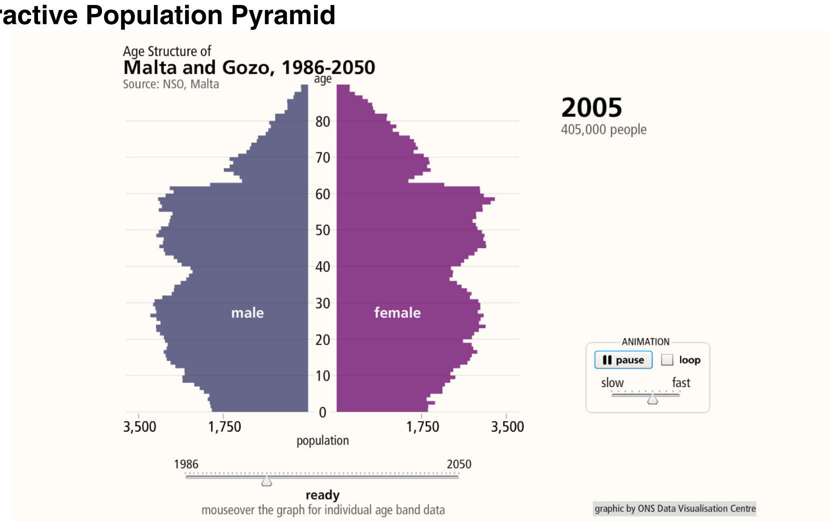
Figure 7.8: Imagemap



Source: Formosa (2000)
http://www.mepa.org.mt/Census/archive/ageimagemap.htm

Interactive Format

Figure 7.9: Interactive Population Pyramid



Source: NSO Malta, 2009
http://www.fernuni-hagen.de/statliteracy/chapter4/Malta_Pyramid/pyramid6_29.html

Charting Tools

Many tools can create charts as are generic Office tools that have spreadsheets integrated in them. However there are specialised tools in the commercial and opensource domains that target specifically the creation of static and interactive charts.

Commercial applications include Microsoft Excel[2], SmartDraw[3], amCharts[4], and the ozgrid[5] collection.

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2 http://office.microsoft.com/en-us/excel/
3 http://www.smartdraw.com/

Opensource tools also exist which allow one to create static and interactive charts which are free to use. Amongst these one can use, OpenOffice Calc[6], FChartsSE[7], The Google Visualization API[8], lovelycharts[9]. A comprehensive list of such tools can be found at the free DOWNLOADScentre[10] and at New Free Downloads[11].

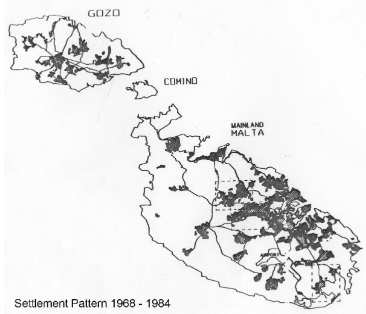
Mapping

Why is mapping so important for statistical analysis? Whilst not necessarily important for calculations and measures related to numerical studies, it is becoming increasingly difficult to carry out statistical analysis without the employment of mapping or spatial techniques.

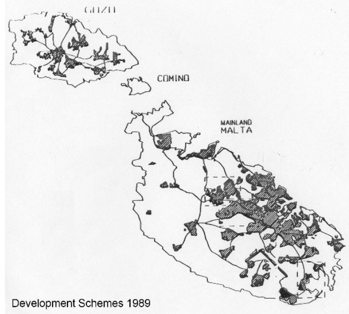
Let us initiate this part of the study with a review of a map series depicting development in the Maltese Islands. Sourced from various entities and sensors, Formosa (2007; 91) outlined the changes over time in a combination of drawings (1910 – 1989), a map (1990 – 2020) and imagery (2001).

The drawings were originally extracted from old maps and drawn onto a map of the islands. The 1990-2020 map is an extract from GIS data layer (data is stored in a series of layers on top of each other as in the case of a stack of transparencies. This allows analysis across the tables in a spatial format). The satellite image is virtually a photo from space which empowers the researcher with an ability to code each individual colour and relegate it to a particular land cover, in this case the bluish/purple colour represents the urban land cover.

Figure 7.10: Urban Growth 1910 to 2001



Settlement Pattern 1968 - 1984



Development Schemes 1989


Limits to Development 1990-2020


LandSat Imagery TM7, Path 188, Row 35, 06/11/2001 showing extent of built up areas in blue

Source: Formosa (2007, 91), Structure Plan Report of Survey Vol. 1 (August 1990), LimDev GIS Layer – MEPA, LandSat 2001 Imagery.

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4 http://www.amcharts.com/
5 http://www.ozgrid.com/Services/ExcelChartTools.htm
6 http://www.openoffice.org/
7 http://www.spacejock.com/FreechartsSE.html
8 http://code.google.com/apis/visualization/interactive_charts.html
9 http://www.lovelycharts.com/
10 http://www.freedownloadscenter.com/Search/chart.html
11 http://www.newfreedownloads.com/find/chart.html

On reviewing such a series of maps of images, one can immediately reach the conclusion that the expansion of the urban areas took off after 1968 and expanded rapidly in the 1980s and 1990s forming a very large conurbation.

Tables and charts would give us the exact rate of change but the visual aspect is more direct and to a certain extent highlight the rapid growth that accelerated over the decades.

Today, technologies such as image recognition software help one to carry out this analysis automatically. Software such as eCognition[12] represent a step forward in the analysis of massive volumes of data that such maps generate. To give an idea of the file sizes between a table and a map (grid file format). Whilst the former can register a size of 30Kb, a grid file can take up 2Gb which is equivalent to 2,000,000Kb or 67,000 times larger than the excel file. However the output is immediate and significant.

GIS as a Tool for Scientific Research

The use of mapping tools has been debated for a long time and though used by the military since the 1960s, it really took off in the 1990s due to the physical and environmental sciences and has since been taken up by the social sciences post-2000.

Formosa (2007; 3) in his focus on environmental criminology states that:

> Until recently, most crime investigations concentrated on non-spatial sociological issues whilst some painstaking geographic research looked into specific locations but only in a descriptive way (Campbell, 1993). The advent of high-end information systems and spatial software has changed the direction that these studies are taking. Environmental criminology (as one such a theme delving into GIS) has been brought back as a theoretical issue through the use of Geographical Information Systems (GIS), which has become one of the main means of bringing together previously disparate research analysis (Openshaw, 1993). The use of GIS together with other tools (such as SPSS, Vertical Mapper and CrimeStat), enhance analysis over more than 2 dimensions. It integrates both spatial and temporal crime, whilst linking crime statistics to such information layers as development and urban sprawl, crime hotspots, social and community facilities, locations of policing infrastructure, location of crime near bus stops, amongst others (Hirschfield, 2001; Haining, 1987; Clarke, 1995). In addition, analysis and dissemination tools such as 3-Dimensional mapping, Virtual Reality Modelling Language (VRML), and Web-mapping give access to researchers to carry out comparative spatio-temporal analysis. This said, caution must be taken to understand the limitations of such systems and methodologies (Pease K., 2001)[13].

Whether one is studying crime, population movements, air pollution dispersal, noise dispersal, ecology and a thousand other themes, one needs to be aware that there are tools that one can employ to aid statistical analysis that go beyond tabular and graphing methodology. One has to note that irrespective of the glitz being shown by such maps, there are also limitations and one needs to be specialised in the field to ensure that the tools are used correctly.

What is a GIS?

GIS is known by many names, from Geographical Information Systems / Geographic Information Systems to Spatial Information Systems to Land Information Systems to Automated Mapping/Facilities Management and Geomatics. All these have been integrated into the term Spatial Information Systems.

By definition, GIS is:

> A geographical information system is a group of procedures that provide data input, storage and retrieval, mapping and spatial and attribute data to support the decision-making of the organization. (Grimshaw, 1994)

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[12] http://www.ecognition.com/

[13] Such a methodological debate is a hot topic in the CrimeMap list (15th August 2006) between the digital-leaning school Dr. Ned Levine (CrimeStat III) creator and Prof. Marcus Felson who promotes the traditional methodologies of crime analysis.

GIS combined spatial data tools, cartographic tools, computer-aided design and remote sensing technologies. This combination, together with its specialist tools, has resulted in a very powerful technology that is only now becoming widely recognised as a very useful tool for researchers in the natural, physical and behavioural sciences. Due to this change, later definitions included the people factor which is now seen as the most important factor!

Very few specialists used to work with GIS as a spatial analytical tool that goes beyond the simple generation of maps. Theoretical and practical issues started spreading beyond mere use to incorporate the hard-scientific physical and earth sciences approach to the more complex fuzzy concepts identified by social-scientific theories. This led to a transformation in the use of maps and spatial tools for research.

In addition, the advent of online maps, mobile gps and real-time mapping services changed all that. Today anyone can go on line and access Google Maps[14], Multimap[15], National Geographic Map Machine[16], MapQuest[17], Bing Maps[18], Yahoo! Local Maps[19], and many others. Thus mapping is no longer the domain of a few specialists but is a tool for all. Also, the tools can be handled by many disciplines and have taken up the work formerly carried out by cartographers and geographers, with the terminology also changing from geographic information systems to spatial information systems. This change has been brought about by the inclusion of context in the various physical, natural and behavioural sciences.

A S.W.O.T. analysis on the USE of GIS for scientific-mapping research

Before one can decide to employ GIS as the main tool in scientific analysis, a SWOT (Strengths, Weaknesses, Opportunities and Threats) exercise was carried out to enable the reader to understand the issues that emerge when implementing such a scientific-mapping system that does away with the rose-tinted glasses perspective of a one-solution product. GIS as used for scientific-mapping has its positive and negative aspects of the technology and its service in a 'scientific' construct. The SWOT analysis helps to clarify these issues.

Each part of the process is analysed for its technical, policy-social-environmental and, marketing-economic functions (Table 7.1).

Table 7.1: SWOT Analysis of the Use of GIS for Scientific Research

SWOT Analysis of the USE of GIS for Research **Strengths, Weaknesses, Opportunities, and Threats**	
Strengths	***Weaknesses***
Technical • Immediate availability of data to analysts, researchers • Queries are automated and pre-formulated letters sent to decision/policy makers • Attribute data available on one single keyboard stroke linked to a map • Routines automate queries and instructions through cross-referencing • Use of Common Database (CDb) eliminating need for redundancy in databases	**Technical** • Potential bias by employees in favour of older non-technological systems • Confidentiality issues • Inputting, updating and reading rights are not always adequate - wide access • Distribution of data to a large number of people: staff • Incompatibility with older datasets/systems • Prone to rare but possible data theft or sabotage particularly by "rogue

[14] http://maps.google.com/
[15] www.multimap.com/
[16] http://maps.nationalgeographic.com/map-machine#s=r&c=43.74999999999998, -99.71000000000001&z=4
[17] http://www.mapquest.com/
[18] http://www.bing.com/maps/?wip=2&v=2&style=r&rtp=~&&msnurl=home.aspx?%26redirect%3dfalse&mnsculture=en-US#
[19] http://maps.yahoo.com/

• Use of buffering analysis and zonal searches can be carried out within single-theme data layers as well as multi-theme layers. Buffering methodology identifies activities within a specific area from the area under study such as offences occurring at a distance of 100m from a school. Zonal searches review population movement-patterns occurring at differing distances from the area under study such as interactions occurring every 100m from a bar	professionals". E.g.: having access to maps of areas of affluence and unprotected areas turns a security map into a treasure-trove of opportunities to an offender.
Policy, Social and Environmental	**Policy, Social and Environmental**
• Faster analysis of alarm calls such as pollution-threshold exceedances • Determination of the effects different parameters types have on different physical and socio-economics variables • Crime analysis results can be utilized by a number of disciplines and activities such as real estate estimation, fraud, security companies and social services suppliers • Integration of data from different sources, leading to improvement in rapid reaction delivery and projections based on trends	• Specialised data is viewed as being the domain of the managing agency rather than social scientists in general – data is kept at a distance through a series of barriers to access the data • Limited support from management and non-technological-oriented chiefs • Lack of understanding by policy makers of the process to mine and analyse data for analysis • Lack of skills in information technology and information systems by social science students and practitioners • Some data is seen as too dangerous to research as it highlights a nation's weak points or failure in policy making and GI outputs makes it even more dangerous
Marketing and Economic	**Marketing and Economic**
• Real-time mobile input can be easily updated and defaulters acted upon • Incentives for research-related organisations to invest in new technologies • Reduction of data entry errors and overhead costs for field-based and office work	• Policy and Decision makers take time to realize the utility of GIS • High initial cost of hardware and software plus cost of training, cost of managing the GI system, costs of updating the data and costs of answering queries and requests for information • There is no 'monetary' profit in these activities and hence refusal to see profit against reduction in staff time to analyse data

Source: Adapted from Formosa (2007)

SWOT Analysis of the USE of GIS for Research Strengths, Weaknesses, Opportunities, and Threats	
Opportunities	***Threats***
Technical • Establish a real-time variable identification system • Link to international datasets such as those created by WHO, EUROSTAT • National and International quick analytical function • Need for the setting up of systems compatible with the mapping agency's GIS allowing future exchange of data	**Technical** • Inputted data is not updated regularly • Changes in categorizations can lead to incomparable results • New hardware can make whole systems obsolete • Project stoppage midway through completion
Policy, Social and Environmental • Identification of specific areas of hot-spots • Provide progressive incident-reduction environments • Work towards data sharing schemes • Identification of potential needs by victims of exceedances	**Policy, Social and Environmental** • Data is mishandled or misused by non scientists • Political and economic uncertainty impede investment • Poor timing of decision making • Assumptions can be "mistaken" leading to wrong and costly decisions
Marketing and Economic • More action taken by operational staff, less time in office allowing more efficient and effective outcomes • Wide availability of data to other related agencies for inter-disciplinary data exchange • Spin-offs of the attribute section of data • Allows time-scheduling - third parties are better served	**Marketing and Economic** • Data sold/bought at exorbitant prices that do not reflect reality (includes social data) • Real-time analysis needs real-time updated 3rd-party data exchanges that reflect the ground-truth such as new development, new transport routes

Source: Adapted from Formosa (2007)

The SWOT descriptions given here can be carried out for any of the other methods and processes listed in this book. The choice of GIS as the conveyor for such a description was made on purpose due to its integration of software, hardware and the human component in the inherent DIKA steps within which it operates.

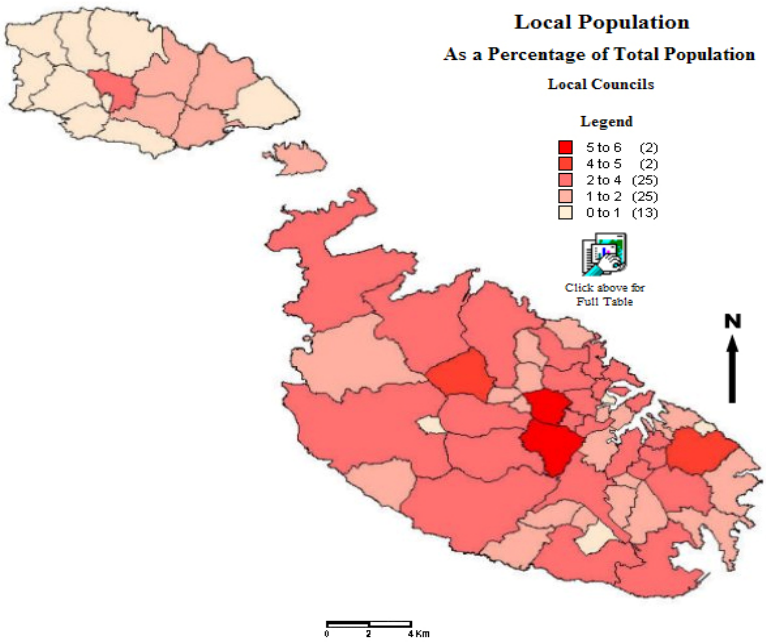
Some mapping outputs:

It is best at this stage to depict some outputs in mapped format which users can use in conjunction with their tables and charts.

Map 1: Choropleth Map

A map that depicts data based on ranges.

Figure 7.11: Choropleth Map

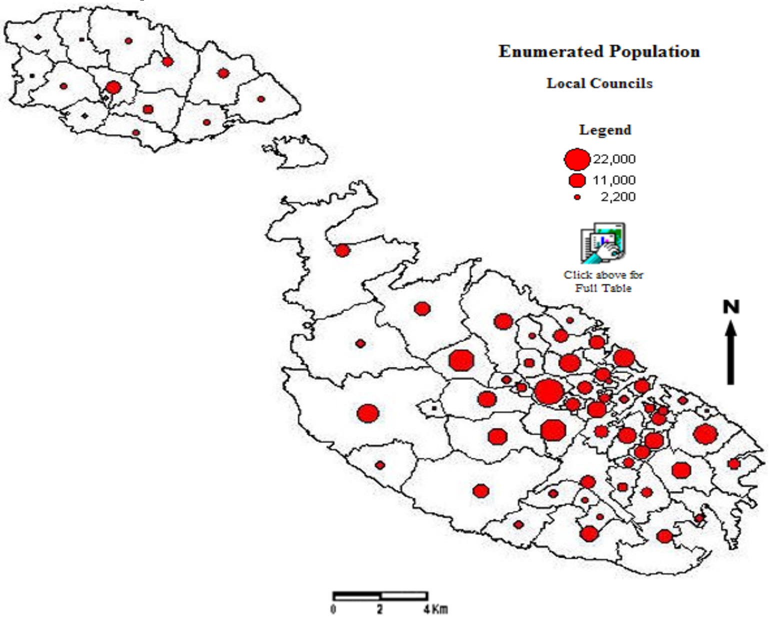


Source: Formosa (2000)
http://www.mepa.org.mt/Census/archive/ageimagemap.htm

Map 2: Graduated Map

A map that depicts data as a series of graduated points (which could also comprise pie-charts).

Figure 7.12: Graduated Map

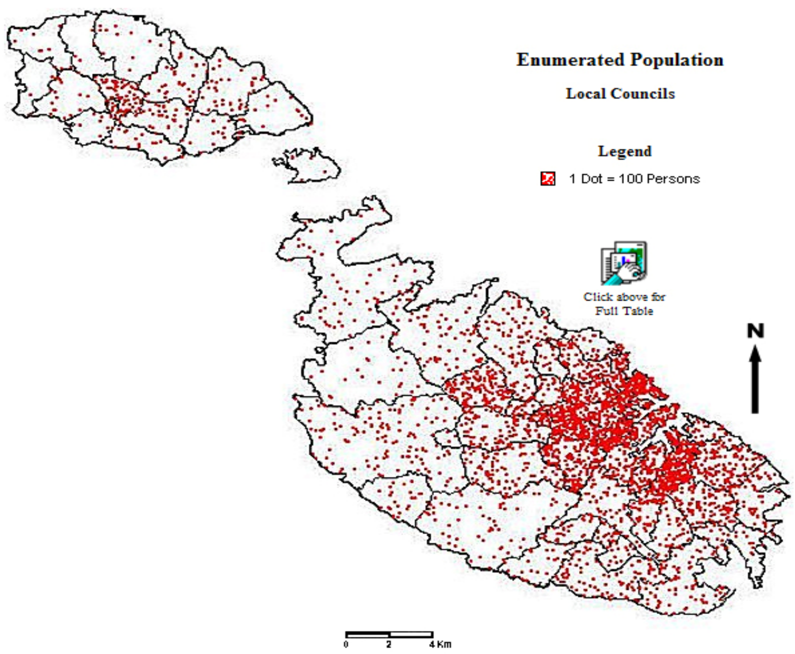


Source: Formosa (2000)
http://www.mepa.org.mt/Census/archive/ageimagemap.htm

Map 3: Dot Density Map

A map that depicts data based on randomly-located dots representing numbers of cases.

Figure 7.13: Dot Density Map

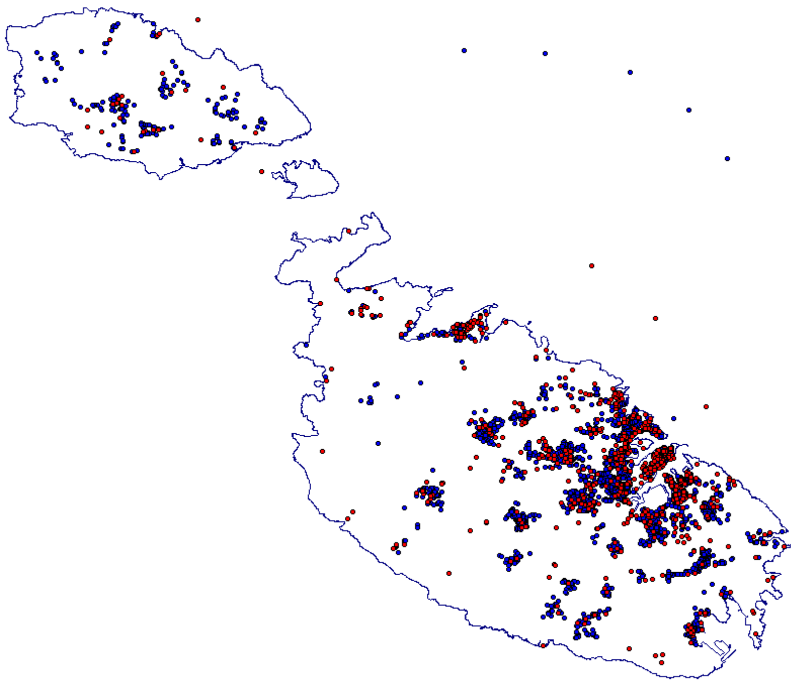


Source: Formosa (2000)
http://www.mepa.org.mt/Census/archive/ageimagemap.htm

Map 4: Point Map: Actual Location of Offences Map

A map that depicts data based on points representing the actual location of an activity

Figure 7.14: Point Map

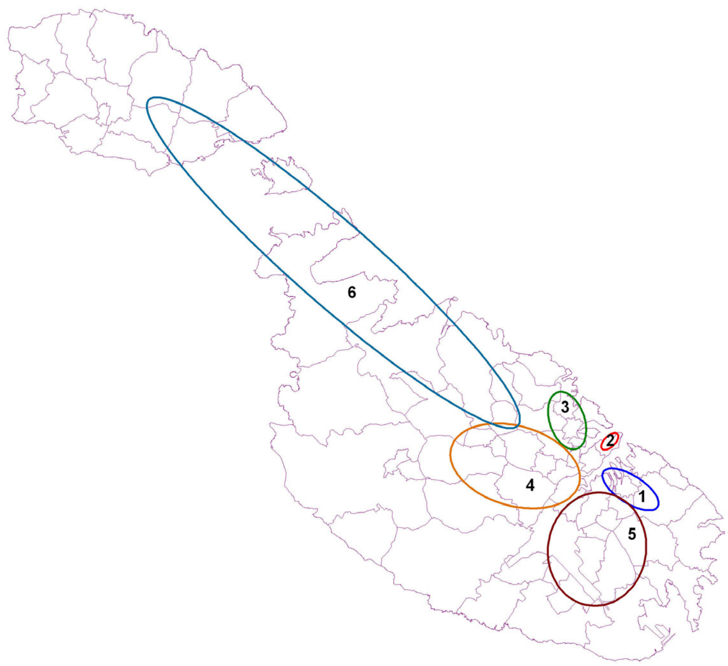


Source: Formosa (2007)

Map 5: K-Means clustering Map

A map that depicts data based on statistical clustering of related data points.

Figure 7.15: K-Means Clustering Map

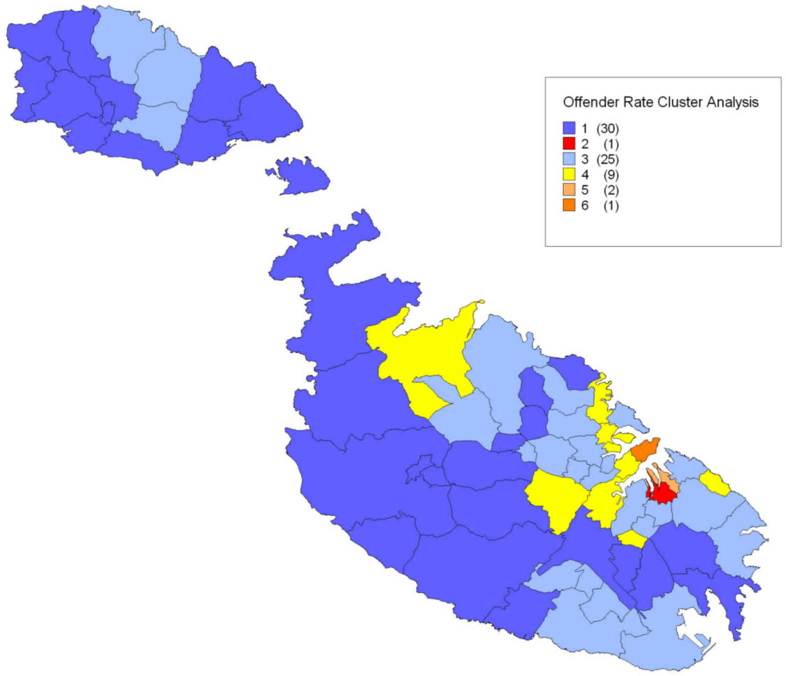


Source: Formosa (2007)

Map 6: Polygon-Based Cluster Analysis

A map that depicts cluster data ranged across polygons (areas).

Figure 7.16: Polygon-Based Cluster Map

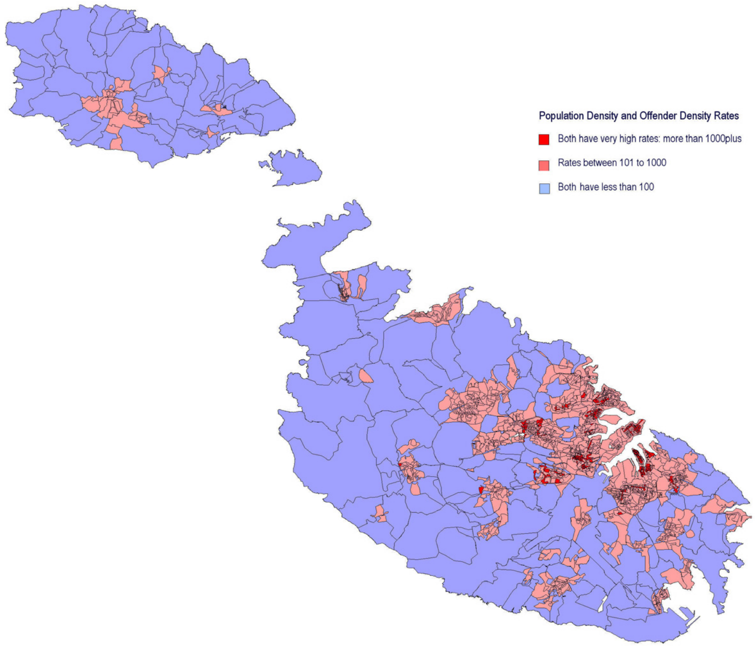


Source: Formosa (2007)

Map 7: Small-Area Choropleth Map

Same as Map 6 but depicted very small polygons (areas) for niche analysis.

Figure 7.17: Small-Area Choropleth Map

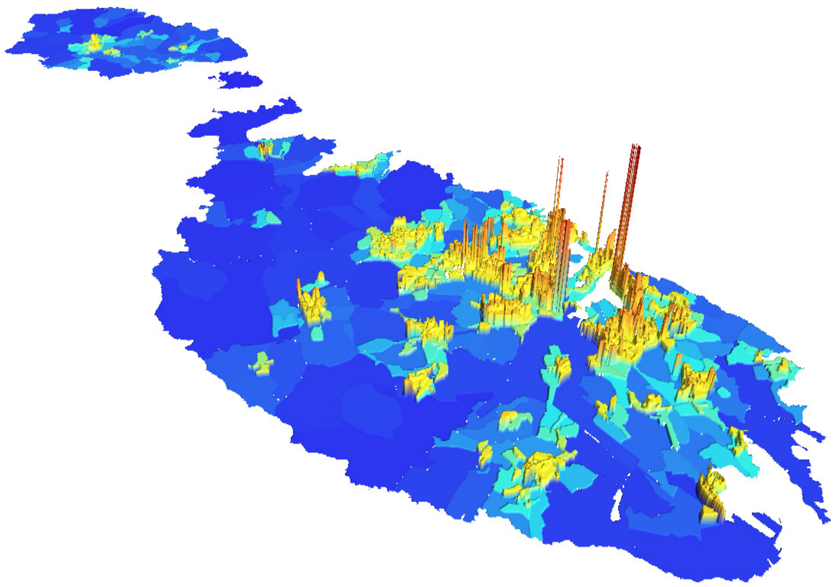


Source: Formosa (2007)

Map 8: 3D Map: Population Density

A map that extrapolates the polygon data of such maps as Map 7 into 3D format. One can immediately tell which areas have the highest population density. This type of map can be overlaid with another map such as that of poverty in order to analyse whether there is a correlation between population density and poverty.

Figure 7.18: 3D Map

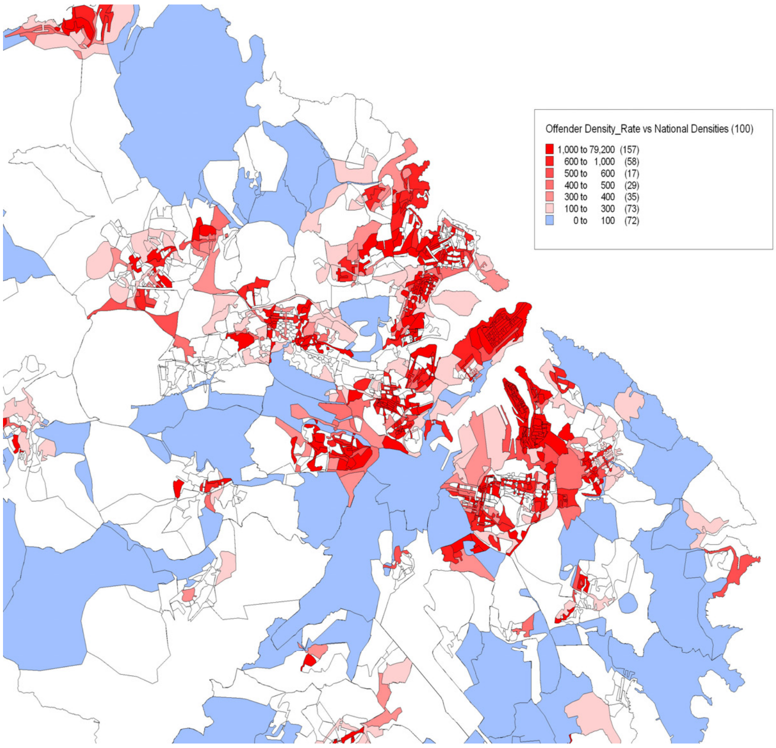


Source: Formosa (2007)

Map 9: Correlation Map: Small Area densities vs. National densities: EAs

A map that depicts correlations between two variables in polygon format.

Figure 7.19: Correlation Map

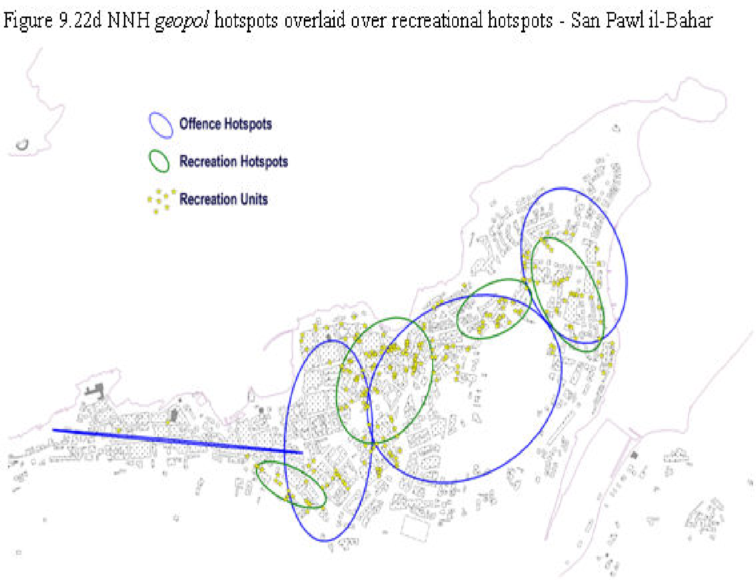


Source: Formosa (2007)

Map 10: Nearest Neighbour Hierarchical Analysis (NNA) Map: Offence Hotspots: Spatial – Retail Crime

A map that depicts data showing hotspots in the form of ellipsoids.

Figure 7.20: Nearest Neighbour Hierarchical Analysis Map

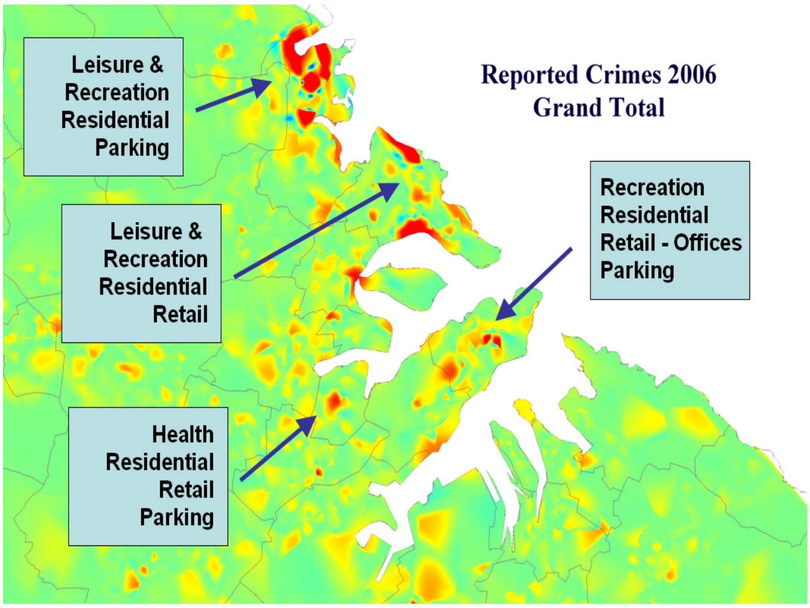


Source: Formosa (2007)

Map 11: Offence NNA: Spatial – Type by spread – Most effected

A map that depicts those areas having similar characteristics and indicating very high levels of activity.

Figure 7.21: Nearest Neighbour Hierarchical Analysis Spread Map

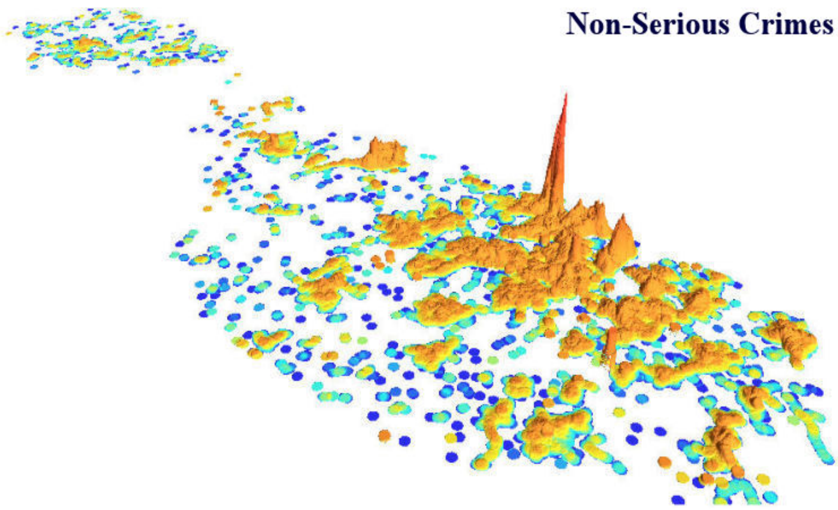


Source: Formosa (2007)

Map 12: 3D extrapolation of activity spread: NNA: Non-Serious Crimes

A map that depicts data developed through the process outlined in Map 11 in a 3D format for ease of visual reference to the hotspots.

Figure 7.22: Nearest Neighbour Hierarchical Analysis 3D Extrapolation Map



Source: Formosa (2007)

GIS Tools

As in the other instances of tool review, GIS has seen a veritable expansion in the availability of tools in both the commercial and opensource domains that target specifically the creation of spatial data and its outputs.

Commercial applications include MapInfo[20], IDRISI[21], ARCGIS[22], and ERDAS Imagine[23].

Opensource tools include GRASS GIS[24], SAGA GIS[25], Quantum GIS[26] and MapWindow GIS[27].

Other free software lists can be found at the GIS Development[28] site and the GeoCommunity site[29]. In addition, comprehensive list of tools and documentation can be found at the Directionsmag[30] site.

In summary, there are various tools that can be used to visualize a research output. To present results, researchers can choose between tabular, graphic or mapped format. There are no hard and fast rules on which one should be preferred, but it is best to refer to the specific discipline to relate to the relative visualization developments.

Questions (refer to Appendix for the answers)

1. List five simple types of research visual tools.
2. Graphing is a way to summarise data. List the graphing formats most commonly used.
3. Briefly define the following: (a) Bar Charts; (b) Pie Charts; (c) Histograms; (d) Line Charts; (e) Area Charts; (f) Composite Charts; (g) a Population Pyramid.
4. Why is mapping important?
5. Briefly explain what you understand by GIS.
6. What do the letters "S.W.O.T." stand for and why would one carry out a S.W.O.T analysis on GIS?
7. Briefly DESCRIBE what each of the following maps depicts: (a) Choropleth Map; (b) Graduated Map; (c) Dot Density Map; (d) Point Map: Actual Location of Offences Map; (e) K-Means Clustering Map; (f) Polygon-Based Cluster Analysis; (g) Small-Area Choropleth Map; (h) 3 D Map: Population Density; (i) Correlation Map: Small Area Densities Vs National Densities: EAs; (j) Nearest Neighbour Hierarchical Analysis Map; (k) Offence NNA: Spatial-Type by spread – Most effected; and (l) 3D Extrapolation of Activity Spread: NNA: Non-Serious Crime.

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[20] http://www.pbinsight.com/welcome/mapinfo/
[21] http://www.clarklabs.org/
[22] http://www.esri.com/
[23] http://www.erdas.com/
[24] http://grass.itc.it/
[25] http://www.saga-gis.org/
[26] http://www.qgis.org/
[27] http://www.mapwindow.org/
[28] http://www.gisdevelopment.net/downloads/gis/
[29] http://software.geocomm.com/
[30] http://www.directionsmag.com/