Desertification: the broader context

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ABSTRACT

After over twenty years of research, there is still not complete consensus on even how to define desertification. This is reflected in the changing emphasis of UNCCD and EU programmes. The focus on physical processes in the 1990s has changed, first to an emphasis on the impacts of desertification and global change, and more recently towards sustainability rather than degradation as the core of most research effort, although much is still concerned with scenarios of possible future change. Different research tools are able to survey different windows on changing degradation status. Remote sensing methods, for example, provide an excellent window on the recent past, but little forecasting potential beyond projecting linear trends. Dynamic models add some understanding of the interaction of different components, and are increasingly engaging with socio-economic as well as strictly bio-physical processes, but are still limited by the intervention of the unexpected – the boom in biofuel demand, the credit crunch etc – that severely limit their forecasting horizons.

This survey examines some of the over-arching relationships that must always constrain the relationships between population, food, land, water and energy, constraining the overall sustainability of global systems in a way that can only temporarily be ignored through irreversible mining of resources and exploitation of one region at the expense of another. The land sets constraints on food production that can partially be overcome through technological development, linked as both cause and effect to population growth, and may also be reduced by degradation. Less developed countries generally have a larger proportions of rural population and higher rates of rural-urban migration, but higher overall rates of population increase still lead to increasing rural populations (in contrast to more developed economies with falling rural numbers), adding to pressure on land resources and, almost inevitably, to degradation. This example demonstrates how broader social and economic forces lie at the root of much desertification, so that alleviation measures should not be confined to the directly affected area, but linked to national policies and development.

KEY WORDS
Forecasting, scenarios, desertification, sustainability, policy

INTRODUCTION

“Desertification" has been defined by the UNCCD (1996) as meaning land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities

“Land Degradation" means reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as:

- (i) soil erosion caused by wind and/or water;

- (ii) deterioration of the physical, chemical and biological or economic properties of soil; and
- (iii) long-term loss of natural vegetation;

“Combating Desertification" includes activities which are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development which are aimed at:

- (i) prevention and/or reduction of land degradation;
- (ii) rehabilitation of partly degraded land; and
- (iii) reclamation of desertified land.

It is, however, also recognised that desertification is primarily a problem of sustainable development, addressing poverty and human well-being, as well as preserving the environment. Social and economic issues, including food security, migration, and political stability, are closely linked to land degradation and drought. (UNCCD Fact Sheet 10).

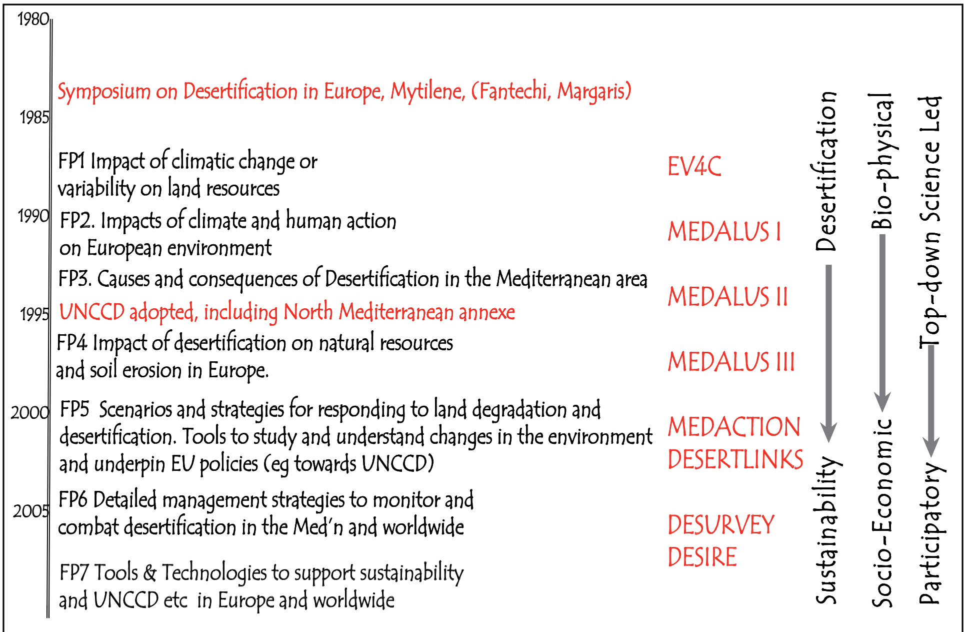

Table 1. The changing role of desertification in EU framework programmes

Since the concept of desertification was first widely discussed, the emphasis on different components of this definition have gradually shifted. This can be seen quite clearly in, for example, the changing emphasis as the framework programmes of the European Union have evolved over the last 20 years. Table 1 summarises these changes and it is possible to draw some broad conclusions about the trends. It can be seen that early discussions and the early framework programmes focussed on climate change as the main driver of desertification processes. However, by Framework 3, work programmes were increasingly emphasising the influence of human as well as climatic drivers, as well as concentrating specifically on Mediterranean Desertification as having some distinctive characteristics. This phase culminated in the formal adoption of the UNCCD in 1995, with a North Mediterranean annexe and National focal points that identified apparently clear end users with whom to develop research collaboration. More recently there has been an international shift towards more funding for applied research, it was considered that a significant body of basic research on desertification had already been accomplished. FP6 therefore focussed more on the exploitation and practical application of existing research knowledge and we see work programmes focusing more on detailed management options to monitor and combat desertification, and on demonstrating the efficacy of specific remedial strategies in affected areas. FP6 also increased the scope of research, from Europe to global. Finally, in the current FP7, there has been a further shift, explicitly referring to sustainability rather than desertification, and further extending the potential for application to global aspects. Three strands that run through these changes in emphasis, and that reflect changes in other aspects of global and European science may be identified as first the shift from a largely bio-physical view to a recognition of the importance of socio-economic processes; second an associated change from a largely top-down science approach toward an increasingly participatory approach involving stakeholders at local to national of European levels; and third a change from the view of desertification as a specific problem to a view that it should be embedded within the broader issues of sustainability.

As well as these changes in perception, there has also been an accumulation of evidence, primarily from remote sensing, that there is a trend, at least over the last 20 years recorded in satellite imagery (Xiao & Moody, 2005; Hill et al, 2009) towards greening, although evidence from different satellite sensors is not unanimous. This has been partly attributed to climate changes, for example showing strong greening at high north latitudes in response to temperature rise, but some of the changes are also thought to result from changing land use. Increasing irrigated areas and the recovery to semi-natural cover of abandoned marginal land are both effects that have been observed, and are related to deliberate changes, and ultimately to socio-economic drivers.

DESERTIFICATION SYNDROMES

Many components of desertification are readily reversible, but in some cases there is a positive feedback between interacting cause and effect that leads to a collapse in soil or vegetation resources that is only remedied at unrealistic cost, so that it is effectively irreversible. Such irreversible changes are the total stripping of shallow upland soils, severe dissection by gully erosion, salinisation of the soil by sodium salts and the encroachment into grazing lands of unpalatable plant species. The pathways and processes that tend towards desertification of the land have been described as ‘desertification syndromes’. The most severe degradation tends to occur when two or more of these processes combine to create a positive feedback, for example when population increase and soil erosion combine, each exacerbating the effect of the other.

Desertification syndromes have been categorised, for example by Gleist (2005) as due to Resource scarcity, Changing markets or External policy intervention (Table 2). It is clear from this list that resource degradation is rarely absolute, but almost invariably linked to increased demand due to population change or the changing economics of production. Desertification must therefore be placed in this wider context which has both local, regional and global components, many of them far beyond the control of the farmer.

Table 2: Desertification syndromes (modified from Gleist, 2005)

Resource scarcity	Subdivision of land
	Increased population exceeding carrying capacity
	Reduction in available labour (emigration, disease)
	Loss of productivity (e.g. erosion, nutrient loss, salinisation, invasion of undesirable species)
	Failure to maintain conservation systems
	Inadequate water resources (quantity and/or quality)
Changing markets	Increased commercialisation
	Improved communications
	Price changes
	Off-farm wage changes
External policy intervention	Economic development
	Perverse subsidies
	Frontier development
	Poor governance
	Insecurity

POPULATION, FOOD, WATER AND ENERGY

Any consideration of the relationship between food and population has to begin with the ideas of Malthus. In his 'Essay on the principle of population' (1798), he assumed that food resources were substantially constant, and set an upper limit on the population that could be supported. Where populations are low, then available labour may limit production, provided that each family can produce enough for its own needs. As the population is increased, food production is limited by the available land and level of technology, and so remains constant, largely independent of the population density (figure 1).

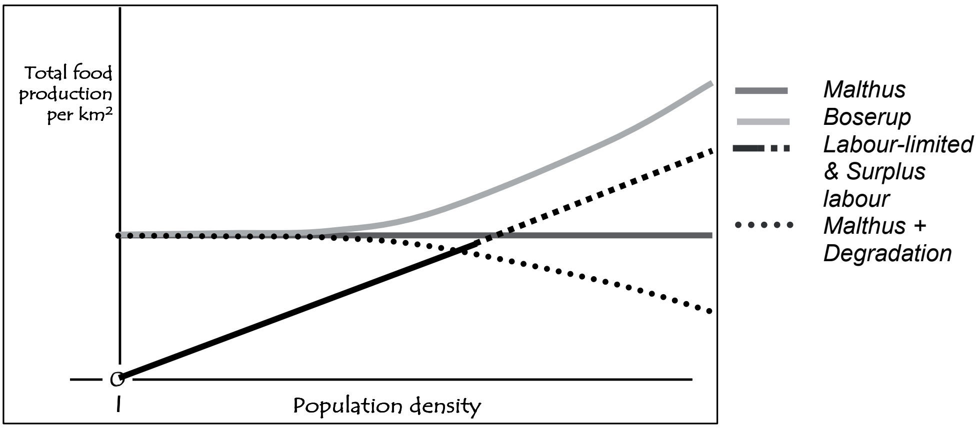

Figure 1. Alternative theories about the possible relationships between population density and food production.

The conclusions drawn from this analysis have ranged from the pessimistic view that, for many, the struggle for survival would inevitably dominate their lives to various scenarios through which the quality of life might improve, either despite these limitations or by overcoming them. Malthus strongly influenced Charles Darwin, who envisaged 'natural selection' (1859) through 'survival of the fittest' as the driving mechanism of evolution, although on a time scale that goes far beyond the present context.

For desertification, two other directions of analysis are highly relevant. Boserup (1981) has argued that, over man's history and still today, technological advance has increased food production, often enough to keep pace with population growth. This process was begun with breeding of cereals during the early Neolithic in both Eurasia and Meso-America, and has continued or accelerated with the development of mechanised cultivation, fertilisers and continued breeding of high-yielding crops, so that although the Malthusian trap is always in waiting, we continue to keep ahead of its jaws. Karl Marx (1867) and other economists envisaged an important mechanism to drive this feedback through the 'Theory of Surplus Value'. If there is more than enough labour to till the land, then the surplus labour can combine with a suitable infrastructure of communications, education and equipment to drive a cash economy. This creates the wealth (measured for example as GDP) to buy food and/or to drive technological innovations that will support self sufficiency.

Desertification can add another dimension to this relationship, where pressure of population relative to the quality of the land leads to degradation of the soil resource. In this case, the relationship may be even worse than Malthusian, with a loss of production as the land is exhausted, for example by reducing fallow periods on marginal land, by irrigating with increasingly saline water or by overstocking rangeland. This is the issue that desertification studies most commonly address, seeking detailed mitigation while ignoring the wider context.

Some of the key relationships between population and production are outlined in figure 2. Population growth can, following the Boserup model, stimulate technical innovation that increases food production and so supports continued growth. Part of this innovation may improve conservation practice, although this is not necessarily the case, and there are many counter- examples. Population growth can also lead to intensification of land use without changes of technology, particularly where GDP is low and there is no scope to apply even well known technological improvements, and this type of intensification commonly degrades the land and reduces productivity. In addition to these relationships with the land, technical innovation and population growth can, for example, lead to improvements in public health and to conflict over scarce water or land, with the availability of more sophisticated weapons.

Globally, there are clear relationships between national levels of wealth, measured through GDP (Gross Domestic Product) per capita, and population trends. Rates of population growth, even accounting for lower standards of public health, are greater where GDP is low, and only very strict application of national policies appears capable of modifying this relationship. The proportion of the population living in urban centres increases with GDP, and the population density within cities decreases. GDP per capita is also growing steadily, tripling every time the population doubles for the past 1,000 years. Putting these figures together, rural populations are declining in developed countries and increasing in less developed areas, driving land degradation where there is least potential for technological improvement through investment in either industrial or agricultural infrastructure.

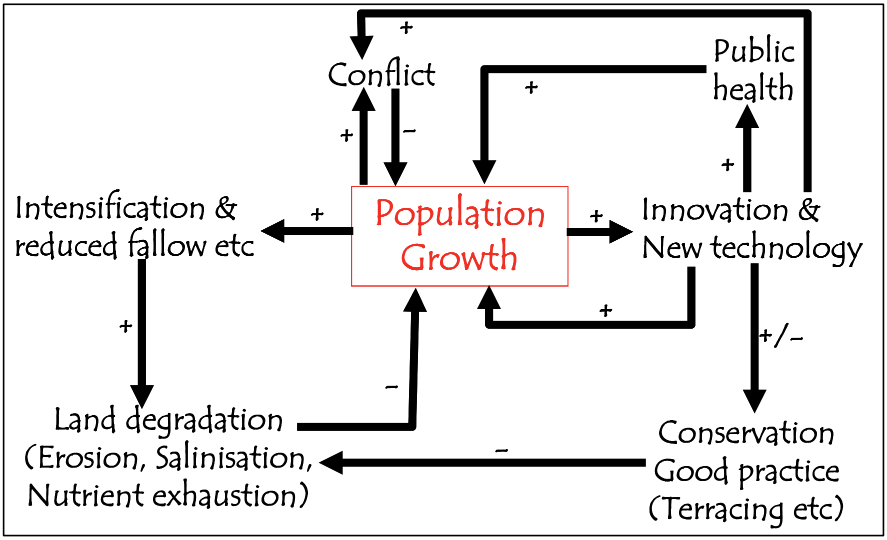

Figure 2. Possible relationships between population growth and land degradation.

Current attempts to mitigate desertification thus seem to have some elements in common with the EU Common Agricultural Policy – an initiative not primarily to reduce land degradation and promote good agricultural practice but to keep people living in rural areas, without going to the heart of the underlying population and development issues.

The overarching issues that constrain desertification may be defined in terms of the key resources that are globally in short supply, namely water, food and energy. Figure 3 shows how these are related to one another, and to land and population. It is clear that there is a great deal of potential for interchange between these resources, although the costs, in some cases make interchanges uneconomic. Historically, cheap energy has made human labour uneconomic in a cash-rich economy, so that tractors and cars have replaced slavery and sedan chairs except under subsistence conditions. Energy is also used to produce fertilisers that have greatly increased cereal yields, and could be used to desalinise sea water, although the costs for irrigation are still generally too high. Similar interdependencies exist for food and water. It is clear that, using only renewable resources, we could continue to fuel and water the planet at existing and higher levels of population, but only with a currently unimaginable level of capital investment, and that the prospect of an eventual global city may not be an attractive one. We therefore need to look for intermediate global solutions that address both population growth and levels of investment in infrastructure.

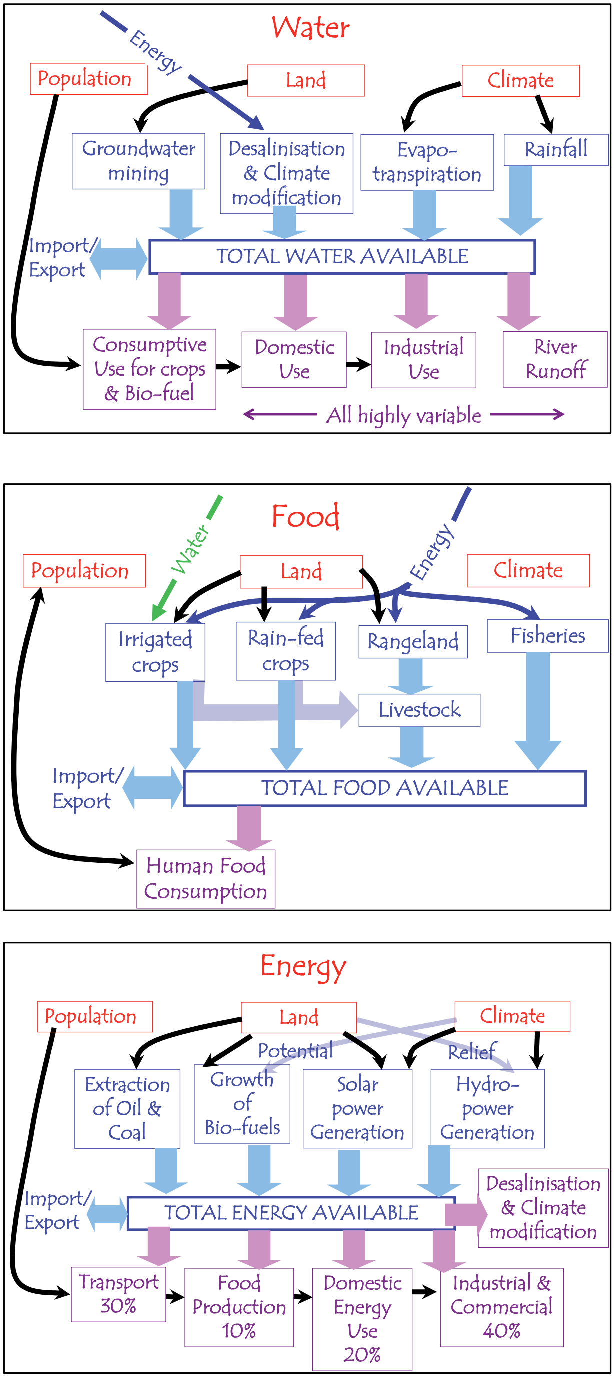

Figure 3. Relationships affecting desertification centred around water, energy and food. Note that there are strong linkages between the three approaches.

It may be too soon to propose the radical changes that might be needed to address the underlying causes of desertification and move towards a sustainable global system, balancing agriculture and development. Figure 4 suggests a minimum web of interactions that might form a basis for understanding the essential dynamics involved in a sustainable system. Climate and population density provide the essential natural constraints on food production, determining the labour and water available for agriculture, either through grazing or cultivation. If there is a labour surplus, then there is the scope to take advantage of the existing infrastructure (education, communications, machinery etc.) to generate some wealth that can be reinvested in energy to improve agricultural production (through mechanisation, fertiliser or irrigation) and to invest in maintaining or improving infrastructure, ultimately creating further surpluses in the strong positive feedback that is associated with active development. Investment in infrastructure is generally paid for through taxes, so that adequate governance is also essential for a developing economy, ensuring that wealth is not diverted to building pyramids, off-shore bank accounts or equipping private armies.

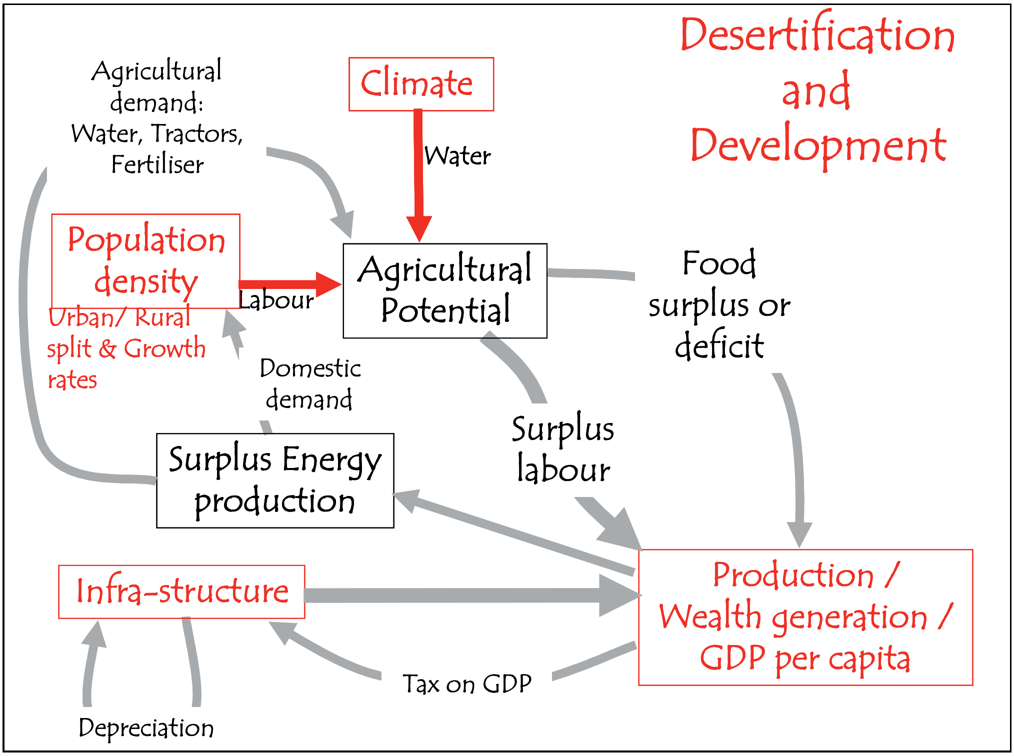

Figure 4: Interactions between land, population, GDP and the development of infrastructure

Following this line of reasoning, a preliminary indicator of desertification risk compares the climatic potential of an area (described in figure 5 by average cereal yields) with the rural population it has to support. Where this ratio is higher, that is for points plotting above and to the left on the graphs, there is greater pressure on the land, and the risk of degradation is greater. This takes no account of external pressures, the processes of degradation or the resilience of the land. What it does take into account, however, is the effect of economic development, which affects both cereal yields (to some extent) and the proportion of rural population. For example, in comparing Spain and Portugal, the higher proportion of rural population in Portugal has led to higher rural densities, and a higher indication of risk.

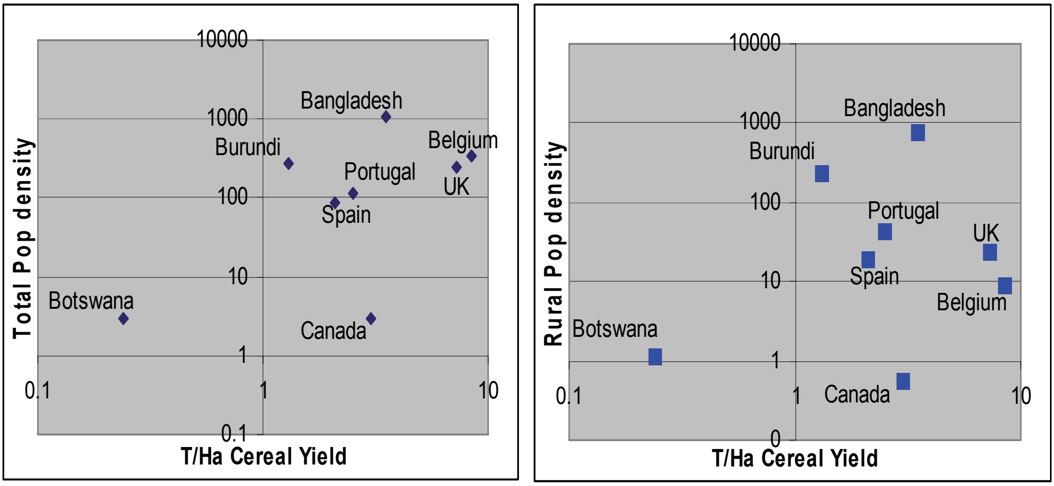

Figure 5. Population density v Cereal Yield as an indicator of susceptibility to desertification. Areas plotting above and to the left have a higher population to support with less food resource. Rural population (on right) shows a better relationship than total population (left).

REFERENCES

- E. Boserup. 1981. Population and Technological Change: A Study of Long-term Trends. Chicago: University of Chicago Press.
- C. Darwin, 1859. On the Origin of Species by means of Natural Selection. John Murray, London.
- H. Geist, 2005. The causes and progression of desertification. Ashgate studies in environmental policy and practice.
- J. Hill et al, 2009. NOAA Pathfinder to MEDOKADS, GIMMS inter-comparison. Unpublished deliverable 1.5.1.6 for Desurvey EU project. 16pp.
- T. Malthus, 1798. An Essay on the Principle of Population, as It Affects the Future Improvement of Society.
- K. Marx, 1867. Das Kapital: Kritik der politischen Ökonomie. Otto Meissner, Hamburg.
- J. Xiao and A. Moody, 2005. Geographical distribution of global greening trends and their climatic correlates: 1982–1998. International Journal of Remote Sensing 26 (11), 2371-90.