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Introduction

Desertification is widespread across the Dryland zones on all continents along and either side of the Equator. Its nature, extent and causes were examined in Geodate Issue 3 2016 which showed the influence of long-term natural events and human-induced accelerated changes. Either or both of these triggers produce a tough competition by plants, animals and people for scarce resources. The crucial elements in demand are water, soil and vegetation. As major agents of environmental change, great human endeavours are being undertaken to access, restore and enhance these elements as a process of reducing desertification. An important recent focus is now also on preventing desertification.

‘BIG’ scale attempted Solutions and Unpredictability

Given the semi-continental scale of desertification effects, the problem is big and it is typical of energetic humans to take a ‘big picture’ approach to repairing the damage in attempting to solve matters on such a scale. However, three examples show that this may not be as effective as expected which has influenced a change in ongoing thinking and problem-solving.

During the 1930’s the western United States suffered terrible extended drought, creating the ‘Dust Bowl’ where loose dry soil blew away in huge volumes leaving behind devastation and destitution across the affected rural population. A major developed country with a stable government was then able to provide large financial resources to subsidise poor farmers, buy back marginal land, provide cheap loans for innovative agricultural techniques and undertake re-zoning land use. While these initiatives worked, however they did not prevent the recurrence of two more devastating ‘Dustbowls’ in the 1950’s and 1970’s. One of the world’s biggest countries with a big budget was unable to ‘fix’ such a big desertification problem.

Recurrent droughts are a pattern in the southern hemisphere along the Tropic of Capricorn in Australia, Southern Africa and South America. Various decadal droughts occurred in these continents in the 1890’s, 1920’s and early 2000’s with similar effects to those of the USA ‘Dustbowls’ in the northern hemisphere and sometimes coinciding with them. Historians and agronomists have recognised that these sub-continental areas share a common factor that did not occur in the Central African and Western Asian deserts - they were exposed in the last few hundred years to large herds of hoofed grazing animals brought by Europeans who were colonising vast tracts of pastoral lands. However, (similarly to the USA) the developed nation of Australia, despite capital injections and large-scale planned management initiatives (eg the Snowy River hydro and irrigation Scheme) has been unable to prevent the recurrence of the destructive drought patterns and their effects on the landscape and population.

Map 1: Dryland Systems of the World, generally defined as “all terrestrial regions where the production of crops, forage, wood and other ecosystem services are limited by water”. Notice that they are not spread along the Equator but in parallel bands along the Tropic of Cancer (the Sahara and Western Asia) and the Tropic of Capricorn (Southern Africa and Australia). Less recognised are the elevated dry plateau deserts in the mountain areas of North America (The Rockies), South America (The Andes) and high plains of Asia (Mongolia). Dry subhumid areas are only narrow fringes of these large regions.

As described in the previous Geodate, the ‘SAHEL’ region which crosses the full width of the African continent has suffered repeated drought periods in lengths of years or decades which is widely considered to be a permanent trend. However, the ‘big picture’ view now provided by satellite technology has recorded post-drought periods of significant recovery of vegetation to an extent which blurs the concept that desertification is permanent. One conclusion being drawn from this experience is that vegetation revival on this scale is dictated by rainfall patterns far more than human activity. Within Australia, rainfall records and earlier historical evidence indicate that the substantial decline in rainfall that has occurred across the last century is not a repeat pattern of the previous one and the perception that our rainfall has been declining since European settlement may also be a misconception.

**Changes in Thinking about Solutions for Desertification**

These scientific possibilities are challenging to proponents of the ‘anthropological’ argument that humans are entirely the cause of desertification and ongoing drying climates. Certainly, all agree now that more and longer monitoring from earth and space is needed to understand real trends and fluctuating environments. Collection of information upon which to build analyses and interpretation is known as establishing ‘baseline’ data. From this, concerned countries and their land managers have a chance to identify uncertainties and develop appropriate remediation methods.

‘Big’ solutions and perceptions have provided unexpected evidence which suggests that attempting to solve desertification issues on a large scale may not be the best approach. While desertification causes are complex, it has been observed that they are frequently local and possibly linked with the immediate and short-term demands of agriculture for productivity and income. This has triggered a movement toward smarter thinking about sustainable land use, environmental rehabilitation, re-establishing biodiversity and rethinking local rural practices.

**a) Science**

Fundamental issues emerging from a reassessment of ‘big’ solutions have been identified -

- It is more cost-effective to focus on prevention of desertification and land damage
- More rational climate science approaches should be based around -
  - careful assessment of crop suitability, resilience and productivity
  - adaptability of crops, techniques and local agricultural practices
  - better quality and quantity of data - eg seasonal forecasting
  - historical weather pattern analysis
  - soil distribution and performance
  - diversity and flexibility of farming systems
  - improved land management techniques
- Water management - storage, recycling and desalination
- Soil management - a ‘Brown Revolution’ restoring healthy soils via stock & crop rotation
- Plant management - working with ecosystems, not against them; including Permaculture

**b) People**

Another major breakthrough in the process of providing successful evidence-based solutions is the vital realisation that attempting to apply them effectively requires the understanding of the local people involved, their acceptance and active participation. This works both ways as science can benefit from local knowledge, long-learned observations and established techniques where useful. Imposing solutions as was done for ‘big’ projects is not inclusive and assumes there is only one lot of workable answers, whereas over periods of history, desert peoples have innovated a variety of methods to collect water and sustain local agriculture by adapting to local conditions, often with only basic technology. And survival is not the aim - enhanced capacity through improvements will eventually require better access to transport and markets for communities to develop and raise their standard of living, a fundamental human right.

**c) Women in Land Management and Business**

In many of the world’s countries, women are the farmers as well as the gatherers of resources (water, firewood,
Empowering women by offering shared access to desertification solution technology and ideas, together with support policies, will enable them to strengthen their families and communities. Assistance organisations are increasingly developing gender-sensitive and social equity programs in ways that may be taken up positively by women, empowering them without directly confronting local male traditions and capable of demonstrating benefit to the community as a whole. For example, women across the Sahel region are forming tree-care and planting groups to rehabilitate their living environments. These opportunities are being willingly taken up and are generating a multiplicity of small-scale women-run business initiatives.

Women often play a key role in water management in drylands (Mauritania)

Women drawing water at a well in Mauritania
(Photo Scott Christiansen)

Indian woman with mobile phone capacity running a cattle enterprise
(Photo: Prashanth Vishwanathan (CCAFS))

An Algerian woman establishing a ‘kitchen garden’, reducing dependence on food aid programs (Photo Miriam Hirzel)

‘Small’ Solutions across the world

Experience since the 1970’s has indicated that ‘Small’ solutions to desertification challenges present a better chance of application, uptake, success and a positive return for the time and resources invested by all concerned. In a practical way, this also has the positive impact of setting less daunting tasks which are more manageable and able to be overseen. These are encapsulated in the philosophies expressed in the well-known sayings -

- “Think Globally, Act Locally”
- and -

- For 98% of re-greening techniques you need to work the ground. You need a spade!”

The concept of ‘Small’ solutions have released energy and enthusiasm of motivated groups, communities and individuals to tackle desertification at local scales with determination. As desertification problems have been linked directly with the alleviation of poverty, and food security, the efforts and initiatives are focused on vulnerable farming systems, men and women smallholders and low income farmers in countries right across the desertified world. Here are some of the innovations being undertaken as ‘Small’ Solutions.
ALGERIA ‘Kitchen Gardens’

The ‘Kitchen Gardens’ initiative, illustrated by the woman in the previous photo, focuses on growing vegetables within a small fenced area for access, security and maintenance. Variations are “container gardening” and “vertical gardening” for closely-built communities. The use of plastic covers retains moisture and protection from wind-blown dust, acting as a greenhouse for tomatoes (in the Sahara Desert!). Cost of investment is extremely low for the household and proponents ask ‘Why not everywhere in the drylands?’

Kitchen Gardens: protected vegetable patches and a plastic-lined greenhouse in the family enclosure
(Photos: Taleb Brahim and Miriam Hirzel)

Drip irrigation Technologies are improving vegetable production while use of solar energy for cooking and home lighting reduces reliance and hence demand for increasingly scarce firewood (Photos: JORGEN SCHYTTE/Peter Arnold, Inc.)

KENYA - Using much less firewood

Traditional cooking in Kenya uses a three-stone open fireplace which has an inefficient rate of burning. A simpler and much more efficient cookstove has been developed that requires 60% less wood to produce the same outcome. These stoves have been distributed through Kenyan village communities with the result that less of the remaining timber is removed and reduced to carbon. The initiative is known as the Hifadi Project as part of a broader reforestation program which also features a coffee subcrop planted under the treeshade, a dual-growth agricultural initiative.
SYRIA - Simple Irrigation for Seedlings for Land Rehabilitation

Bedouin communities had been herding several million animals for many years across the Badia Rangelands of central and eastern Syria. This land is a desertified zone of low rainfall and poor soils which is only able to support the grazing of small animals, horses and camels and degraded after years of drought and over-grazing. The Bedouin recognised that rehabilitation and land management was necessary and worked with an aid group to select sites suitable for rehabilitation, establish agreed boundaries and limiting the number of grazing herds while the repair work was undertaken.

One million hectares of the land was simply rested for up to two years. Native plants that had long since disappeared returned, and the full range of vegetative cover has come back to life. (Certain rehabilitated wetlands in Australia have generated similar recovering native vegetation.) Badly-degraded land was first furrowed and then reseeded with native or adaptable plants acclimatised to local conditions. Each plant was surrounded by a small handmade soil bank to protect the plant and collect rain (see photo). No further watering is needed with this method and manage stock access crops the shrubs, maintaining new regrowth and self-seeding. Native creatures are now returning.

BRAZIL - Water in a Dry Landscape

North-eastern Brazil is an area which endures an annual drought season which may extend for nine months of the year. The tree cover becomes grey due to severely-reduced water availability. The dry wood is suitable for the production of charcoal, although only a low-income generator for the local community. In times of prolonged dryness and timber harvesting, wood became scarce and the community was force to crush the only remaining natural resource, local stones, for gravel to be carted away for the building industry.

The priority was to establish reliable water for the community which was achieved by digging aid-funded local wells to supply small underground covered dams that protected water supplies which were vulnerable to evaporation. The underground dams are capable of holding up to 16,000 litres each after only light rain (200mm) and enabled the community to grow reliable vegetable produce in quantities sufficient to prevent loss of population migrating to the cities.

TUNISIA - Soil Stabilisation

A dry country on the northern edge of the Sahara Desert, Tunisia has to contend with low and unpredictable desert rainfall, and with sand and soil dryness and mobility. Several techniques are used to prevent precious soil and water loss.

To catch water and simultaneously prevent sheet erosion on unvegetated hillslopes, terracing techniques are utilised. Small banks are built laterally across hillsides and stream gullies to slow the floodwater from infrequent rains and retain it in small areas contained by stone walls where it soaks into the impounded soil and provides a small growing area.

Another version is contour trenching, digging 1m deep trenches in the soil ~150m in length with stabilising stone walls. They are set level in the landscape to retain all the water falling on them, soaking into the ground beneath with minimal evaporation, encouraging grass growth followed by larger bushes and restoring a ‘small water cycle.’ A permaculture initiative constructing gabions (cages filled with rocks) have a similar role to contour trenching but achieve this differently. Where mobile sand threatens to cover useful land, sand fences and anti-sand shields are used to control sand drifting and soil erosion. Complementary techniques are shelter belts, woodlots and windbreaks.
NIGER - Tree Regeneration

One constant demand in developing countries and desertified areas is firewood for fuel. In more treed areas, building timber of all sizes is required and taken. In one of the provincial areas of Niger, West Africa, it was recognised that the remaining root systems generated tiny tree shoots after rains. However, these were cleared away for crops or quickly grazed back to the ground by stock animals.

It was realised that the continued lack of trees from any regrowth was depriving the landscape of shade and soil stability. A program known as ‘Assisted Natural Regeneration’ was initiated by an aid agency with local consultation and a community who were interested in engaging with the concept. Leaving a selection of the sprouting shoots undamaged by re-routing stock has resulted in the revival of tree cover to such an extent that soil fertility is improving and other communities in the region, who did not initially participate, are now keen to do so having seen the results for themselves.

The technique is known as Farmer-managed natural regeneration (FMNR). As trees become re-established in larger numbers, the residue from pruned trees can be used to provide mulching for fields. This increases soil water retention and reduces evaporation while properly spaced and pruned trees can increase crop yields. This simple and low-cost method has enabled farmers to regenerate some 30,000 square kilometers in Niger.

ZIMBABWE - Managed Grazing by mimicking Wild Herds

Prior to large-scale agriculture, prehistoric lands were roamed by very large grazing herds whose mass movement, wide-scale excrement and churning of soil cover maintained a cycle of biological decay, improving soil quality, deepening plant roots and stimulating plant growth. With human herding, the previous natural grazing impact was replaced by often poorly-managed domestic and relatively sedentary livestock, leading to significant grasslands overpressure (a major trigger for desertification) and inappropriate techniques such as burning vast areas annually to remove old dead grass in an attempt to keep such grasslands healthy.

New thinking aims to spread the pressures of these human activities and change the way animals are managed. One strategy is to mimic the earlier natural movements of the large wild grazing herds by regularly moving modern animal herds. Livestock are grazed in one area for a maximum of three days, and are not returned for at least nine months. This offers a chance to refresh savannah grasslands and their soils more toward their former ‘animal-maintained’ grasslands health and function. The soils of these revitalized grasslands represent a sizeable natural carbon sink that will sequester carbon into the soil and store it as stable humus.
Another version of mimicking natural grazers for the restoration of grasslands uses fences with many small paddocks (where that investment exists); by moving herds from one paddock to another after a day so the grass can grow more effectively. Further management improvements include -

- ‘Transhumance’ (rotational use) of stock movement across rangelands and water well sites
- more shrewdly matching stocking rates to the carrying capacity of ecosystems
- expanding into a more diverse mix of farming species

However, for the grazing regimes to operate successfully, the communities must work together and stick to the strategy. This is not always easy, as whole communities need to be motivated and prepared to contribute but there is nothing like seeing positive results (see photos) and creating opportunities for increasing people capacity and skills. Even with the commencement of new management techniques, one village reported that “in one season, and doing the grazing badly, we still got approximately four times the yield of grass.”

NAMIBIA, ZAMBIA, KENYA AND ETHIOPIA - Mixed Farming

Wide-ranging stock farming has often clashed with cropping agriculture in many places in the world, currently and historically. However, with limited resources available there is a vital need to be innovative with them. Agriculturally, conditions in the dry subhumid and semi-arid zones can equally favour pastoral and cropping land use. Therefore mixed farming practices in these zones allows a more efficient recycling of nutrients within the agricultural system where a single farm household combines livestock rearing and cropping.

Mixed farming in these regions involves integration of local cultural and economic practices. Reducing the perceived need (or tradition!) of competition between the two farming approaches is an important step towards cleverly maximising use of limited assets without destroying them and reducing the environment to desertified status. There are also broader community social benefits to be gained from such cooperative initiatives.
Communities are also being taught how to use livestock to improve their crop yields with new stock management techniques. Now communities are bringing their livestock together for several nights in the fields before the crops are planted. This is an effective substitute for ploughing and soil preparation, saving the time, expense and labour of transporting manure from the cow to the field. During the dry season, farmland also benefits from livestock manure being kept on fields at night, thus effectively retaining more moisture and nutrients. Farmers’ yields are reported to be increasing by three-to-five times.

Such technique combinations can lower livestock pressure on rangelands through better production of fodder and stubble. During and after extended times of low rainfall, this will provide feed when grass is scarce and when protecting new plant growth from early grazing. Mixed farming is also utilised by many West African farming systems where it is also well-suited.

**SOMALIA - Holding Sand Dunes with Cactus and Wind-rows**

Located in the Saharan Desert latitudes and subject to the hot dry winds from the northeast, Somalia suffers from poverty and desertification after several decades of civil war, generally over the limited resources. Stabilising the sand dunes offers a chance to create cultivatable land for dryland farming. As dry sand is so mobile, techniques being used here involve planting of heat-tolerant, low water demanding plants like low-profile cactus. To give these plants protection while they become established, wind-rows of interwoven dried tree branches are laid at right angles to the prevailing dry winds and along crests of dunes which stops their top-driven mobility. Similar dune-top vegetation (planted or retained remnants) are utilised in Australia’s wide sand-ridge broad-acre dryland regions across all our southern mainland States.

**ETHIOPIA - Carbon Sinks Funding**

Similar FMNR techniques (see Niger above) are applied in Ethiopia under funding from the World Bank’s BioCarbon Fund. This is because the practice conserves carbon in forests and agricultural ecosystems and is therefore a targeted undertaking which attracts global subsidies, assisting the developing nation.

**SAHEL - Alternative resources**

In some areas among the Sahel countries where the geology is suitable, farmers who are involved in rehabilitating tree growth have discovered that certain types of rocks when crushed and powdered can be used as fertiliser to accelerate growth. These are usually phosphate deposits, similar to those on the Pacific Island of Nauru.

**SAUDI ARABIA - Seawater Use in Agriculture**

Many deserts have a maritime border. Salt-flats are one of the most promising desert areas for seawater agriculture and could be revitalized without the use of freshwater or much energy. Seawater agriculture has been found to work well in the sandy soils of desert environments for growing salt-tolerant crops on land using water pumped from the ocean for irrigation. One estimate is that up to 15% of the world’s desert areas (see Map 2) could be suitable for growing crops using saltwater agriculture for human or animal food production. Crucially, this would not involve deforesting or diverting more scarce freshwater for desert agriculture.

**Volunteers slowing desertification by planting vegetation in Somalia**

*Photo: National Geographic/Getty*

**Map 2** LOCATIONS in coastal deserts and inland salt deserts (green areas) could be used for seawater agriculture or irrigation from salty underground aquifers to grow a variety of salt-tolerant crops for food or animal forage. Source: Irrigating Crops with Seawater, Scientific American 76
One such location is the salt-flats in the Rub’ al Khali desert in Saudi-Arabia. It is capable of supporting the growth of the Glasswort species (Salicornia bigelovii) which can grow in coastal marshes. Because of their ability to flourish in salt water, glasswort plants are the most promising crop to be grown so far using seawater irrigation along coastal deserts. They can be eaten by livestock, and their seeds yield a nutty-tasting oil.

Seawater agriculture is promising and has provided successful trials but is yet to be run at a commercial-scale. Pumping seawater to the land and disposal of surplus salt water is costly so productivity must be sufficient to cover this. There are considerations too about the impact of introducing seawater salinity onto landscapes, so environmental impacts need to be taken into account. However, this innovation is likely to be of increasing interest as the dry climates continue.

### Student Activities:

1. What is UNESCO? How does it operate and assist in global problems relating to desertification and improving agriculture?

2. Many organisations are committed to and involved in efforts to resolve the problems of desertification at local scales. Here are some examples of many:

   - Clean Up The World
   - Livelihoods
   - Down To Earth
   - Green Facts
   - Just Dig It
   - Africa Centre for Holistic Management
   - IFAD
   - FSD International (Foundation for Sustainable Development)
   - Acclimatise Climate Change Adaptation Consultants
   - Climate Change, Agriculture and Food Security (CCAFS)

2a Choose four from the above list or find some others on the Web that interest you.

2b Outline the background of these organisations and the reasons why they undertake this work.

2c Where does their funding come from? Evaluate their success.

2d Choose a project being undertaken by each of your selections. Identify any problems they encounter in their work.

3. What is Philanthropy? Who does it and where?

4. Can you find some examples that relate to ‘Solutions for Desertification’ and ascertain the amount and types of support they can provide?

5. Many individuals have been influential in developing innovative solutions for combating desertification issues. What ideas or contributions have been made by these people?

   - Allan Savory
   - Bill Mollison
   - Geoff Lawton
   - Peter Westerveld
   - Willem Van Cotthem
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THE VALUE OF GIS IN GEOGRAPHY

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Viewing our world

When we view our world we are influenced by the country where we live, our upbringing, biases, education and intelligence, among other things. In Figure 1 the engineer, farmer, botanist, marine biologist, and the geographer all look at the land in different ways.

According to the GISGeography.com website article “What is Geographic Information Systems (GIS)" (See reference below), a Geographic Information Systems connects geography with data.

Often the primary output from a GIS is a map showing geographic relationships on a background of mapped information, such as you might find in a street directory (Figure 3).

What is a Geographic Information System?

A Geographic Information System, or GIS as it is commonly known, allows geographical data, stored in a computer database, to be processed into information. Spatial features on the Earth's surface, such as trees, lakes and roads and their attributes, such as the species of a tree, the salinity of a lake or the type of road surface, can be stored in the computer so that relationships within and between features, as well as relationships with human activity can be determined and analysed (Figure 2).

So where did GIS come from?

The History of GIS

The basic idea of a GIS is not new. In fact, in 1854, Doctor John Snow was able to halt a Cholera epidemic in London by determining the source of the outbreak. He was able to locate a specific public water pump which was contaminated by the disease. Figure 4 is part of John Snow’s map. The red dot (upper left) and the green dot (bottom right) show the locations of water pumps. The dark rectangles indicate the location and number of deaths due to cholera. The cholera deaths are clustered around the pump marked by the red dot. Doctor John Snow was able to deduce from the clustering of deaths that water from this pump contained the cholera disease.
Geographical processing and analysis is now very sophisticated due to powerful data manipulation and analysis tools that can be found in GIS software.

**The Value of GIS to Geography**

When a geographer uses a GIS, the original data, such as those relating to the tree, road and forest may be stored in a very precise way in a digital computer file (Figure 5). Data can then be analysed individually and collectively so that spatial relationships of features can be determined.

**Applications of GIS**

The applications of GIS in geography are far ranging.

The following applications will help you to understand how GIS can be applied to many aspects of our world.

**Human Geography**

The applications of GIS in human geography are those where the emphasis is on people.

**Patterns of Movement**

Chances are that you own a smart phone. It will contain a lot of apps; many of these will use similar computer programs that are found in a GIS.

Some specific applications are:

- **Pedestrian Behaviour** – Determining the behaviour of pedestrians on the streets of a city, or in shopping centres, to plan for improved flow or the strategic placement of facilities.
- **Estimated Travel Time** – Calculating the time it will take to travel on a particular route.

GIS can analyse both the spatial and temporal components of the patterns of movement.
Patterns of Settlement

A GIS is ideal for use when determining existing patterns of settlement or when planning for new settlement. The GIS allows historical records of settlement to be considered when developing new areas for settlement.

Some specific applications are:

- **Relationships** – Analysing data to reveal individual, family and community relationships, and the impact on the environment in which they live.
- **Development** – Monitoring the change in socio-economic zones within a city or town.

Geographers all over the world use GIS to study patterns of settlement.

Infrastructure and Services

A GIS can store the location of pipes, cables and other linear conduits allowing their location to be determined before any earthworks are undertaken. Roads, street lighting, public security cameras and other such infrastructure can be monitored and maintained using a GIS to store the location and attributes of these features.

Some specific applications are:

- **Network Management** – Managing a telephone, electricity, gas, road, rail or other network effectively and efficiently, even in real time.
- **Underground Utilities** – Storage and management of the locations of underground gas, water, electrical and telephone utilities.

GIS data is vital to the management and upkeep of the infrastructure and for the efficient implementation of services.

Socio-Economic Development

A GIS can assist in socio-economics at the global, continental, country, state, local and household level of development. The impact of economic decision making on society can be analysed within the one computer system using a GIS.

Some specific applications are:

- **Drive-Time Analysis** – Using a GIS to analyse driver behaviour and linking the findings to real-time road traffic conditions can help to improve the driving experience and will aid in determining how far people are willing to travel to purchase products.
- **Geocoding Businesses** – If the characteristics of all businesses such as restaurants, banks and take-away shops are stored in a GIS, along with their GPS location, then questions, such as “Where is the nearest shoe shop?”, can be answered quickly and in real-time.

There is an increasing need for computer systems, such as GIS, to be used to provide answers to complex problems in society.

Social Media & Virtual Reality

Your smart phone uses many of the smarts that are in a GIS. Location is important in the virtual world of social media.

Some specific applications are:

- **Geosocial Tools** – Searching twitter geographically for tweets which have a common theme.
- **Building Virtual Environments** – Designing future buildings, roads, cities, and parks with video game contributions.

Every time you use your smart phone, or computer, to locate something or someone you are using computer
software that can be found in a GIS.

Location Based Services

Services, such as postal, courier, public transport, taxi, waste disposal, roadside assistance, ambulance, police, fire brigade, rail travel, air travel, can all be managed using real time GIS functionality.

Some specific applications are:

• **Sustainable Tourism Planning** – Giving consideration to the cost and benefits of a tourist development in the virtual environment of a GIS.

• **Virtual Fencing** – Creating limits on the movement of animals, people or vehicles using GPS enabled GIS to alarm, immobilise or report any breach of the virtual boundaries.

We are a mobile society and we demand accurate real-time information to support our everyday activities.

Early Warning & Emergency Management

The wide reach of the Internet has led to spatial data from all over the world being assembled and used to determine the impact of climate change. GIS is used worldwide by emergency services and disaster management organisations.

Some specific applications are:

• **Contamination** – The use of dyes, trace elements and soil tests can be used to trace the location and flow of contaminants in soil, water and air.

• **Desertification** – Cross discipline analysis of inappropriate agriculture practices, deforestation, drought and other factors which may lead to desertification.

GIS is an indispensable tool for emergency services with their emergency management activities and the development of early warning systems.

Health

Online access to medical records and global health and disease patterns has led health professionals to turn their attention to using GIS technology.

Some specific applications are:

• **Disease Spread Patterns** – Charting the development of a disease over space and time.

• **Geomedicine** – Tracking a patient’s location history to determine if past associations can be linked to current health issues.

A health records database when linked to location in a GIS can be used to assist health professionals to understand the relationships between health issues and other environmental factors such as water pollution, soil contamination and air quality.

Historical Analysis

The movement and settlement of humans can be traced by accessing historical documents. GIS can be used to analyse the patterns of movement and settlement over many years.

Some specific applications are:

• **Shipwrecks** – Documenting the remains of shipwrecks, aircraft, hulks, lost anchors and any other objects on the seabed.

• **3D Historical Fly-through** – Recreation of historical sites as virtual reality animations.

GIS is a valuable tool for historical analysis as it can be used to allow a user to visualise what a geographic area may have looked like many years ago.
Physical Geography

Topography

The underlaying ‘elevation’ and the overlaying ‘topography’ of our Earth are the foundation of physical geography and are key layers in a GIS.

Some specific applications of GIS to topography:
- **Digital Models** – Creation of a digital elevation model of the Earth’s surface and a digital terrain model representing the features on the surface.
- **Geomorphology** – The study of the shape of the Earth and the underlying structure.

GIS enables geographers to engage with other professionals when studying topography.

Vegetation

Vegetation is one of the key overlays in physical geography. Vegetation can be represented by areas (polygons) with common characteristics, for example a eucalypt forest, or by a grid (raster) of squares (pixels) which have spectral reflectance values associated with a specific vegetation type.

Some specific applications are:
- **Deforestation** – Gauging deforestation using land cover change over time.
- **Weeds** – Identification and eradication of weed infestation.

Vegetation is linked to so many environmental factors, such as climate change, soil loss, groundwater levels, that it is a key layer of data in any GIS database.

Geology and Soil

Underlying geology determines the form of the land. Soil, derived from the geology of an area determines the nature of the land cover and land use. Each is a vital layer for inclusion in a database of the physical geography of any area.

Soil Types – Modelling soil types.
- **Geology** – Interpreting the geology of an area using aeromagnetic data, aerial photography, satellite imagery and topographic data.

A GIS helps geographers to interpret why certain areas of land have particular characteristics.

Water & Climate

Water, the source of life, is a key player in a GIS when analysing physical geography. Surface water, such as rivers, wetlands and lakes, contribute greatly to the formation of the land and the nature of the life that exists in particular regions. Groundwater, water below the surface, is stored in aquifers, and ensures a regular supply of water during drought. The oceans are full of marine life, influence greatly the climate, are responsible for many natural disasters, such as Tsunamis, and are used for major shipping routes between countries. The inclusion of water related layers in a GIS allows analysis to be undertaken on flow, contamination, resources, volume, supply, climate, channels and bores, drainage catchments and navigation.

Some specific applications are:
- **Surface Water & Groundwater**
  - **Wetland Inventory** – Recording the flora, fauna and water quality of wetlands.
  - **Groundwater** – Analyzing the productivity of agricultural land based on groundwater availability and quality.
Oceans
• **Live Marine Traffic** – Tracking ships worldwide over the Internet using data streamed from a ship’s GPS navigation system.
• **Sea Level Rise** – Collecting data to study sea level rise and climate change.

Climate/weather
• **Climate Change** – Mapping areas on the Earth impacted by climate change.
• **Earth Interactions** – Modelling vegetation, atmospheric, rainfall and ecosystems to study their interactions simultaneously

Some common water related layers in a GIS are: streams, drainage areas, hydrography, channels, surface water, groundwater, rainfall, snow and ice, salinity, water quality, water logging, water temperature, flood plains, wetlands.

**Biodiversity**
The study of the plants and animals in the world and their habitat is one of the areas where GIS is invaluable. A GIS is ideal for determining relationships between species which co-exist in particular ecosystems.

Some specific applications are:
• **Biogeography** – Studying ecosystems in geographic space and through (geological) time.
• **Species Biodiversity** –Using temporal GIS to monitor changes in a species over space and time.

Studies within species, between species, and within and between ecosystems are greatly assisted when a GIS is introduced.

**Land Cover / Land Use**

Common land cover types, the observed physical cover, are open water, wetland, ice/snow, bare rock/sand/clay, shrubland, grassland, forest.

The same land cover type may be used for quite different land use. A GIS can store both land cover and land use information.

Some specific applications are:
• **Land Inventory** – Assessing land capability for sustainable agriculture, forestry and recreation.
• **GIS & Precision Viticulture** – application to planting, growing, harvesting, wine making and packaging.

Land cover and land use are dynamic entities and as such the GIS containing such data needs to be constantly updated to reflect the current situation.

**Concluding Comments**

In a GIS, visual analysis is replaced by digital analysis. Many different geographers with different backgrounds can use a GIS to ask “What if?” type questions. What if I plant a vineyard in a specific location? Based on the analysis of data in a GIS, information can be generated which may give an indication of the likelihood of success.

GIS is an enabling technology that allows a geographer to make better decisions based on the knowledge that is gained from the information which is generated from spatial and attribute data stored in the GIS.

There are many applications of GIS. You can discover more by viewing “Applications of GIS” and “Stories of Real People Using GIS” in the reference list.

If you are really keen you can read “Getting started with GIS” provided online by a leading GIS software provider called ESRI. See reference to this site below.
**Student Activities:**

1. Name three distinct geographical features (other than those given as examples) and describe what characteristics of the feature enabled you to determine what it was.
   a. Three point features (e.g. pole)
   b. Three linear features (e.g. fenceline)
   c. Three areal features (e.g. lake)

2. Describe one spatial attribute for each of the following: [NOTE: Spatial attributes relate to locational information (measurement of location, length, perimeter, area, height, etc.).]
   - Built up area (e.g. perimeter)
   - Road
   - Embankment
   - Building
   - Rainforest
   - Sand
   - Tree
   - Recreation reserve
   - Vehicle track
   - Bridge
   - Contour
   - Lake
   - Paddock

3. Describe one non-spatial attribute for each of the following: [NOTE: A Non-Spatial attribute relates to a defined characteristic of an entity other than locational information. (composition, structure, form, purpose, use, etc.).]
   - Built up area (e.g type of housing)
   - Road
   - Embankment
   - Building
   - Rainforest
   - Sand
   - Tree
   - Recreation reserve
   - Vehicle track
   - Bridge
   - Contour
   - Lake
   - Paddock

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**References**


Getting started with GIS [https://www.esri.com/training/catalog/57630434851d31e02a43ef28/getting-started-with-gis/](https://www.esri.com/training/catalog/57630434851d31e02a43ef28/getting-started-with-gis/)


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