The Journal of Animal & Plant Sciences, 21(2 Suppl.): 2011, Page: 317-332
ISSN: 1018-7081

ECOSYSTEM SUSTAINABILITY, CLIMATE CHANGE, AND RURAL COMMUNITIES

P. S. Meadows

Institute of Biodiversity, Animal Health and Comparative Medicine, School of Life Sciences, College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow G12 8QQ, Scotland, UK
Corresponding author: e-mail: peter.meadows@glasgow.ac.uk

ABSTRACT

Ecosystem sustainability and rural community uplift are essential to address in terms of the progressive pollution of global ecosystems, rapid urbanisation, and the increasingly severe predictions of climate change. The sustainability of ecosystems in the coastal zone and its wildlife is therefore vital. This review addresses these issues by considering current views on climate change and the United Nations Millennium Development Goals. Models show how international, national and local organisations impact on human communities and on ecosystems and wildlife, and how community sustainability is linked with ecosystem sustainability. Research is described on ecosystem sustainability and biodiversity in the coastal zone. This focuses on marine sedimentary ecosystems in the intertidal and sub littoral zone. Colonisation of sediment by living organisms changes the sedimentary ecosystem. Interactions between organisms living in sediment and the physical and chemical properties of sediment are also important. Sediment microorganisms reduce sediment permeability. This reduces in faunal biodiversity. Beds of the cord grass *Spartina* at the edges of estuaries make water flow turbulent. This alters potential flood risks and riverbank or estuarine erosion. Changes in temperate and tropical aquatic ecosystems have a central role in determining the abundance and sustainability of larger organisms. These organisms (shellfish, finfish, and birds) are used directly by rural communities, and are also important for ecotourism. Ecosystem sustainability is therefore central to coastal zone rural communities and their economies. The education and awareness building of the coastal communities in these issues is therefore vital.

The current climate change scenario: Climate change is continuously occurring, and has done so since the beginning of the earth as an ecosystem. It is possible to obtain a fairly accurate picture of changes in global temperature over the past 2000 years (Figure 1). Ten different published reconstructions of temperature anomalies – the difference in temperature from the average – all show the same effects for the Northern Hemisphere. There is considerable variation from decade to decade. However it is clear that a medieval warm period existed from about 950 to 1300 AD and a colder period existed from about 1300 to 1800 AD. These are documented in writings and paintings of the period. Since then, there has been a dramatic increase in the temperature anomaly. The increase began at the onset of the industrial revolution in about 1830 AD. This is obvious at the right hand side of figure 1, and is illustrated in more detail in Figure 2.

There are widespread variations during this period. For example there was an extremely cold winter in 1947, and a similar one in 1963 - when the sea froze along parts of the coast of Scotland. But the overall increase in the temperature anomaly is indisputable, and its long term upward trend shows no tendency to abate.

The IPCC 2nd Feb 2007 report "Climate Change 2007: The Physical Science Basis. Summary for Policymakers" makes the case very clearly (IPCC, 2007). Meadows and Meadows (2006a) identify the following almost verbatim

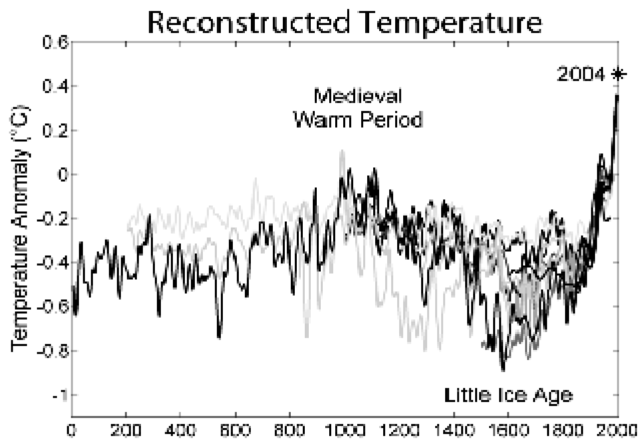


Figure 1. Constructed global temperature over the last 2000 years, based on ten different published reconstructions (Meadows and Meadows, 2006a; Wikipedia, 2007).

quotations from the IPCC report and emphasise the extreme seriousness of global climate changes, many of which are now clearly evident. In these quotations, radiative forcing is defined as "a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it. In the IPCC 2007 report radiative forcing values are for 2005 relative to pre-industrial conditions defined at 1750 and are expressed in watts per square metre (W m^{-2})" (IPPC, 2007).

- "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.

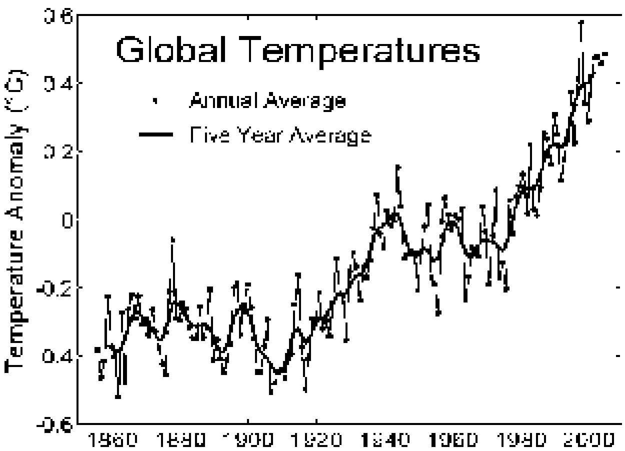


Figure 2., Change in the global average temperature over the last 150 years (Meadows and Meadows, 2006; Wikipedia Web site 2007).

The Wikipedia web site states that 'the instrumental record of global average temperatures was compiled by the Climatic Research Unit of the University of East Anglia and the Hadley Centre of the UK Meteorological Office. Data set TaveGL2v was used. The most recent documentation for this data set is Jones and Moberg (2003). This figure was originally prepared by Robert A. Rohde from publicly available data and is incoporated into the Global Warming Art project'.

- "The understanding of anthropogenic warming and cooling influences on climate has improved since the Third IPCC Assessment Report (TAR) leading to a very high confidence (9 out of 10 chance) that the globally averaged net effect of human activities since 1750 has been one of warming, with a radiative forcing of + 1.6 to + 2.4 W.m^{-2}. "
- "The combined radiative forcing due to increases of carbon dioxide, methane and nitrous oxide is +2.07 to +2.53 W.m^{-2}, and its rate of increase during the industrial era is very likely to have been unprecedented in more than 10,000 years. The carbon dioxide radiative forcing increased by 20% from 1995 to 2005, the largest for any decade in the last 200 years."
- "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air temperature and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Eleven of the last twelve years (1995-2006) rank among the 12 warmest years in the instrumental record of global surface temperature since 1850."
- "At continental, regional, and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in Arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and intensity of tropical cyclones."
- "Paleoclimate information supports the interpretation that the warmth of the last half century is unusual in at least the last 1300 years. The last time polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 metres of sea level rise."

These extremely worrying series of event sequences quoted directly from IPCC (2007), have been reviewed in detail in the Stern's seminal book on The Economics of Climate Change (Stern, 2007). They are going to have major impacts on all global ecosystems, and on the sustainability of these ecosystems and their wildlife and human populations (Common, 1995; UN Millennium Project, 2005a,b; Ghani and Lockhart, 2008; Green 2008). The events will have a disproportionate impact on rural communities in developing countries. There are a number of reasons for this, amongst which the following are of central significance.

Firstly, the most important negative environmental changes associated with climate change are predicted to occur in the tropics and subtropics. These include rising temperatures and sea level, and an increase in the intensity and frequency of storms and cyclones.

Secondly, the majority of developing countries are located in the tropics and subtropics. Here, isolated rural communities have little or no infrastructure in terms of roads, schools and hospitals. So the effects of climate change and the resultant increase in the frequency and intensity of natural hazards are greater than elsewhere.

Thirdly, the governmental organisations in many developing countries are not able to address climate change issues effectively. There are a number of reasons for this. Corruption is not uncommon, standards of governance are not high enough, and commitments to help the poorest in a community are often lacking.

Fourthly, the governments of developed countries are lacking in commitment. They are often not fully aware of the current situation on the ground, and do not care enough to increase their aid packages. This is not to belittle the outstanding work done for example by the Canadian International Development Agency (CIDA), the UK Department for International development (DFID), the British Council, Oxfam, the Red Crescent, and Save the Children. However the point needs making and needs to be addressed.

A recent article in the Financial Times of London emphasises the political nature of the climate change problem. Following the election of US President Obama, Dizard (2009) views the coming months as being critical within Obama's administration. The administration needs to rework environmental law and regulation of environmental pollution to allow for the regulation and reduction of carbon emissions. This will involve changing the current cap-and-trade arrangements between high emitters of carbon and low emitters of carbon into the atmosphere. Companies utilising renewable energy such as wind or solar, are examples of low emitters, and coal-fired power stations are examples of high emitters.

The cap-and-trade system works broadly as follows. Supposing the carbon produced per company is legally limited or capped at 100 units. A company producing more than 100 units per year would then be breaking the law and liable to prosecution. Suppose that a low emitter produces 40 units while a high emitter produces 140. The former is below the limit and the latter above the limit. Then under the cap-and-trade system, the low emitter can if it so wishes trade 45 units with the high emitter, and still remain below the 100 limit. In other words the low emitter sells 45 units to the high emitter at a price agreed between the high emitter company and the low emitter company. Both companies benefit from the 45 unit trade between them. The high emitter's carbon emissions per year become notionally 140 – 45 = 95 units per year, which is now below the legal limit. The low emitter receives payment for the 45 units, and still remains below the legal limit at 40 + 45 = 85 units per year.

Trading centres such as Wall Street and the London Stock Exchange thrive on this and similar potential trading situations, especially if the companies involved do not price the cap-and-trade efficiently. There is then room for traders on these stock exchanges see trading opportunities.

Dizard (2009) drew attention to a new problem in the trading of units under the cap-and-trade system in the United States. A US Federal appeals court decision on 11th July 2008 (Barringer, 2008), stated that the US Environmental Agency had exceeded its authority when it set up the 2005 US Clean Air Interstate Rule. It had "fatal flaws". According to Barringer, the US Clean Air Interstate Rule covers 28 states and required a 70% reduction in sulphur dioxide and nitrogen oxide by 2015. This was a central part of the Bush administration's climate change regulation. An appeal is in progress, but the current situation is that a major effort to reduce climate pollution has been invalidated by the court's ruling. As a result, many of the cap-and-trade units have dramatically fallen in value.

The UN Millennium Development Goals: The Millennium Development Goals have a history extending at least 40 or 45 years. The ideas in them were discussed in a number of conferences in the 1960's and 1970's, leading up to the publication of *Our Common Future* (World Commission on Environment and Development. 1987).

This seminal book was instigated by the General Assembly of the United Nations. Its history is as follows. In 1983, the UN Secretary General approached Gro Harlem Brundtland, then Prime Minister of Norway, to establish and chair a special independent commission. The commission's objectives were to identify the major challenges posed by environmental change and sustainability in relation to developing and developed countries and the global community at large.

The commission, which became known as the World Commission on Environment and Development, consisted of 22 members from 21 states (Algeria, Brazil, Canada, Colombia, Cote d'Ivoire, Federal Republic of Germany, Guyana, Hungary, India, Indonesia, Italy, Japan, Nigeria, Norway, Peoples Republic of China, Saudi Arabia, Sudan, USSR, United States, Yugoslavia, Zimbabwe). It met for the first time in October 1984, and published its report as *Our Common Future* in April 1987, 30 months later.

The major challenge identified in *Our Common Future* (World Commission on Environment and Development. 1987, pp. viii to xv) fell into four parts. The four parts are quoted largely verbatim from Gro Harlem Brundtland's forward to the book dated Oslo, 20th March 1987, although I have slightly shortened and changed the English.

Firstly, the commission was asked to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond. Secondly, it was asked to recommend how concern for the environment could be translated into greater cooperation among and between developing and developed countries. This should lead to the achievement of mutually supportive objectives that take account of interrelationships between people, resources, the environment, and development. Thirdly, the commission was asked to consider ways and means by which the international community could deal more effectively with environmental concerns. Fourthly the commission was requested to help to define shared perceptions of long-term environmental issues, and to help to define the appropriate efforts needed to deal successfully with the problems of protecting and enhancing the environment. In this it was also requested to advise on a long-term agenda for action in the coming decades and to identify aspirational goals for the world community.

Viewed from 2009, 25 years after the UN Secretary General's initial approach to Gro Harlem Brundtland, the four parts are perhaps not defined specifically enough. However the resultant book by the 22 members of the World Commission on Environment and Development entitled *Our Common Future* was a tour-de-force (World Commission on Environment and Development 1987). It largely defined and guided thinking by the UN and international aid and scientific communities in their production of the Millennium Goals in 2000.

Annexe 1 in *Our Common Future* (World Commission on Environment and Development 1987, pages 348 to 351) makes environmental statements that are even more relevant now than they were at the time of writing. The annexe summarises legal principles for the protection of the global environment and the need for sustainable development. States are expected to conserve and use the environments of the state in a way that benefits present and future generations. They are also expected to maintain ecosystems and ecological processes that are essential for biosphere function, to preserve biodiversity, and to maintain optimal sustainable yield – a well known principle of fisheries regulation (Beverton and Holt, 1957; Meadows and Meadows, 1988). *Our Common Future* also calls on states to put in place environmental protection standards, to monitor these and publish the results of the monitoring, and to have procedures for environmental impact assessment before any major changes to the environment are undertaken.

The Millennium Development Goals were then defined in more detail in an article entitled *Shaping the 21st Century: The Contribution of Development Co-operation* (OECD Development Assistance Committee, 1996), and were formally adopted in September 2000 at a meeting of the General Assembly of the United Nations in its fifty fifth session, as Resolution 55/2 the Millennium Declaration (UN, 2000).

At the September 2000 UN meeting the Millennium Declaration was adopted by 189 nations and signed by 147 heads of state and governments. The MDG's have been listed and subsequently commented on in a large number of publications (UN, 2002a,b; UN, 2008). There are eight MDG's divided into twenty-one quantifiable targets measured by sixty indicators. The eight goals and twenty-one quantifiable targets are as follows, listed verbatim from the UNDP website (UNDP,2008). Unless otherwise stated, the UN aims to achieve the targets by 2015.

"Goal 1: Eradicate extreme poverty and hunger
Target 1a: Reduce by half the proportion of people living on less than a dollar a day.
Target 1b: Achieve full and productive employment and decent work for all, including women and young people.
Target 1c: Reduce by half the proportion of people who suffer from hunger."

"Goal 2: Achieve universal primary education
Target 2a: Ensure that all boys and girls complete a full course of primary schooling."

"**Goal 3: Promote gender equality and empower women**
Target 3a: Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015."

"**Goal 4: Reduce child mortality**
Target 4a: Reduce by two thirds the mortality rate among children under five. "

"**Goal 5: Improve maternal health**
Target 5a: Reduce by three quarters the maternal mortality ratio.
Target 5b: Achieve, by 2015, universal access to reproductive health. "

"Goal 6: Combat HIV/AIDS, malaria and other diseases
Target 6a: Halt and begin to reverse the spread of HIV/AIDS.
Target 6b: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it.
Target 6c: Halt and begin to reverse the incidence of malaria and other major diseases. "

"Goal 7: Ensure environmental sustainability
Target 7a: Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources.
Target 7b: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss.
Target 7c: Reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation.
Target 7d: Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020."

"**Goal 8: Develop a global partnership for development**

Target 8a: Develop further an open, rule-based, predictable, non-discriminatory trading and financial system.

Target 8b: Address the special needs of the least developed countries.

Target 8c: Address the special needs of landlocked developing countries and small island developing States (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly).

Target 8d: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term.

Target 8e: In cooperation with pharmaceutical companies, provide access to affordable essential drugs in developing countries. ”

Target 8f: In cooperation with the private sector, make available the benefits of new technologies, especially information and communications.”

Following the identification of the eight Millennium Development Goals and their targets by the United Nations (UN, 2000), an independent advisory body to the UN, the Millennium Project, was commissioned by Kofi Annan, the UN Secretary General at the time, and Mark Malloch Brown, the then UNDP Administrator. The objective of the Millennium Project was to identify the most effective strategies that would achieve the MDG's by 2015. The project ran from 2002 to 2005 under the direction of Professor Jeffrey Sachs. Ten major themes, each having a task force of experts, were set up. In 2005, the Millennium Project submitted its final report to the UN entitled 'Investing in Development: A Practical Plan to Achieve the Millennium Goals' (UN Millennium Project, 2005a). The ten theme task forces each submitted their reports at the same time.

It is doubtful whether all of these goals and targets as identified by the UN and then developed by the ten theme task forces of the Millennium Project will be met by 2015. However progress has been made on a number of issues (UN Millennium Project, 2005a,b; UN, 2008). The 2008 Millennium Development Goals Report (UN, 2008), in its overview of the current status of objectives achieved, gives hope of success in achieving some of the MDG's by 2015, although a significant number will fail. The following two paragraphs are paraphrased from that overview.

It is likely that the goal of reducing absolute poverty by 50% will be met. Primary School enrolment has increased dramatically. Many more girls are receiving primary education. Deaths from measles have fallen significantly. Deaths from AIDS have fallen, as have new infections. Malaria prevention is improving. The incidence of tuberculosis has been halted, and it is hoped that it will begin to decline by 2015. Many more people now have access to clean water for drinking. The release of ozone-depleting substances into the atmosphere that stimulate climate warming has been almost eliminated. The proportion of the export earnings used to service external debt in developing countries has been halved. The private sector has increased the supply of essential drugs and mobile phone technology in developing countries.

However a number of targets have not been met. It is unlikely that the target of reducing by 50% the number of people living on less than one dollar per day in sub-Saharan Africa will be met. Approximately 25% of the children in developing countries are under-weight. Gender equality in primary and secondary education is unlikely to be achieved by 2015 in 105 of the 113 countries that were identified as failing to do so by 2005. Nearly thirds of employed women in developing countries are in vulnerable jobs. Women in developing countries are less than 10% of the members of their respective parliaments. More than 500,000 mothers die in childbirth. Almost half of the population of developing countries, approximately 2.5 billion people, lack improved sanitation. More than one third of the population of developing countries live in slum conditions in towns and cities. Carbon dioxide emitted by industries in developing countries has continued to increase, in spite of international agreement to set limits. International trade negotiations aimed at helping developing countries are years behind schedule. “All citizens of the world, especially the poor and the most vulnerable, have a right to expect that their leaders will fulfil the commitments made in 2000 by the UN in its MDG's” (UN, 2008). This clearly is not happening at the time of writing.

All of this means that the conference on education for wildlife sustainability, which was held at the University of Veterinary and Animal Sciences, Lahore, in January 2008, of which this paper is a part, has played a significant national role in addressing the MDG's. This is especially true of goals three, seven and eight.

Sustainable development and poverty alleviation in rural communities: Poverty alleviation as proposed by the MDG's is central to the sustainable development of rural communities in any isolated environment, and the coastal zone is no exception. This alleviation derives from a number of sources. Firstly, rural communities themselves develop and improve their living standards. Secondly, NGO's provide an element of advice and small-scale to medium-scale funding. WWF and IUCN are especially active in Pakistan. Thirdly, large governmental organisations play a vital national role. The Gwadar Port development in Balochistan is an example that is likely to improve the local living standards of rural communities in the long term. Fourthly, very large scale funding is available from such organisations as UNDP, the World Bank and the Asian Development Bank. The World Bank and the Asian Development Bank are not banks as usually envisaged, but international donor agencies funded by groups of developed countries.

The flow diagram in figure 3 shows how national and international organisations, educational establishments and NGO's such as WWF and IUCN interact with rural and urban poor communities. This in turn has the potential to increase the sustainability of ecosystems and wild life, which can then lead to rural and urban community uplift and income generation.

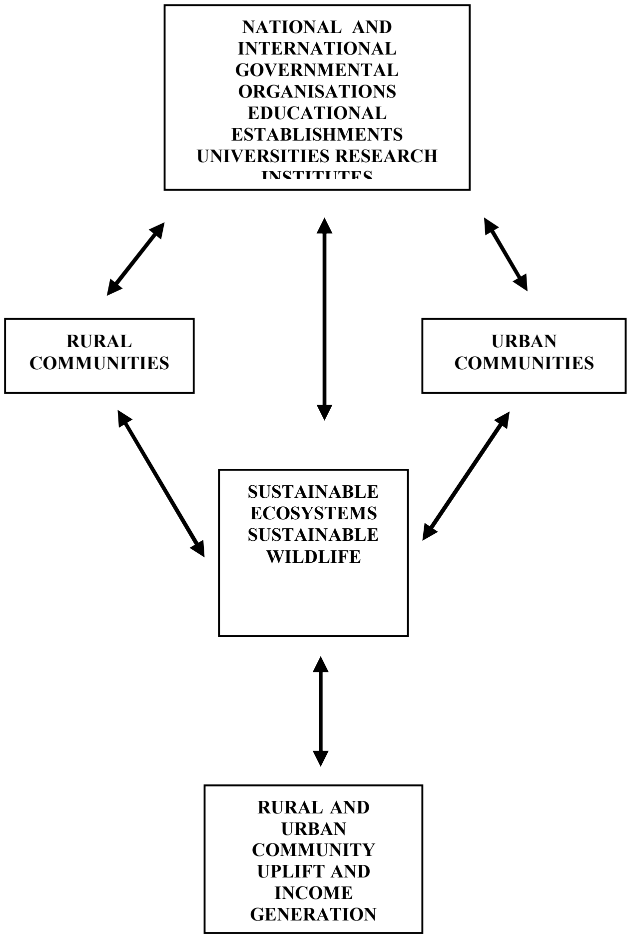


Figure 3. Sustainable development and impoverished rural and urban communities. Flow diagram illustrating the importance of international and national governmental organisations, educational establishments, universities, research institutes, and NGO's on rural and urban communities experiencing extreme levels of poverty. The route to sustainable ecosystems, community uplift and income generation.

The interactions between rural communities and ecosystems in terms of their sustainability can be viewed from a more focussed local point of view. The diagram in figure 4 identifies how a rural community and the ecosystems in its immediate environment mutually interact. The local ecosystems within and adjacent to the rural community are made up of their physical and chemical environment, of their wild and domesticated animals, and of their wild and cultivated plants. These local ecosystems interact with rural communities. If managed in a sustainable manner, the two-way interaction leads to the sustainability of the rural community and its long-term uplift, and at the same time to the long-term sustainability of local ecosystems. However the sustainability and uplift of the rural community is also governed by specific internal and external factors. These factors include the central human requirements of shelter, food and clean water, and the need for effective health and education facilities for both sexes throughout their lives. Population growth and child labour will also play a part. They are likely to have an inhibiting influence.

Two examples illustrate how the uplift of rural communities and the associated ecosystems on which they depend for shelter and food can be enhanced. These examples also show some of the problems that can inhibit this enhancement. Both are British Council Higher Educational Link Programmes funded by the UK Department for International Development that operated from 1997 to 2006 They linked the University of Glasgow with the University of Karachi. The links focussed in different but interrelated ecological and rural community issues.

The first link ran from 1997 to 2001, and was on coastal zone management and environmental impact assessment of mangrove swamps in the Indus delta. It involved staff from the Division of Ecology and Evolutionary Biology, Faculty of Biomedical and Life Sciences, University of Glasgow, and from the Centre of Excellence in Marine Biology, University of Karachi. It had as its overall purpose coastal zone management and environmental impact assessment, and had a number of aims as follows.

1. Assess man's impact, habitat degradation and its amelioration, and the resultant effects on floral and faunal biodiversity of the mangrove swamps.
2. Establish guidelines for subsequent environmental assessment procedures to be used by environmentalists in Pakistan in the form of an environmental handbook.
3. Achieve collaborative research, joint publications, staff development and capacity building, and information transfer between UK and Pakistani scientists.
4. Encourage female participation between academic staff in the UK and Pakistan by providing an interactive environment and collaborative activities.
5. Assess the importance of the roles of females in coastal zone communities.

This first link focussed on coastal zone management and environmental impact assessment, and was achieved by exchange visits by staff between the two universities and by field research. It largely achieved its first, third and fourth objective, but was unable to fully realise the aims of the second objective. During the link there were difficulties associated with too many staff from the University of Karachi wanting to visit the UK under the link. A very successful three day international workshop was held at the Universty of Karachi, and this was subsequently published as a short book (Meadows and Meadows, 2001).

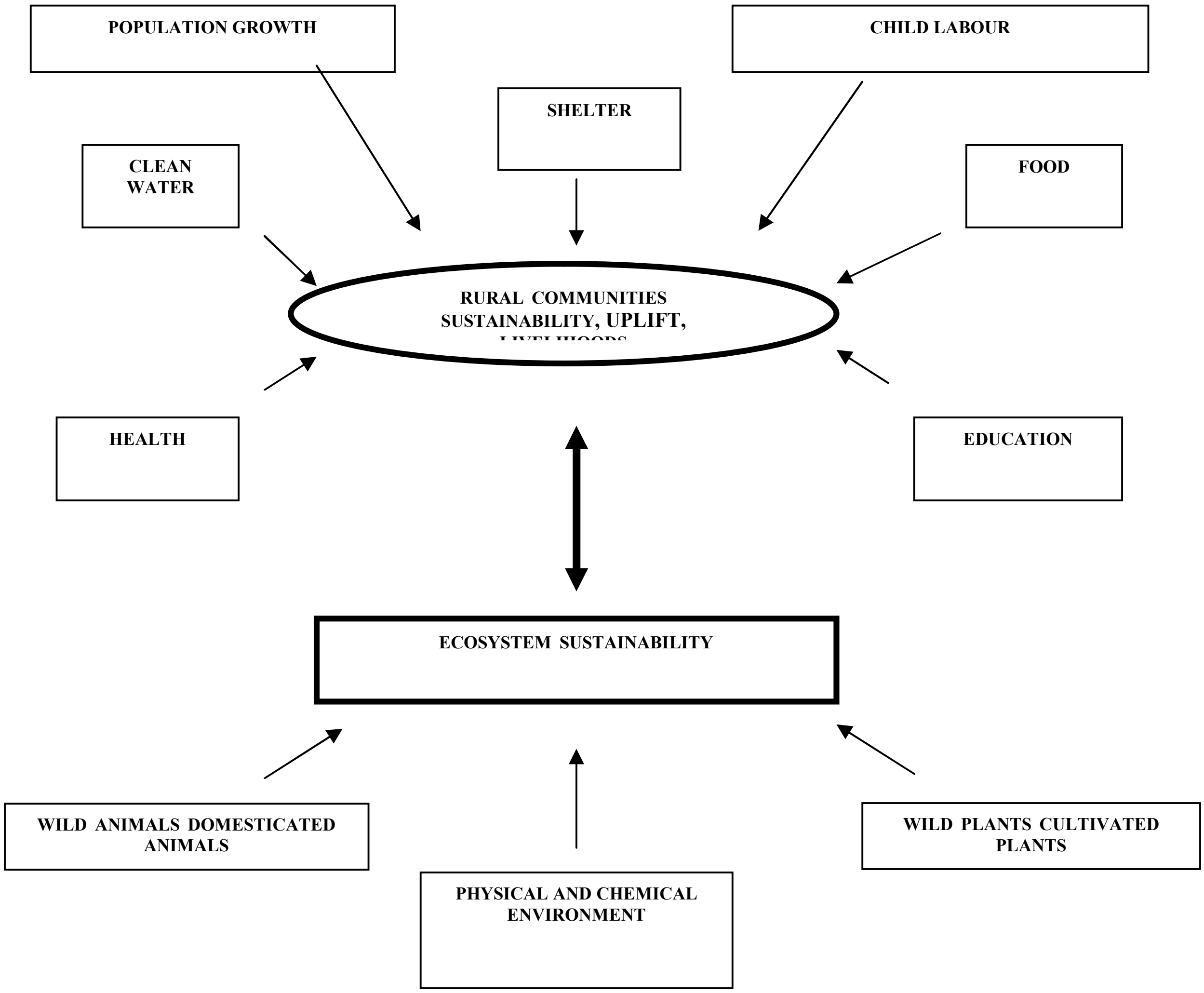


Figure 4. Rural communities and ecosystem sustainability. Diagram showing the importance of water, shelter and food, of health and education, and of child labour and population growth. Ecosystem sustainability depends on rural community sustainability and uplift, and vice versa.

The second link ran from 2003 to 2006 and addressed socio-environmental uplift of rural coastal communities in Balochistan and Sindh. It involved staff from the Division of Ecology and Evolutionary Biology, Faculty of Biomedical and Life Sciences, University of Glasgow, and from the Centre of Excellence in Marine Biology and the Department of Sociology, University of Karachi. The overall purpose of the link was to improve drinking water quality and hygiene in two selected rural communities in the coastal zone, one in Balochistan and one in Sindh. The specific aims of this second project were as follows.

1. Identify the major sources of drinking water in the selected communities.
2. Measure water quality in the communities.
3. Recommend methods for obtaining safe drinking water to the communities.
4. Assess sanitation and domestic waste disposal at the two communities.
5. Implement measures that would ensure safe drinking water in the villages with the active involvement of the local communities.
6. Educate rural women and children in the basics of hygiene and the sustainable use of clean drinking water.

7. Provide cross-disciplinary training and capacity building of academic staff on the link at the University of Glasgow and the University of Karachi. This included career progression for women.

This second link was more successful than the first link, largely because it was more focussed and involved only two academic staff from the University of Karachi and two academic staff at the University of Glasgow, thus allowing a finely tuned programme to develop within the original aims of the project. A number of social science students took part in the field surveys at the two rural communities, and were provided with certificates to this effect. As part of the link, a one-day seminar was held at the University of Karachi, and two one-day village workshops were held, one at each village. The seminar and the village workshops were very successful.

I now want to consider large-scale international aid projects such as those funded by the World Bank and the Asian Development Bank. These are funded at a much higher level than the British Council Higher Education Links. These also address the needs of poor rural communities in developing countries, and contain a large element of ecosystem sustainability. The Asian Development Bank funds major projects in developing countries aimed at alleviating poverty (ADB, 2008a,b; ADB, 2009). It was established in 1966, and like the World Bank is supported financially by a consortium of developed countries. The overall aim of the ADB is to alleviate poverty and improve the welfare of the poor in the Asia and Pacific region. This aim is achieved by providing large-scale grants, loans, and technical assistance for sustainable development projects in developing countries in the Asian and Pacific region, that target the Millennium Development Goals (MDG's) (ADB, 2008a). These projects are broadly in line with the Millennium Development Goals. They provide funding and large-scale long-term loans that improve the welfare of communities currently experiencing extreme levels of poverty. The funding covers technical assistance, infrastructure development, sustainable resource development of the environment, and rural community income generating activities.

A recent Asian Development Programme is focusing on rural communities along the Sindh coast. This is the "Sindh Coastal Community Development Project (SCCD Project)", whose funding of US$ 36 million covers a six-year programme. The project started in 2007 and will run to 2013. Dr Azra Meadows and the current author acted as consultants to the project during its planning stage in Pakistan (Meadows and Meadows 2006b,c). They paid a number of field visits to the area centred on Thatta and Badin as part of a high-level advisory team in summer and autumn 2006. These two areas have a human population of about 1.2 million, most of whom live in great poverty. The coastal zone is periodically hit by cyclones, and it experiences inland flooding from storm surges. It also suffers from large-scale degradation and loss of agricultural land due to salinisation, and great shortage of clean fresh water. As a result, the coastal rural communities often live under conditions of extreme hardship.

The proposals that were forwarded to the Asian Development Bank by the high-level advisory team included an assessment of the marine and freshwater fisheries of the area followed by upgrading of fish hatcheries for aquaculture. They proposed that the potential for aquaculture of shellfish and seaweeds should be assessed, and that the culture of salt tolerant terrestrial plants should be instituted. The team also advised that the coastal zone should be protected by planting strategically positioned stands of mangroves, and that renewable energy devices and flood rescue centres should be put in place. All of these interventions, including fisheries, aquaculture, agriculture, and forestry are part of the Government of Pakistan's environmental strategy, so the project receives added value. The intervention proposals of the high-level team were put before the Board of Directors of the Asian Development Bank in late 2006, and were approved by the Board in January 2007. The programme is now in progress.

The sustainability of ecosystems and wildlife: The sustainability of ecosystems and the wildlife that inhabits them is a multidimensional phenomenon. It involves rural communities, urban communities, and educational establishments concerned with these issues on a national and international scale (Figure 3), functioning of rural communities and ecosystems at a local level (Figure 4). It also involves the need for much cross-disciplinary collaboration, including dialogue and joint research and educational initiatives between sociological, scientific and engineering experts.

As examples of this cross-disciplinary collaboration, I focus on biological activity in the sediments of sub littoral and intertidal marine environments. I describe two cross-disciplinary programmes being conducted at the University of Glasgow. The first assesses the role of microorganisms in determining the permeability of natural sediments. The second describes experiments on the role of semi-aquatic plants in slowing water movement on the banks of rivers and estuaries.

Firstly however it is necessary to have an overview of sedimentary ecosystem function, and the role that biological activity plays in this function. Biological and microbiological activity in sediments in the sub littoral and intertidal marine environment is often at a very high level (Meadows, 1964; Meadows and Anderson, 1966, 1968; Rhoads, 1967; Shäfer, 1972; Cadée, 1976; Reise, 1985; Meadows and Tufail, 1986;

Meadows and Campbell, 1988; Meadows and Meadows, 1991; Meadows and Meadows, 2004). Two conceptual diagrams show how biological activity affects the properties of the sediment, and how the properties if the sediment affects biological activity (Figures 5, 6). In figure 5, uncolonised sediment – or soil in a terrestrial environment, is colonised by micro- and then by macro-organisms. These organisms increase in numbers and in activity, which in turn modifies the sedimentary or soil environment. The modification of the sedimentary or soil environment affects its subsequent colonisation by micro- and macro-organisms. The sedimentary system as a whole can also be viewed as a two-way interacting system between the sediment and the benthos (Figure 6). In this model, the sediment affects the benthos, and the benthos affects the sediment. Benthos in the model shown in figure 6 includes autotrophic and heterotrophic microorganisms, meio- and micro-fauna, and macro benthos - macro invertebrates and macro algae. The properties of the sediment that affect the benthos are divided into chemical properties such as redox, pH, and organic content, and physical properties such as permeability, shear strength, and particle size.

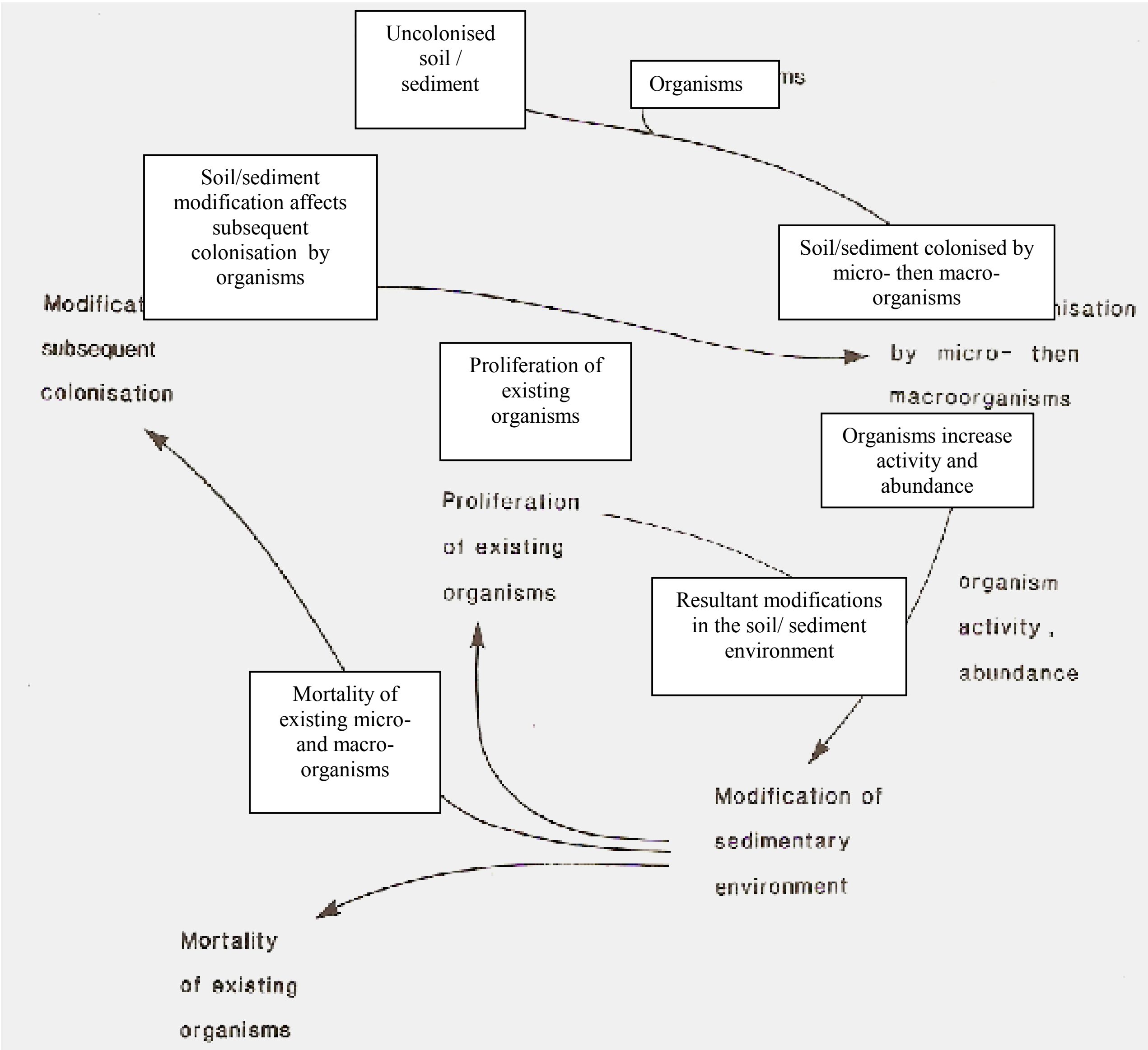


Figure 5. Colonisation by biological species and the subsequent effects of biological activity on soil and sedimentary environments (Modified from Meadows and Tufail, 1986 and Meadows et al. 2006).

Microorganisms play a central role in determining many of the properties of sedimentary ecosystems, including one of their key physical attributes - sediment permeability (Meadows and Anderson, 1966, 1968; Tufail, 1985, 1987; Meadows and Meadows, 2004). The cross-disciplinary research programme at the University of Glasgow that has investigated the role of microorganisms in determining sediment permeability is as follows.

Permeability is defined as the rate at which water can flow either horizontally or vertically through a column of sediment. It is determined by putting sediment into a glass tube, sealing the bottom of the time with fine mesh that prevents the sediment from being washed out, and then allowing water to flow through the sediment from above. The rate at which this occurs is measured by the fall in height of the water, from which permeability in $mm.sec^{-1}$ can be measured.

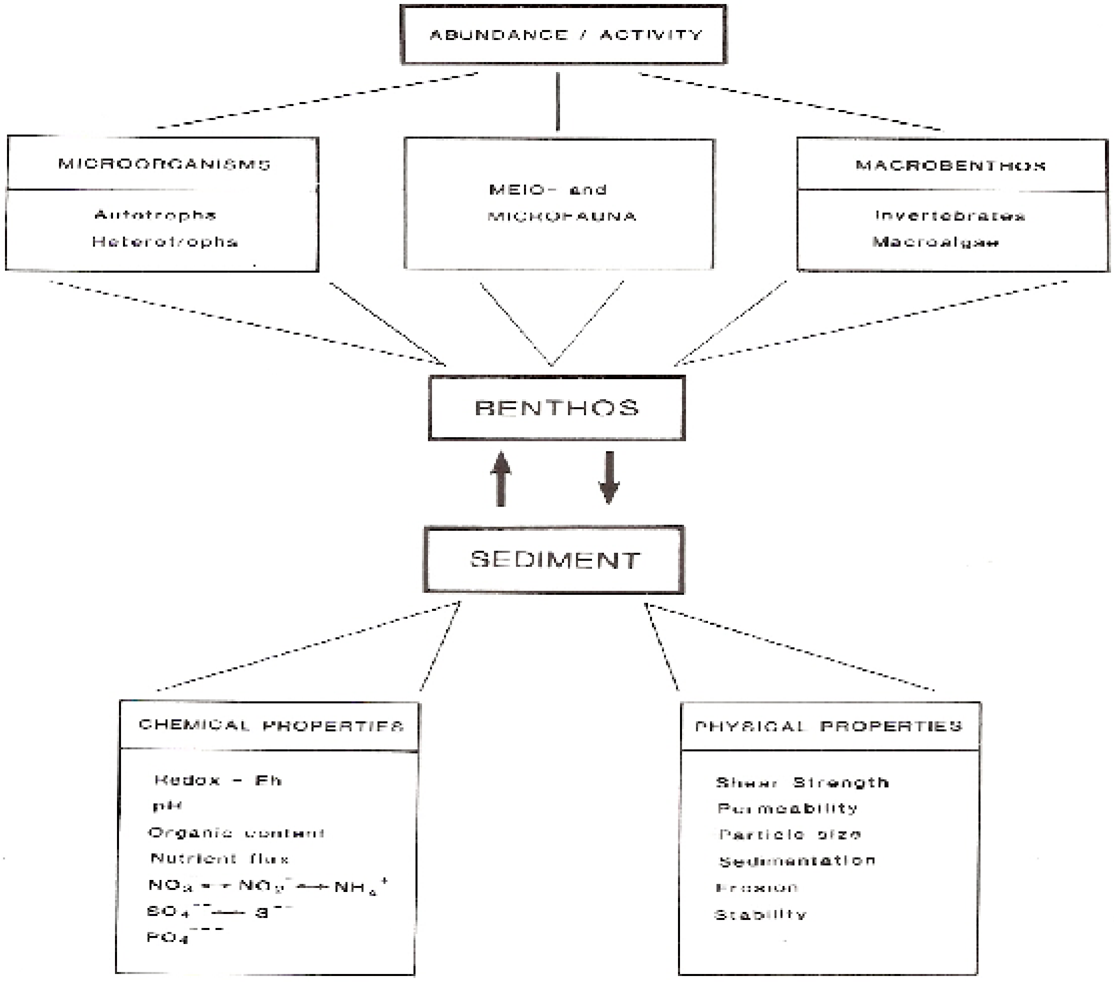


Figure 6. A model for the sediment/benthos ecosystem –here considered as acting in a coastal marine ecosystem. The original diagram was intended to represent any marine sediment/benthos ecosystem from the intertidal to the sub littoral and to the deep sea (Meadows and Tufail, 1986; Meadows et al. 2006).

The mathematics are simple. The permeability of a soil or sediment is calculated as follows (Meadows and Meadows, 1991;Fetter, 1994; Viessman and Lewis, 1996).

$k = (L / T). \ln (H_1 / H_2)$

Where k is the permeability coefficient of the soil or sediment, L is the length or height of the column of soil or sediment, and T is the time that it takes for the water in the cylinder above the soil or sediment to fall from a height of H_1 to H_2.

In our experiment (Meadows and Meadows, 2004) ten glass columns were set up containing natural intertidal sediment. These are referred to as cores. Four of the cores were filled with a photosynthetic culture medium to stimulate the growth of photosynthetic microorganisms - diatoms and blue green algae (M), four with bacterial culture medium (B) to stimulate the growth of heterotrophic bacteria, and two controls with formalin (C) to inhibit all microbial growth. The ten cores containing sediment were maintained at 18°C.

Two of the photosynthetic medium cores and two of the bacterial medium cores were maintained in a 17h light / 7h dark photoperiod (L), and the remaining two from each medium were maintained in the dark (D). The control formalin cores were left in the light. The experiment was run for 25 days and every third day the medium was changed and permeability readings taken.

Thus the ML cores contained photosynthetic medium and were kept in the light/dark regime. MD cores contained photosynthetic medium and were kept in continuous darkness. The BL cores contained bacterial medium and were kept in the light/dark regime. BD cores contained bacterial medium and were kept in continuous darkness. The C cores contained formalin, and were kept in the light.

The results of the experiment are shown in figure 7. The more rapidly the curves fall, the more rapid the reduction of permeability. As the experiment progressed, the heterotrophic and photosynthetic microorganisms increased in numbers, and progressively blocked the interstitial spaces between the sediment particles. The greatest microbial blocking effect occurred in the BD cores and BL cores, the two curves which fell most rapidly during the experiment. Hence heterotrophic bacteria had the most marked effect on reducing sediment permeability, either in the light/dark regime or in the dark regime. Photosynthetic microorganisms in the ML and MD cores also had an effect but this was less marked. The control cores, C, showed only a slight reduction during the progress of the experiment, which was taken to mean a slight but progressive increase in packing as the experiment progressed.

Some of the microbial growth on and between the sediment particles that developed during the experiment is shown in the four scanning electron micrographs in figure 8. The SEM's illustrate detritus and diatom frustules in fine detritus, diatoms and bacteria on a sand grain in the ML core, an interesting unidentified network of fibres, and bacteria and detrital material on and between sediment particles in the BL core. This experiment established the significant difference between heterotrophic microorganisms – the heterotrophic bacteria, and photosynthetic microorganisms – diatoms and blue green algae, in blocking the flow of water through intertidal sediments. The effect has important ecological implications. As permeability decreases, so does water exchange with the overlying water. As a result, the sediment becomes progressively more anaerobic. In some instances this can lead to extremely anaerobic sedimentary environments in which hydrogen sulphide is produced by the growth of the strictly anaerobic bacterium *Desulfovibrio desulfuricans.* These anaerobic sediments are only colonised by a small range of specialised meiobenthic and macro benthic organisms. So the infaunal invertebrate species diversity of the sediment is decreased. In the Clyde Estuary, Scotland, where many migrating birds feed, there are only three or four invertebrate species that can live in these conditions.

It has been known for some years that aquatic and semi-aquatic plants slow and alter the flow of water in rivers and in marine environments along the coastal zone (Anderson and Charters, 1982; Jackson and Winant, 1983; Neushul et al., 1992; Sisneros et al. 1998; Ozaki et al. 2004; Rosman et al. 2007). However most of these studies have been in the field or concerned with marine macro-algae. We have recently investigated the effects of the Cord grass (*Spartina* spp) on the flow of water in a large laboratory flume. This species occurs in large stands bordering salt marshes along the edge of the lower reaches of the Clyde River as it becomes the Clyde Estuary, Scotland (Figure 9).

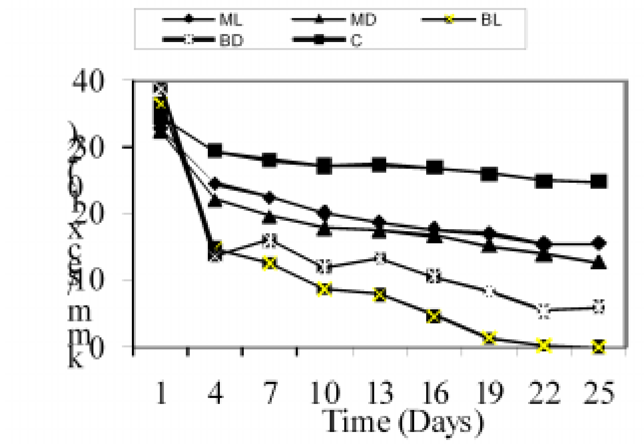


Figure 7. Effect of microorganisms on the permeability of natural intertidal sediment. Mean permeability coefficient k (mm.s-1) x 10^{-2} of the 2 replicate cores for ML, MD, BL, BD and C for days 1 to 25. M - photosynthetic medium; B - bacterial medium; L - light; D - dark; C – control (Meadows and Meadows, 2004).

Plants were collected from the field, and then immediately placed in an Armfield Flume at the Department of Civil Engineering, University of Glasgow, where they were submitted to a range of current speeds (Figure 10). Measurements were taken of the pattern of water flow just upstream of the plants and just downstream of the plants. This consisted of velocity profiles, which are illustrated in 3-D in figures 11 and 12. Figure 11 is upstream of the plants and figure 12 is downstream of the plants. In each figure, the bed of the flume is at the bottom left of the velocity profile, underneath the number 1. The water surface is at the top centre of each figure. The two x axes are channel width on the left and velocity on the right. The vertical axis is depth, normalised to range from 0 at the bed of the flume to 1 at the air/water interface.

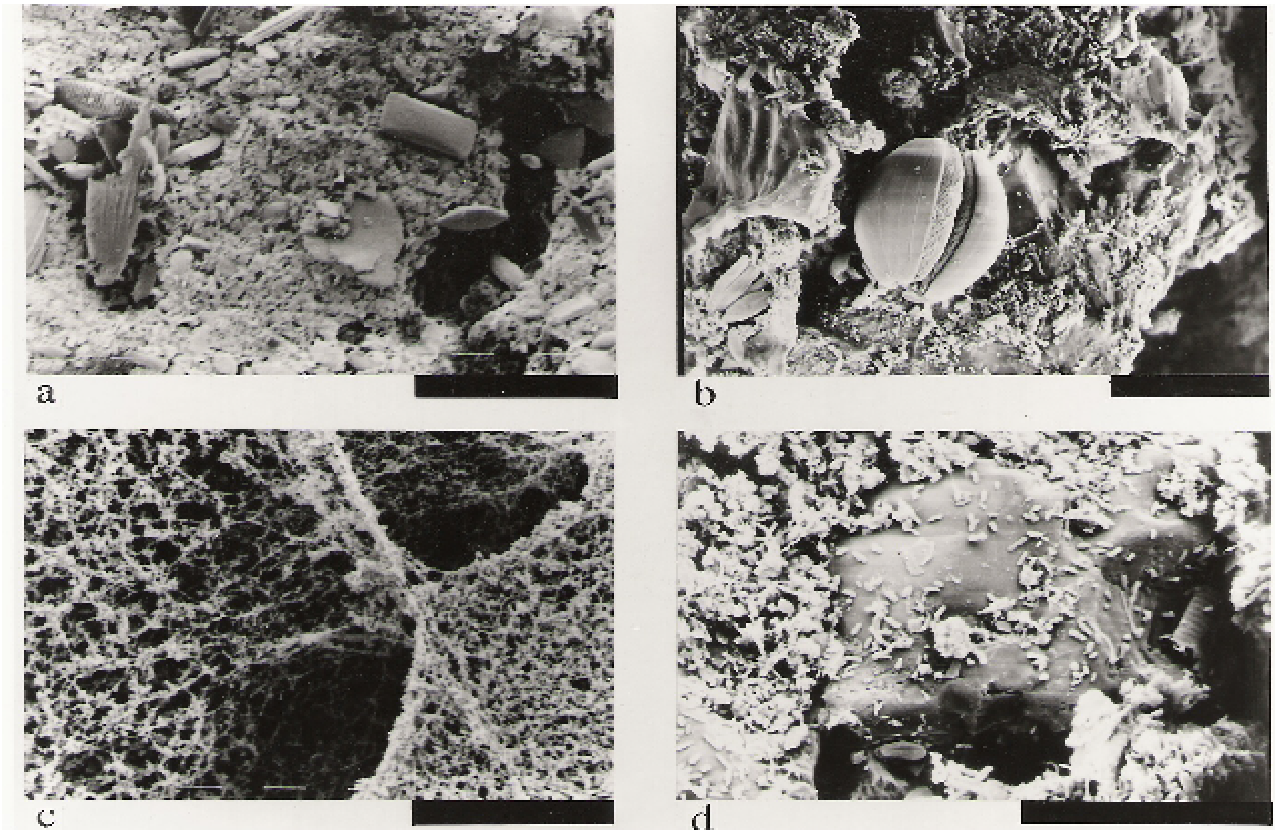


Figure 8. Scanning Electron Microscope photomicrographs. (a) Detritus and diatom frustules in the fine detritus from sediment used in the experiment. (b) Diatoms and bacteria on a sand grain in the ML core. (c) Unidentified network of fibres. (d) Bacteria scattered on a sand grain surface and detrital material in interstices of the sediment (on left hand side) in BL core.
(a), (b), (c) and (d): Scale bar 50µm (Meadows and Meadows, 2004).

Figure 9. The estuarine fringe of the saltmarsh at the Erskine Golf Club site. Dumbarton Rock and Castle can be seen in the distance. The large stands of *Spartina* in the centre and left of the picture are very obvious (Klemm et al., 2006)

The two velocity profiles are clearly different. Upstream, water velocity increases smoothly from a minimum at the flume bed to a maximum near the air/water interface. Downstream, the velocity profile is more complex. The water velocity is slow in the centre of the flume through the *Spartina* plants (1 and 2) both near the bed and at the air/water interface. It is fastest at the edges of the flume at either side of the *Spartina*. The complex nature of the profile when compared with the velocity profile upstream indicates that the *Spartina* plants have caused a considerable degree of turbulence immediately downstream.

Further experiments using the Armfield flume are now required to determine the effects of this turbulence on water flow and on sediment erosion or deposition. These should run in parallel with field measurements on stands of *Spartina* in the Clyde Estuary at different stages of the semi-diurnal tidal cycle and at different river flows that occur during dry periods – low river flow, and periods of heavy rain – high river flow. The alteration of flow caused by *Spartina* is likely to have important implications for the control of estuarine and coastal flooding and shore line erosion.

Figure 10. Spartina bending towards the left at high water velocities in the flume (Klemm et al., 2006).

Figure 11. Velocity profile upstream of Spartina in the flume. 3-D plot. Note smooth profile of velocities across the flume (1 and 2), with high velocities above the bed of the flume (2, 3), which is at the bottom of the diagram. Also note the uniformity of the flow across the flume – compare 2 and 3 (Klemm et al., 2006).

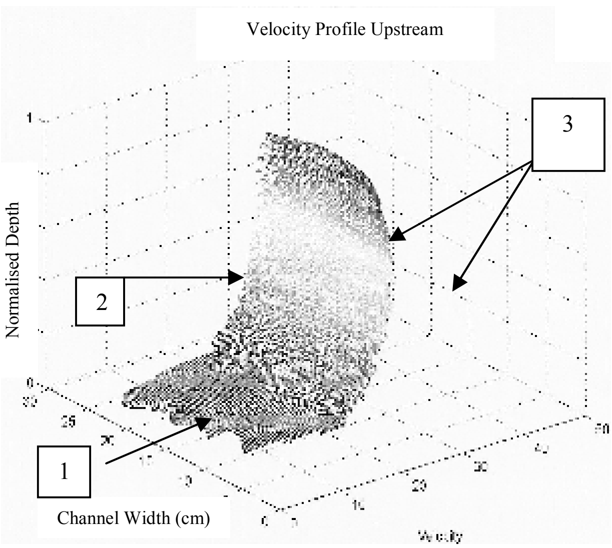


Figure 12. Velocity profile downstream of Spartina in the flume. 3-D plot. Current velocity is slow in the centre of the flume through the Spartina (1 and 2), and fast at the edges of the flume on either side of the Spartina (3). Note confused profile of velocities indicating a high degree of turbulence (Klemm et al., 2006).

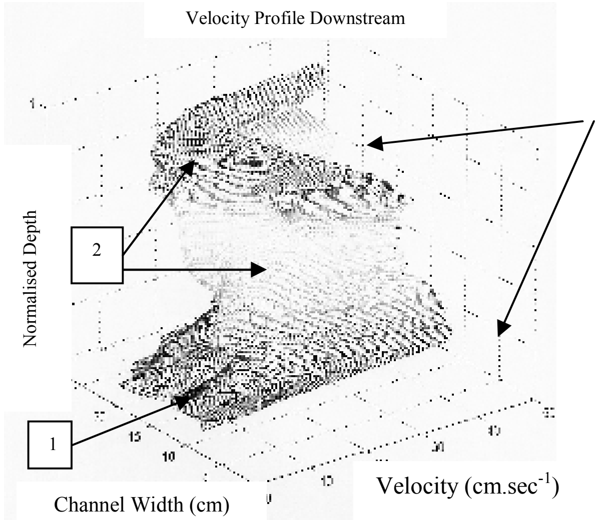


Figure 13. Temperate region estuarine wading birds that feed at different levels in the sedimentary column, with their macro invertebrate benthos food sources. The Eurasian Curlew, *Numenius arquata* with the polychaete *Nereis diversicolor* and the bivalve mollusc *Macoma baltica*, the European Redshank, *Tringa totanus totanus* with the amphipod crustacean *Corophium volutator,* and the Common Ringed Plover, *Charadrius hiaticula hiaticula,* with the gastropod mollusc Hydrobia ulvae.
(Green, 1968; Meadows and Campbell, 1988; Forrester et al., 2007; Zonfrillo, 2009)

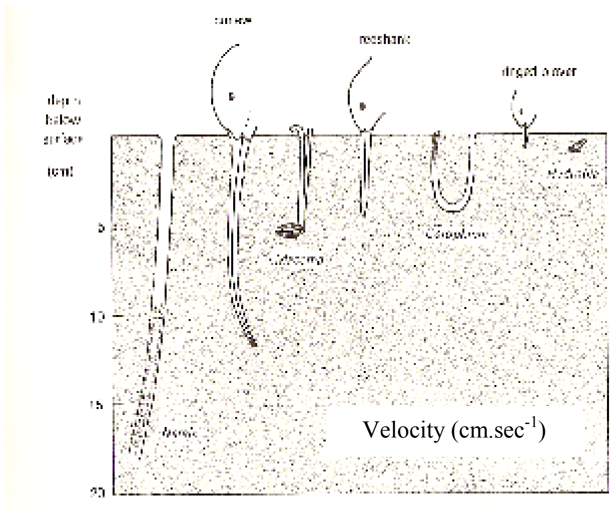
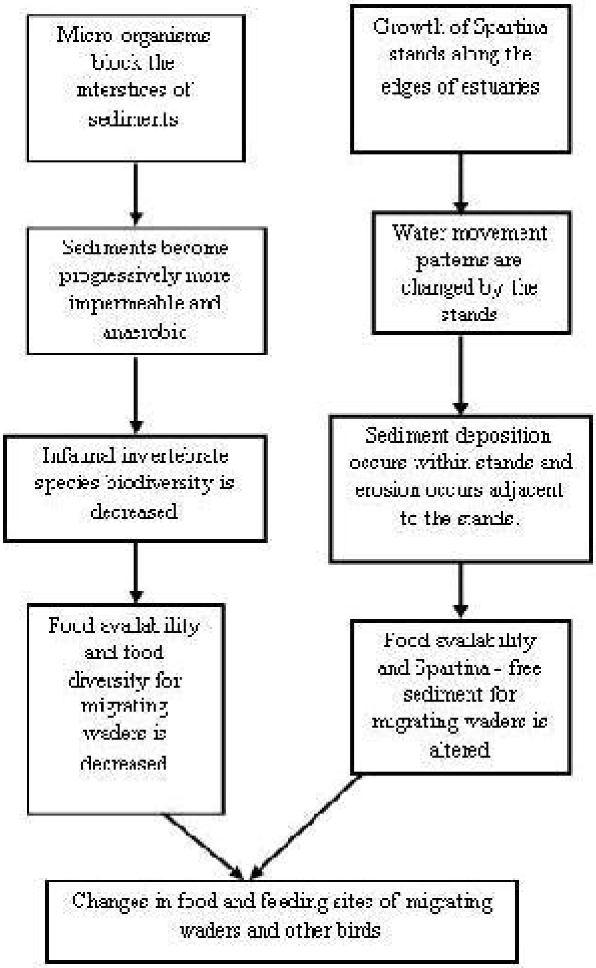


Figure 14. Potential effects of the growth of sedimentary micro-organisms (left hand side) and of *Spartina* stands (right hand side) on the availability of infaunal benthic food and of open sediment for migrating waders and other birds.



The results of the microbial experiment and the *Spartina* experiment have interesting implications for the availability of food and feeding grounds of migrating birds, especially for the waders that occur in the Clyde Estuary (Forrester et al., 2007; Meadows, personal observation). Figure 13 illustrates some of these species that feed in the Clyde Estuary, and shows the length of their beaks in relation to the depth to which their potential food organisms – the benthic infauna - can burrow. The Eurasian Curlew, *Numenius arquata,* can eat the polychaete *Nereis diversicolor* and the bivalve mollusc *Macoma baltica,,* as well as being able to reach the two shallower species. The European Redshank, *Tringa totanus totanus*, can eat the amphipod crustacean *Corophium volutator* and the gastropod mollusc *Hydrobia ulvae*. The Common Ringed Plover, *Charadrius hiaticula hiaticula,* is only able to eat the gastropod mollusc *Hydrobia ulvae*, although it will be able to eat *Corophium volutator* when this species comes to the surface. All three species of waders are known to feed on exposed intertidal sediments in the Clyde Estuary, together with a number of species of gull and duck. Many of these birds migrate between temperate and tropical climates, so global biodiversity issues are involved, and any changes in their feeding grounds will have important implications (Zonfrillo, 2009).

In the microbial experiment, microbial activity leads to reduced sediment permeability and anaerobic conditions in the sediment column. The development of anaerobic conditions in sediments decreases the biodiversity of the infaunal benthos. In the Clyde Estuary under extremely anaerobic conditions in the sediment, only *Corophium volutator* and *Nereis diversicolor* are abundant. This then affects the quantity and quality of food available to the birds that use the intertidal sediments as feeding grounds. In the *Spartina* experiment, the alteration of flow caused by *Spartina* beds affects turbulence and current velocities, and so is likely to have important implications for the control of estuarine and coastal flooding and shore line erosion and deposition. This will have implications for the availability of food and the size of intertidal mud banks that are used by migrating birds in spring and autumn.

Figure 14 summarises the potential effects of both microbial activity and *Spartina* beds on migrating birds. It would be very worthwhile conducting laboratory and field experiments, and field observations of migrating birds to find out whether these effects are important. The nature and changes in these populations and the ecosystems, in which they live, have a central role in determining the abundance and sustainability of larger organisms that are exploited by man. These larger organisms (crabs, finfish, and birds) are used directly by rural communities, and are potentially important for ecotourism. Ecosystem sustainability is therefore central to coastal zone rural communities and their economies, and the education of the coastal communities in these issues is vital.

Acknowledgements: I am very grateful to Professor Dr Mohammad Nawaz, Vice Chancellor of the University of Veterinary and Animal Sciences, Lahore, for his help and support during a number of visits to his university. Dr Zulfiqar Ali and his co-workers at the University of Veterinary and Animal Sciences are to be congratulated on the most efficient organisation of the 2008 international conference of which this paper is part. The kind support of Professor Dr Naureen Qureshi, University of Veterinary and Animal Sciences, is also appreciated. Lastly, I am most grateful to my wife Azra for her many invaluable comments on this paper, which refers to much of our joint work.

REFERENCES

Anderson, S. M. and A. C. Charters (1982). A fluid dynamics study of seawater flow through *Gelidium nudifrons. Limnol Oceanogr,* 27: 399-412.

Barringer, F. (2008). Court rejects clean air rules. *New York Times*, 11th July 2008.

Asian Development Bank, (2008a). *ADB Key Indicators for Asia and the Pacific 2008.* 39th Edtn. Asian Development Bank. Manila.

Asian Development Bank, (2008b). *Comparing Poverty Across Countries: the Role of purchasing Power Parities.* Asian Development Bank, Manila.

Asian Development Bank, (2009). ADB web site. www.ADB.org.

Beverton, R. J. H. and S. J. Holt (1957). *On the Dynamics of Exploited Fish Populations.* Ministry of Agriculture Fisheries and Food. Fisheries Investigations Series II, Vol XIX HMSO, London.

Cadée, G. C. (1976). Sediment reworking by Arenicola marina on tidal flats in the Dutch Wadden Sea. *Netherlands Journal of Sea Research* 10, 440-460.

Common, M. (1995). *Sustainability and Policy. Limits to Economics.* Cambridge University Press, Cambridge.

Dizard, J. (2009). Struggle over climate change on horizon. Financial Times, 19th January 2009, 9.

Fetter, C. W. (1994). *Applied Hydrogeology*. 3rd Edtn. MacMillan, New York.

Forrester, R. W., I. J. Andrews, J. C. McInerny, R. Murray, R. Y. McGowan, B. Zonfrillo, M. W. Betts, D. C. Jardine and D. Grunday (2007). *The Birds of Scotland.* Vol 1 and 2. The Scottish Ornithologists Club, Aberlady, Scotland.

Ghani, A., and C. Lockhart, (2008). *Fixing Failed States. A Framework for Rebuilding a Fractured World.* Oxford University Press, Oxford.

Green, D. (2008). *From Poverty to Power. How Active Citizens and Effective States can Change the World.* 522pp. Oxfam International. Oxford.

Green, J. (1968). *The Biology of Estuarine Animals.* Sidgwick and Jackson, London.

IPCC (2007). C*limate Change 2007: The Physical Science Basis.* Contribution of Working Group I to the Fourth Assessment Report of the International Panel on Climate Change. Summary for Policymakers. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. WMO, UNEP.Available at web site: www. aaas. org/ news/ press _ room / climate _change/media/4th_spm2feb07 as a pdf file.

Jackson, G. A. and C. D. Winant (1983). Effects of a kelp forest on coastal currents. *Continental Shelf Research,* 2: 75-80.

Jones, P. D. and A. Moberg (2003). Hemispheric and large-scale surface air temperatures: An extensive revision and update to 2001. *J Climate*, 16: 206-223.

Klemm, G., A. Ervine, A. Meadows, and P. S. Meadows, (2006). Saltmarsh vegetation and coastal protection: an experimental flume study of the Cord Grass *Spartina* spp. in the Clyde Estuary. *Glasgow Naturalist* 24 pt 4, 49-56.

Meadows, A. and P. S Meadows, (Edit.) (2001). *Coastal Zone Management and Environmental Impact Assessment.* Mews Publishers, Glasgow.

Meadows, A. and P. S. Meadows (2004). The effect of fine detrital material and microbial activity on the permeability of intertidal sediments from Ardmore Bay, Firth of Clyde. *Glasgow Naturalist* 24 pt 2: 93 - 106.

Meadows, A. and P. S. Meadows (2006a). The International Panel on Climate Change, the Stern Review, and Scotland. *Glasgow Naturalist* 24(4): 7-23.

Meadows, A. and P. S. Meadows (2006b). Supplementary Appendix. Mangrove, freshwater and seawater fish pond and raft, seaweed, halophyte, and fishery sector survey interventions. Sindh Coastal Community Development Project. pp. 1-28.Asian Development Bank.

Meadows, A. and P. S. Meadows (2006c). Sector Analysis. Mangrove Rehabilitation, Fish Hatcheries and Ponds, and Fisheries Sector Survey. Sindh Coastal Community Development Project. Pp. 1-10.Asian Development Bank.

Meadows, A., P. S. Meadows, H. Flowers and N. Qureshi, (2006). Sediment patterns of the intertidal zone in the Firth of Clyde: visualisation of biological, chemical and physical effects. *Glasgow Naturalist,* 24 (4): 83-108.

Meadows, P. S. (1964). Experiments on substrate selection by *Corophium* species: films and bacteria on sand grains. *J Exp Biol,* 41: 499-511.

Meadows, P. S. and J. G. Anderson (1966). Micro-organisms attached to marine and fresh-water sand grains. *Nature, London*, 212: 1059-1060.

Meadows, P. S. and J. G. Anderson (1968). Microorganisms attached to marine sand grains. *J Mar Biol Ass UK*, 48: 161-175.

Meadows, P. S. and J. I. Campbell (1988). *An Introduction to Marine Science.* 2nd Edtn. Blackie, Glasgow.

Meadows, P. S. and A. Meadows (1991). The geotechnical and geochemical implications of bioturbation in marine sedimentary ecosystems. In: *The Environmental Impact of Burrowing Animals and Animal Burrows*. (eds P.S. Meadows and A. Meadows). *Sym Zool S* 63, 157 – 181.

Meadows, P. S. and Tufail (1986). Bioturbation, microbial activity and sediment properties in an estuarine ecosystem. *P Roy Soc Edinb B* 90B, 129-142.

Neushul, M., J. Benson, B. W. W. Harger and A. C. Charters, (1992). Macroalgal farming in the sea:water motion and nitrate uptake. J Appl Phycol, 4: 244-265.

OECD Development Assistance Committee (1996). *Shaping the 21st Century: The Contribution of Development Co-operation.* 20pp. Organisation for Economic Co-operation and Development, Paris.

Ozaki, A., K. Mori, E. Inoue, T. Haraguchi (2004). Impact of aquatic plants on entrainment phenomena based on wind-induced flow in a closed density stratified water area. *Paddy and Water Environment,* 2:125-134.

Reise, K. (1985). *Tidal Flat Ecology*. Springer .Verlag, Berlin.

Rhoads, D. C. (1967). Biogenic reworking of intertidal and subtidal sediments in Barnstable Harbor and Buzzards Bay , Massachusetts. *J Geol*, 75, 461-476.

Rosman, J. H., J. R. Koseff, S. G. Monismith and J. Grover, (2007). A Field investigation into the effects of kelp forest (Macrocystis pyrifera) on coastal hydrodynamics and transport. *J Geophys Res,* 112:, C02016, doi:10.1029/2005JC003430.

Shäfer, W. (1972). *Ecology and Palaeoecology of Marine Sediments.* Oliver and Boyd, Edinburgh.

Sisneros, D, M. Lightwardt and Green (1998). Low-dose metering of endothall for aquatic plant control in flowing water. *Journal of Aquatic Plant Management* 36: 69-72

Stern, N. (2007). *The Economics of Climate Change*. Cambridge University Press, Cambridge.

Tufail, A. (1985). Microbial aggregates on sand grains in enrichment media. Bot Mar 28: 209-211.

Tufail, A. (1987). Microbial communities colonising nutrient - enriched marine sediment. *Hydrobiologia* 148: 245-255.

UN, (2000). General Assembly Resolution 55/2 *United Nations Millennium Declaration.* Resolution adapted by the General Assembly. Fifty-fifth session. A/RES/55/2. Agenda item 60 (b). 9 pp. United Nations, New York.

UN, (2002a). *Report of the World Summit on Sustainable Development.* A/CONF.19920*. 167pp. United Nations, New York

UN, (2002b). *Implementing the Millennium Declaration. The Millennium Development Goals and the United Nations Role.* 4pp. Fact Sheet. United Nations Department of Public Information October 2002. United Nations, New York.

UN, (2008). *The Millennium Development Goals Report 2008.* 52pp. United Nations, New York.

UN Millennium Project, (2005a). *Investing in Development: A Practical Plan to Achieve the Millennium Goals*. 329 pp. UN New York. Earthscan, London.

UN Millennium Project, (2005b). *Environment and Human*

Well-being: A Practical Strategy. Report of the Task Force on Environmental Sustainability. 139 pp. UN New York. Earthscan, London. UNDP, (2008). http://www.undp.org/mdg/basics.shtml

Viessman, W. and G. L. Lewis (1996). *Introduction to Hydrology*. 4th Edtn. Harper Collins, Addison-Wesley, New York.

Wikipedia (2007). http:// en. wikipedia. org/ wiki/ Main _ Page.

World Commission on Environment and Development. (1987). *Our Common Future*. Oxford University Press, Oxford.

Zonfrillo, B. (2009). Personal communication.