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Future demographic change and its interactions with migration and climate change☆

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ABSTRACT

This paper examines global demographic change as a driver of migration within the context of anticipated climate change. It begins by briefly considering some theoretical formulations which relate demographic change and migration. It then considers evolving global demographic trends and discusses some of their potential impacts upon migration. It is shown that there is a close spatial coincidence between demographic and climate change "hotspots" that will influence migration in complex ways. It then turns to the complex interaction between demographic change, environmental change and migration, both in the past and potential developments in the future. It concludes with a discussion of the potential impacts of future trends and their policy implications.

1. Introduction

Among the massive changes which have swept the world in the last half century, those in demography have been among the most dramatic and significant. They have been both a cause and effect of wider social and economic transformations and have occurred unevenly across the globe to produce significant differences between and within countries in the level and pace of population growth. The objective of this paper is to summarise the nature of these changes and their relationships with migration and climate change. The paper is focused on the complex interrelationships depicted in Fig. 1. Each element is very dynamic and changes in one can influence changes in one or both of the other. There is little theoretical or empirical work which has addressed this complex set of interrelationships but the paper seeks to draw together what is currently known and discusses potential implications for the future.

Accordingly, this paper seeks to examine global demographic change as a driver of migration within the context of anticipated climate change. It begins by briefly considering some theoretical formulations which relate demographic change and migration and attempts to relate these to environmental change as well. It then considers evolving global demographic trends and discusses some of their potential impacts upon migration. It then turns to the complex interaction between demographic change, environmental change and migration, both in the past and potential developments in the future. It concludes with a discussion of the potential impacts of future trends and their policy implications.

2. Theory relating demographic change and migration and its links with environmental change

The complex relationship between demographic change and migration has attracted a large body of both empirical and theoretical research but little of this has explicitly included any consideration of environmental factors.

The major theoretical focus in demography is Demographic Transition Theory which seeks to describe and explain the patterns of demographic change that occur as a society experiences economic development. Fig. 2 depicts the conventional form of the Demographic Transition model. The model posits that in societies populations transition from a high stationary (high fertility, high mortality, low growth) to a low stationary (low fertility, low mortality, low growth) situation as development proceeds. In traditional societies high fertility is cancelled out by high mortality, although the level of the latter fluctuates with periods of high loss of life through famine, disease etc. being punctuated with periods of population growth. The onset of development sees mortality decline as societies gain greater control of their environment through agriculture, health interventions etc. However, fertility remains high because the cultural 'props' that were developed to support high fertility during the period of high mortality remain in place. Hence in the second stage of the transition there is very rapid population growth. In time, however, the cultural props supporting high fertility are eroded and fertility too starts falling. Hence in the third stage population is

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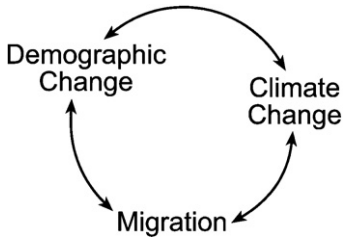

Fig. 1. The relationship between demographic change, migration and climate change.

still increasing but at a falling rate. Finally, fertility and mortality are more or less in equilibrium in a stationary final stage. Clearly, this is an oversimplification but the general pattern of transitioning from a high stationary situation through a rapid growth stage to a low stationary situation has wide applicability and the countries of the world can be located at some point along this transition at any point in time.

The extent and timing of the initiation of fertility decline has varied enormously from country to country (e.g. Leete and Alam, 1993), but it has impinged upon all countries. The early stages of the Demographic Transition involve quite rapid population growth, since fairly high fertility levels are accompanied by declining mortality. There is a lag before fertility decline eventually is translated into population decline. Although the familiar Demographic Transition model shown in Fig. 2 is a major oversimplification of a complex process, it is useful in the present context to think of developing countries as being located at various points along the curve of population growth with developed countries mainly being near the end of the transition. Many nations have reached replacement level fertility on the far right-hand side of the diagram.

Every country in the world has either begun the fertility transition from high to low fertility or completed it with 76 countries now having below replacement fertility (United Nations, 2009). For many countries, especially in Europe but also East Asia, the fertility decline has continued below replacement level so that they are faced with the prospect of declines, not only in their workforce age numbers but their total population.

What are the connections between the Demographic Transition and population mobility? There has long been an understanding that as development proceeds there tends to be an increase in personal mobility (Ravenstein, 1889, pp. 288). The arguments for this can be summarised as follows:

- Economic growth has generally been associated with population growth which produces overcrowding in some areas forcing movement to more sparsely settled areas;
- Identification of new natural resources associated with development attracts migrants to those areas;

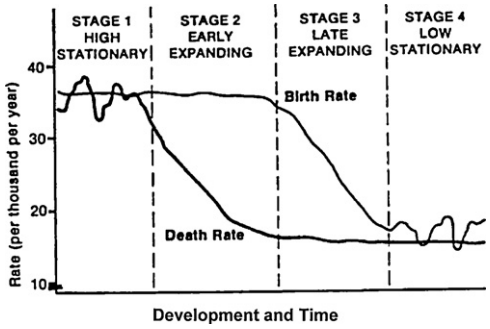

Fig. 2. Simplified model of the demographic transition.

- Transport is cheaper and more efficient putting mobility within reach of a wider spectrum of the population;
- Technological change makes some jobs obsolete (especially in rural areas) and increases jobs in other areas (especially urban centres);
- Increasing prosperity leads to non-survival/job related migration.

However, how does this relationship between development and mobility interact with the demographic changes associated with the Demographic Transition?

There have been a number of attempts by researchers to make this connection. One of the earliest of these was by Gibbs (1963) which postulated the following stages of population concentration associated with development:

- Cities come into being, but at this stage the percentage increase of the rural population equals or exceeds the percentage increase of the urban population;
- The percentage increase of the urban population comes to exceed the percentage increase of the rural population;
- The rural population undergoes an absolute decline;
- The population of small cities undergoes an absolute decline;
- There is a decline in the differences among the territorial divisions with regard to population density, i.e. a change toward a more even spatial distribution of population.

Friedlander (1969) described the rural to urban transition associated with the 'Demographic Transition', and Long (1985) has elaborated upon the Gibbs' model. Rogers' (Rogers, 1979, pp. 29–30) model of changing levels of urbanisation with development is 'depicted by attenuated S-shaped curves which tend to show a swift rise around 20%, a flattening out at a point somewhere between 40 and 60% and a halt or even decline in the proportion urban at levels above 75%'. Further he states that 'Urbanisation results from a particular spatial interaction of the vital and mobility revolutions. It is characterised by distinct urban-rural differentials in fertility-mortality levels and patterns of decline and by a massive largely voluntary net transfer of population from rural to urban areas through internal migration'.

However, the most comprehensive attempt to integrate changes in population mobility associated with economic and social change into Demographic Transition Theory is Zelinsky's (Zelinsky, 1971, pp. 221–22) hypothesis of the Mobility Transition, the basis of which is that 'there are definite patterned regularities in the growth of personal mobility through space–time during recent history, and these regularities comprise an essential component of the modernisation process'. This transition identifies five stages, each characterised by particular levels, types and directions of mobility. The transition sees the incidence of migration growing over time, but with improved personal mobility circulation comes to replace some types of migration and ultimately improved communications substitute for some forms of circulation.

An important aspect of Zelinsky's model is that the four initial stages of the Mobility Transition correspond, and are theoretically connected, to the four stages of the Demographic Transition. He suggests, for example, that during the rapid population growth phases of the transition (stages 2 and 3) when fertility remains high (although declining in stage 3) there is an increase of migration in response to rapid population growth. This involves a 'great shaking loose' of migrants (Zelinsky, 1971, pp. 236) from the countryside to the city and out of the country through international migration.

There have been a number of formulations which have linked the rapidly expanding population of the early stages of the demographic transition to the build-up of pressure of population

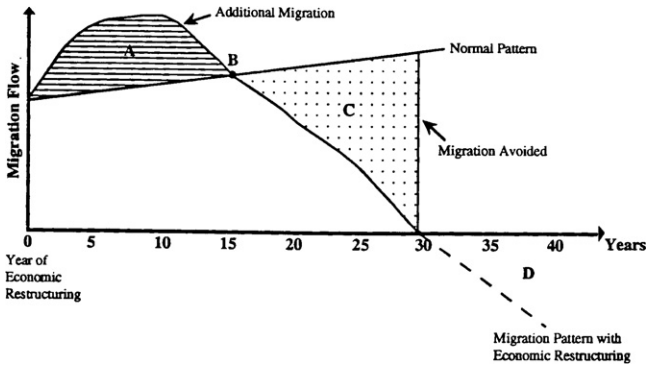

Fig. 3. Model of the international migration transition.
Source: Martin (1993).

on resources and hence outmigration. Outmigration, however, is only one such response to the increase of population pressure on resources in a particular areas. There can be a number of *in situ* adjustments and responses to the onset of such pressure. In Java, for example, which had some of the most densely populated agricultural areas in the world in the eighteenth and nineteenth centuries there were a number of *in situ* adjustments to the build-up in population:

- The intensification of agriculture. Boserup (1966) postulates that there is an evolutionary sequence of land use types of increasing intensity which are adopted by societies which are forced to accommodate an existing population within a limited area;
- Urbanisation and structural economic change from agricultural to secondary and tertiary activity;
- Other demographic change—especially reducing fertility.

Outmigration is hence only one response to increasing population pressure. Moreover, the mobility responses may vary between temporary circular migration of some family members to permanent relocation (Hugo, 1991).

With respect to international migration, Martin (1993) has put forward a Migration Transition model which he argues is an analogue to the Demographic Transition model. This is depicted in Fig. 3 and suggests that 'emigration pressure' tends to build up for the demographic reasons suggested above but also due to economic restructuring. The latter involves adopting outward oriented, market driven economic policies, deregulating, privatising, opening up to the world economy etc. This leads to significant displacement of workers, especially from agriculture and creates what Martin (1994) refers to as a 'migration hump', involving additional migration out of rural areas to urban areas within the country, as well as to other countries. He argues (Martin, 1994, pp. 11):

> A country on the move economically is also awash with internal migrants, some of whom spill over its borders if there is already an established international migration pattern. It has been hypothesised that such a hump would characterise Mexico-US migration, Turkey-EU migration and south-north migration.

Hence this model, like that of Zelinsky, suggests that in the early stages of Fertility Transition there is an acceleration of migration with international migration often being an important part of this.

Martin (1993) identifies four important stages in the transition depicted in Fig. 3:

- This is the migration associated with the early stages of economic restructuring and demographic growth which is above that considered normal in a less developed country;
- With economic growth and reduced population growth, however, the outmigration returns to pre take-off levels;
- With continued development, emigration is reduced because increased home-based opportunities obviate the need to go overseas to gain work;
- Finally, with reduced population growth in the stable low fertility stage of the Demographic Transition and continued economic growth, there is a switchover whereby the country shifts from being a net exporter of labour to one importing labour.

This simple model has a number of shortcomings. Its connection to the simple, and largely discredited stage model of development is one important criticism. Clearly too it is a net migration model and does not capture the complexity of the two-way mobility occurring in all countries. It is also confined very much to considerations of work-related mobility. Nevertheless, this connection between the phase of rapid population growth in the Demographic Transition and high levels of outmigration is important in both internal and international migration.

Each of the models considered in this section is an oversimplification of the complex relationship between population/demographic change on the one hand and population movement on the other. However, there are a number of common elements which can be discerned:

- There is an increase in the scale and complexity of both internal and international movement over time;
- Rapid population growth associated with the middle stages of the demographic transition is especially associated with outmigration, both from rural to urban areas, and international migration;
- In this stage of the demographic transition there is a strong concentration of populations in the young adult, most migration-prone age groups due to the reduction in fertility and this influences mobility;
- Increased mobility with economic development and social change involves not only population *displacement* 'push' elements but also migration as *adaptation* to new economic and social opportunities created by development;
- Countries transition from being net emigration countries in the middle stages of the Demographic Transition to net immigration countries in the later stages.

It is important not to fall into a 'demographic determinism' argument which sees migration being an inevitable response to increases in population in a particular area. Mobility is only one of a number of adjustments which societies have made to such changes and *in situ* adjustments are usually very important and have indeed been more significant than migration. However, the point remains that population change is a significant element which is one of the constellation of drivers of internal and international migration and must be considered in developing future scenarios of migration.

There are a number of important conclusions that can be drawn from the literature which examines linkages between demographic change and migration:

- There is no simple deterministic relationship between demographic change and migration. Migration is only one among an array of ways in which societies respond to demographic change. Indeed it needs to be seen as an exceptional, rather than the dominant, response. Most people adapt locally or respond to that change *in situ*;
- Secondly, demographic change rarely directly drives migration. It usually is often a proximate factor interacting through such factors as a decrease of job opportunities, a decline in agriculture, land degradation, loss of biodiversity etc. to influence migration;

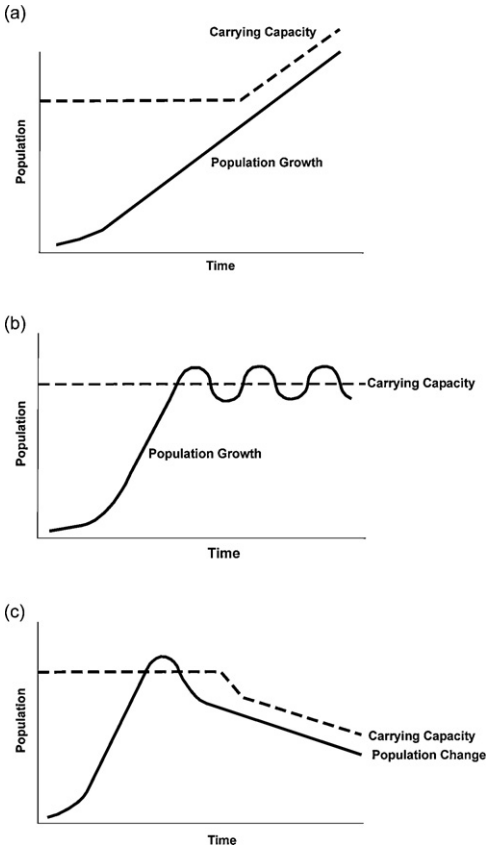

Fig. 4. The carrying capacity model.
Source: Newman and Matzke (1984), 198.

- Thirdly, demographic change alone rarely drives migration. It is usually one of a number of complex interacting drivers;
- Fourthly, most migration in response to demographic change occurs *within* countries.

None of the theoretical formulations discussed in this section explicitly include a consideration of the role of environmental change. Environment is an important factor in the high mortality levels of the early stages of the demographic transition where episodic high levels of death from famine, food shortages and environmental disasters contribute to deaths more or less cancelling out high levels of fertility. Moreover, environmental pressures are crucial in impelling what Zelinsky (1971) refers to as a 'great shaking loose from the countryside' in the second stage of the transition as fertility remains high, mortality falls and rapid population growth puts pressure on the environment to sustain growing agricultural populations.

In fact, it is largely to the rapid growth middle stages of the demographic transition that the theory which explicitly links population change to environmental change tends to relate. The classic, first theory of population change was that of Malthus (1798) which postulated that while population growth tends to occur geometrically, growth of food production increases arithmetically. The increasing gap between the two can be closed by positive checks through increasing mortality or preventative checks through decreasing fertility.

The limits that the environment places on population growth have been an important focus of theoretical and empirical work over the two centuries following Malthus. The Carrying Capacity model is one such formulation. Stated most simply, it suggests that the environment places a limit on the number of people that can be supported in a particular area. The model is depicted in Fig. 4 and was originally applied to animal populations although it has been applied to human populations. It suggests that in each area there is a limit to the number of people that can be supported. If that limit is exceeded (diagram (a)) it can result in a deterioration of the environment and a reduction in carrying capacity (diagram (b)). Hence a population cannot increase its size *and infinition* and finite environmental resources place upper limits on the growth of population. Moreover, there is an implication that if the resources are over-exploited their capacity to renew will be reduced and the carrying capacity will fall. A fall in carrying capacity will be accompanied by a decline in the population through mortality or outmigration.

There have been attempts to extend this concept to apply to humans as well as other species. A countries human carrying capacity has been defined as 'the estimated maximum number of people who can live there indefinitely and be given the opportunity to live long, healthy, self-fulfilling lives' (Cocks and Foran, 1995, pp. 67). However, there are at least two ways in which people differ from other species when considering carrying capacity concepts. Firstly, human beings have the capacity to innovate, use technology, etc. which animals do not so they have the capacity to redefine upward the limits imposed by carrying capacity. On the other hand, the actions of animals can only maintain or diminish a resource (e.g. in the case of over grazing). Hence as diagram (c) indicates, population growth may be associated with an upward redefinition of the carrying capacity because population pressure may be a stimulus for, or be associated with, a redefinition of the resource base due to innovation. Of course people too can be the cause of a downward change in the carrying capacity due to human actions leading to a deterioration in the resource base.

A second important difference about including humans in the carrying capacity concept is that whereas for animals it is possible to determine an upper limit on numbers by the area's capacity to provide sufficient food and water to sustain that number of animals this is not the case for people. Human populations need and use a much wider range of resources from the environment than food and water. As Newman and Matzke (Newman and Matzke, 1984, pp. 198) points out...

> Conceptually it is useful to think of the environment as a resource complex. It provides a more predictable carrying capacity for populations using naturally occurring resources than it does for humans capable of combining, manipulating and transforming resources. Resources in this view are not fixed in their capacity to support populations but make available materials that can be manipulated in various ways, to provide a wide range of population outcomes.

Placing an upper limit on the numbers of people that can be supported in a country, region, etc. is determined not just by the resources in that area but also the technology which is used to exploit those resources and the level of consumption of the resources acceptable to the inhabitants of the area. Increased population growth and increasing population density are readily able to be absorbed by the proliferation of secondary, tertiary and quaternary economic activity. Even in primary industry.

Boserup (1966) suggested that societies can respond to the build-up of population pressure on environments by intensifying their methods of agriculture and Geertz (1963) demonstrated how this occurred in nineteenth century Java. In Java, however, it is clear that 'agricultural involution' was not the only way in which the society adjusted to population increases. It is, for example, clear that while migration, both temporary and permanent, occurred (Hugo, 1975, 1978) the Javanese also limited their fertility using abstinence, late marriage, abortion and infanticide. Clearly these were complex interrelationships between fertility,

mortality, migration and the environment and there is considerable heterogeneity in the experience of population pressures effects on migration and the environment.

3. Global demographic change

The global population has experienced profound change in recent years. The 20th century has been referred to as the demographic century in which the world population increased from 1.8 to 6.1 billion and in 2010 has increased to 6.9 billion. Each successive billion has been added to the global population more quickly than the last until the sixth billion took only 12 years. However, the seventh billion will take a little longer and it is anticipated that the eighth and ninth billion will take successively longer periods to add. Until recently, it was generally believed by demographers that the global population will reach 9 billion by 2070 and is likely to stabilise at around this figure (Lutz, 2008, pp. 18). However, recently the United Nations (2011) revised their projections of the stabilisation total to be 10 million. Nevertheless, the global population is likely to experience a net increase of at least a quarter before it stabilises.

There has been a striking reduction in levels of global population growth which peaked at 2.06% per annum in the 1965–1970 period to the current level at slightly below 1.2% per annum. It is anticipated that this decline in growth will continue to be around 0.5% per annum in 2050. Currently More Developed Country populations are increasing at a rate of 0.34% per annum but Less Developed Countries are increasing four times as fast at 1.37% per annum and Least Developed at 2.3% per annum. By 2050 it is anticipated that More Developed region populations will have been declining for about 15 years while Less Developed populations will still be increasing by 0.41% and Least Developed at 1.15%.

Most of the additional 2.3 billion extra people by 2050 will be concentrated in developing countries. It is anticipated that the population in more developed countries would increase minimally from 1.23 billion in 2009 to 1.28 billion in 2050. However, it would have declined to 1.15 billion were it not for projected net migration from developing to developed countries which is projected to average 2.4 million persons annually from 2009 to 2050 (United Nations, 2009, pp. 1).

Table 1 shows that virtually all of the net increase in global population over the next four decades will be not only in less developed countries but also in the urban areas of those countries. The table indicates that the rural population will undergo a significant decline in both Less and More Developed countries.

To understand the nature and significance of these changes it is important to examine the demographic processes which underlie those trends in population change—mortality and fertility. Improvements in global mortality have been substantial. Over the 1950–2010 period through measures of life expectancy (the average number of years a person can expect to live if the age specific pattern of mortality which prevails at the time of their birth is maintained through their lifetime). The growing inequality in life expectancy between more developed and less developed countries remains although it has closed somewhat over the last 60 years. Globally it is anticipated that life expectancy at birth will rise

Table 1
World projected urban and rural population change, 2007–2050.

Growth, 2007–2050 (billions)	More developed countries	Less developed countries
Total	+.03	+2.5
Urban	+.16	+2.95
Rural	−.14	−.44

Source: United Nations (2008).

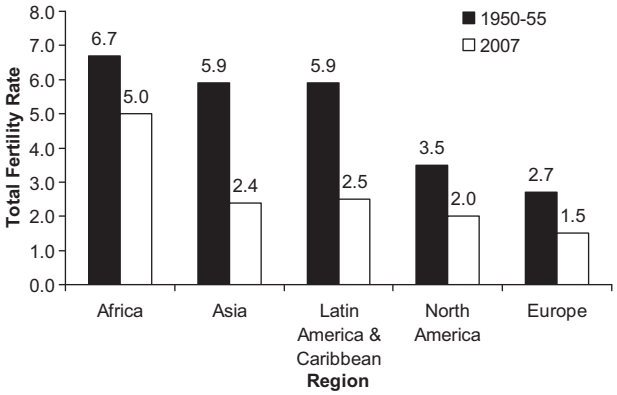

Fig. 5. Fertility levels in major world regions, 1950–1955 and 2007.
Source: United Nations (2003); Population Reference Bureau (2007).

from 68 in 2005–2010 to 76 in 2045–2050 (83 in more developed countries, 75 in less developed countries). The United Nations (United Nations, 2009, pp. 10) points out that this improvement in mortality is 'contingent upon reducing the spread of HIV and combating successfully other infectious diseases'. The latter is of significance since one of the concerns about climate change is that it may influence the spread of infectious disease (McMichael, 2006). Moreover, the United Nations (United Nations, 2009, pp. 10) reports that substantial numbers of poor countries will not reach the Millennium Development Goal of reducing under five mortality by two thirds between 1990 and 2015, most of them from Sub-Saharan Africa. There is concern about the continuing impact of the HIV/AIDS epidemic. The UN reports that the peak of the epidemic appears to have passed during the last decade in two thirds of the 58 countries most affected by it. The scale of the impact of HIV/AIDS is that it is projected that Africa's population in 2050 will be 350 million less than it would have been were it not for HIV/AIDS.

The major factor in the reduction in population growth over the last four decades has been the large, and largely unanticipated, substantial decline in fertility. Fig. 5 charts this dramatic change in the TFR[1] in major global regions over the 1950–2007 period. It will be noted that declines in fertility have occurred in all regions. The number of countries with high fertility (a TFR of 5 or more) declined from 59 in 1990–1995 to 27 in 2005–2010 while the number of developing countries with below replacement fertility increased from 15 to 38. Among 45 developed countries, 42 had below replacement fertility in 2005–2010 although it is interesting to note there was a small increase in the TFR in developed countries from 1.58 to 1.64 in this period. All told in 2005–2010, 76 countries worldwide had below replacement fertility accounting for 47% of the world's population (United Nations, 2009, pp. 9). It is expected that global fertility will fall from 2.56 in 2010 to 2.02 in 2045–2050.

The overall pattern of contemporary population growth is depicted in Fig. 6. It is possible to identify a number of 'hotspots' of rapid population growth which will be important sources of international migration over the coming decades:

- Sub-Saharan Africa;
- South Asia;
- The Pacific.

[1] TFR—Total Fertility Rate: The number of children, on average, a woman would bear if she were to have a childbearing experience identical with the experience of a cross-section of women of different age groups in a given year. It can be used as an estimate of the average number of children per completed family.

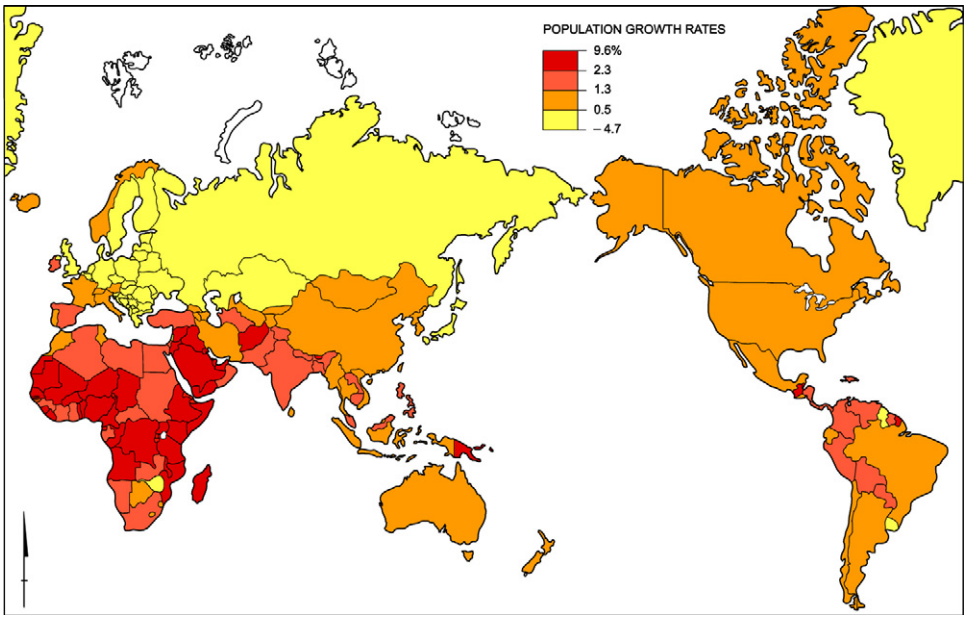

Fig. 6. National annual population growth rate, 2009.
Source: United Nations.

The Middle East also has rapid population growth but is currently a net immigration region due to oil generated economic activity. It is not only areas of rapid population growth which will be the sources of migrants into the future. For example, China currently has a very low level of population growth (0.5%) but has the world's largest population of 1,341 million. China has a workforce of 740 million persons compared with a combined 430 million in European and North American countries and it increases by 10 million each year. Despite its rapid economic growth, it is estimated that there are between 100 and 180 million 'surplus' rural workers in China. In rural China the China National Bureau of Statistics estimates that underemployment is at 35% of the total rural workforce, or over 170 million persons (Bin, 2010). The Chinese Vice Minister of Agriculture in March 2010 told a press conference that the oversupply of rural labour in China will continue as there were 90 million redundant workers in rural China.

In this context it is important to bear the Martin (1993) Migration Transition model in mind which suggests that rapid economic growth in its earliest stages encourages emigration rather than immigration. Hence rapid economic growth in very large countries like China, Indonesia, Brazil etc. will generate emigration as well as the rapid population growth rates in the hotspots identified in Fig. 6.

4. Changing age structure

In examining the implications of demographic change for migration in a context of climate change, the dynamics of age structure are of crucial significance for at least two reasons:

- The propensity to migrate varies greatly with age with the highest morbidity being in the younger adult ages. Hence concentration of a population in those ages can influence *outmigration*;
- Ageing of populations can result in reductions of the number of workforce age population in high income countries and thus create a demand for *immigration* to make up labour shortages.

One of the major demographic distinctions between high income and low income countries is in age structure. Low income countries tend to be at the earlier stages of the demographic transition with higher fertility and higher mortality, although both are declining. Hence they have young age structures. On the one hand high income countries have low fertility and low mortality which results in significantly older age structures. This is evident in Fig. 7 which shows the numbers of people in five year age groups in low and high income countries in 2005. Not only are the numbers much larger in the former countries but also there is a heavy concentration in the workforce age groups. On the other hand, in high income countries there is an undercutting of the base of the age pyramid and large numbers in the older ages. Hence in terms of the two migration impacts of age structure discussed above, it is low income countries that are experiencing the 'push' influence of concentration in the migration-prone ages and the high income countries have a migration 'pull' situation with shortages in the young workforce age groups. From the perspective of climate change it needs to be stressed that there will be increased need for migration toward high income countries from low income countries. This means that there is potential for such migration to be factored in to considerations of how low income countries will adapt to climate change.

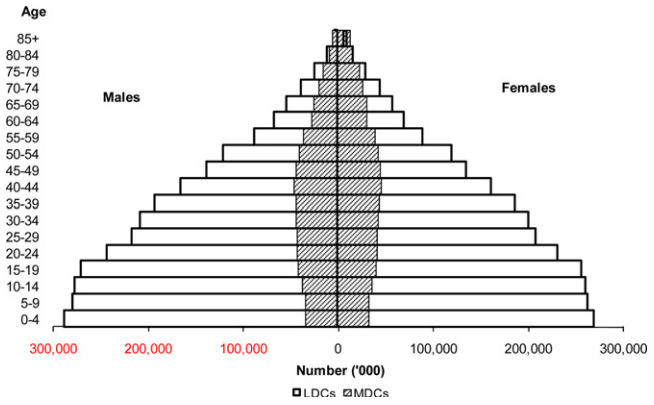

Fig. 7. More developed and less developed countries: age and sex distribution of the population, 2005.
Source: United Nations (2007).

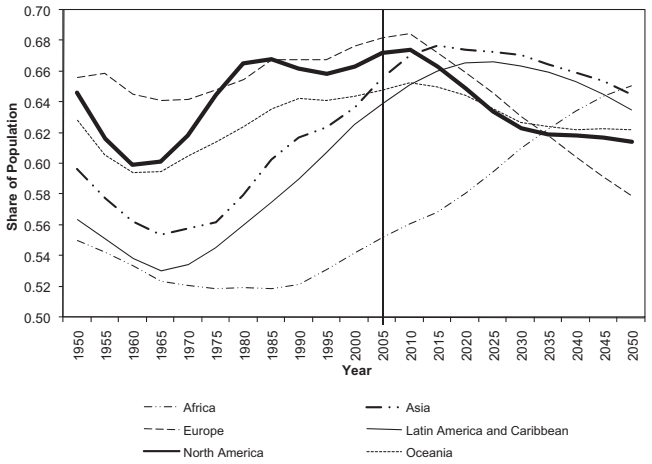

Fig. 8. World regions: share of population in working ages, actual, 1950–2005 and projected, 2010–2050.
Source: United Nations (2007).

The year 2010 has been a pivotal year in the world's demography. The numbers in the workforce ages living in high income countries peaked at 500 million and will now begin to decline to 475 million in 2025, a loss of 25 million (World Bank, 2006). Meanwhile, the numbers in the working ages in low income countries will continue to increase, albeit at a slower rate than in the past, by almost 1 billion from 2010 to 2025.

Much of the demographic impact on migration over the coming decades will be through the influence of changes in age structure. The differences in timing in the commencement of fertility decline and the extent of fertility decline and mortality decline have substantial impacts on age structure of nations. In the early stages of the demographic transition with high mortality and fertility the age pyramid is broad based but with a relatively flat slope because of the attrition of mortality. As mortality declines and fertility remains high the broad base of the age pyramid is maintained through older age groups. However as fertility decline begins, the age pyramid is undercut with smaller numbers being born into the youngest age groups.

The balance between working and non-working populations in a nation has an independent impact on the economy. Countries with a high proportion of their population in the working ages and low proportions in the young and old dependent ages can experience a demographic dividend if appropriate policies are put in place to take advantage of this. This predominantly occurs when countries experience a significant decline in fertility so that the groups born in the final years of high fertility constitute a bulge who produce rapid growth of the workforce as they age into their late teens and twenties. It is estimated that a fifth of China's prosperity in the last two decades is purely attributable to this demographic dividend (Wang and Mason, 2007). Demographers estimate that countries move into this demographic dividend situation when the population aged less than 15 falls below 30% and finishes when the proportion aged 65 years or over goes beyond 15%.

Fig. 8 shows that there is considerable variation between global regions in the current percentages of their population which are in the working age groups, the historical and future patterns. In North America and Europe (and to a lesser extent Oceania) the share of population in working ages has peaked and is beginning to fall as ageing impacts are felt. On the other hand in Asia and Latin America the ratio is increasing and will peak in the next decade or so while that in Africa, due to the young population, will continue to increase over the next four decades.

An important point from the point of view of the present paper, however, is that the same process which concentrates population in the ages which delivers a demographic dividend – the 1920s and 1930s – has important implications for migration. This is because one of the most universal findings in migration research is that peak mobility is concentrated in the 1920s and 1930s age groups. The rapid growth of the 1920s and 1930s age groups in less developed regions in the last two decades has coincided with unprecedented opportunities for international migration. It is of significance in the global increase in international migration (United Nations, 2009) that the proportion of the world's population in the peak mobility age groups of 15–34 years reached an unprecedented 34.2% of the global population in 1995 and continues to increase in absolute size. The large size of the cohorts entering the workforce age groups at present reflects the higher fertility regime of the world prevailing 15–20 years ago and the unprecedented rates of survival of these cohorts through infancy and childhood. Hence globally the young working age group population has been growing very rapidly, especially in less developed countries.

It is not just that there has been a rapid increase in the numbers entering the migration-prone age groups in less developed countries. In almost all such countries youth have experienced some formal education and are easily the best educated ever generation of young people in the region. While post-school formal education has remained the prerogative of a privileged elite in many nations, there has been a spectacular increase in the intergenerational differences in educational attainment. This has meant that there are not only more workers for each dependent than in past generations but also that their per capita productivity is considerably greater and their ability to compete in markets for international migrants has been greater. Moreover, they are the first generation that have grown up during the era of globalisation, universal education, access to global mass media, the electronic age, etc. This not only has a major influence on the human resource skills they have acquired but on their aspirations, preparedness to move, knowledge of the outside world, etc. What the implications of this are for future migration is not known. On the one hand their education, language ability and knowledge of the world may result in them being more likely to make an international move than earlier generations. On the other it may be that they are less inclined to move to OECD nations and be more attracted by other destinations within their own region.

Table 2 focuses on the projected trends for the most migration-prone age group, 15–34 years, and shows the following patterns:

- The numbers of the global population in the migration-prone 15–34 age groups will continue to increase over the next quarter century but at a decreasing rate—0.85% per annum in the 2005–2010 period, 0.55% per annum in the following decade and 0.21% per annum in the 2020s;
- In Europe however this age group will decline over the entire period from 205.7 million in 2005 to 154.1 million in 2030. This points to the growing shortage of young workers in Europe;
- In North America and Oceania the numbers in the 15–34 age group will grow at above the global average in 2005–2010 and 2010–2020 but will fall away and grow only marginally between 2020 and 2030;
- In Asia numbers in the 15–34 age group will decline at a slow but increasing rate over the period;
- The main growth of people aged 15–34 will occur in Africa and the Middle East where the numbers will increase from 320 and 77 million to 540 and 99 million, respectively.

It is not just that there has been a rapid increase in the numbers entering the migration-prone age groups in less developed

Table 2
World regions: population aged 15–34, 2005–2030.

World region	2005		2010		2020		2030		% Growth per annum		
	Number '000	%	Number '000	%	Number '000	%	Number '000	%	2005–2010	2010–2020	2020–2030
Africa	320,874	14.77	363505	16.04	448685	18.74	540024	22.08	2.53	2.13	1.87
Asia	137,4741	63.27	1368520	60.38	1359438	56.77	1324100	54.14	−0.09	−0.07	−0.26
Middle East	76,859	3.54	83080	3.67	92162	3.85	99350	4.06	1.57	1.04	0.75
Europe	205,676	9.47	196711	8.68	170354	7.11	154115	6.30	−0.89	−1.43	−1.00
Latin America & the Caribbean	193,485	8.90	201458	8.89	210398	8.79	211554	8.65	0.81	0.44	0.05
North America	92,017	4.24	97018	4.28	102360	4.27	104778	4.28	1.06	0.54	0.23
Oceania	9,934	0.46	10394	0.46	11433	0.48	11868	0.49	0.91	0.96	0.37
World	2,172,772	100.00	2266644	100.00	2394830	100.00	2445790	100.00	0.85	0.55	0.21

Source: United Nations (2007).

countries. In almost all such countries youth have experienced some formal education and are easily the best educated ever generation of young people in the region. While post-school formal education has remained the prerogative of a privileged elite in many nations, there has been a spectacular increase in the intergenerational differences in educational attainment. This has meant that not only there are more workers for each dependent than in past generations but also their per capita productivity is considerably greater and their ability to compete in markets for international migrants has been greater. Moreover, they are the first generation to grow up with access to global information and communication technology which influences not only their skills but also their aspirations, preparedness to move and their knowledge of potential destinations.

5. Demographic change variations within countries

The focus here has been on variations between countries in the extent and nature of demographic change but it is important also to consider variations in population trends *within* countries for the following reasons:

- There is considerable variation within countries in fertility, mortality and especially migration trends;
- Internal movement rates within countries are usually substantially higher than international migration rates (UNDP, 2009, pp. 32);
- In the past most environmentally induced migration has occurred *within* countries and the amount occurring across national boundaries has been small (Hugo, 1996; Hugo et al., 2009).

Internal migration, like international migration, can be permanent as well as temporary but considerable redistribution of population has occurred and will continue to occur within countries. Most significant here is the rapid rate of urbanisation which is occurring in less developed nations. In 2010 the world passed an important milestone when the proportion of the global population living in urban areas exceeded the number living in rural areas for the first time in human history. This represents a massive internal redistribution of population over recent decades and the trend will continue over the next few decades. Table 3 shows that the proportion of the world's population living in urban areas will increase from 29.1% in 1950 to double in 2030. Moreover, of the increase in urban population more than 90% will be in less developed countries where the urban population will increase from 2.3 billion in 2005 to 3.9 billion in 2030. Indeed most of all net global population growth over the next four decades will accrue to urban areas in less developed countries.

Table 3
World population: percent living in urban areas.

	1950	2005	2030
World	29.1	48.6	59.7
More Developed Regions	52.5	74.0	80.6
Less Developed Regions	18.0	42.7	56.0

Source: United Nations (2008).

Rural–urban migration, while it can result in people moving from an area of low levels of economic opportunity to areas of greater number and variety of job opportunities may also involve moving from areas of low potential climate change impact toward areas where the probability of significant climate change influence is high. This is especially the case in movement to coastal mega cities. Moreover, rural–urban movers often are engaged in low income work, have poor quality housing and occupy a marginal position in urban destinations. Hence they may well be among the most vulnerable groups in destination areas and have limited capacity to cope with the effects of climate change in those areas.

Associated with the trend of urbanisation is an increasing trend for the global population to live in or near coastal areas. This is because not only are the bulk of large world cities located in coastal areas but also because there is a concentration of densely settled agricultural areas in well-watered, fertile deltas and coastal plains. McGranahan et al. (2007) have identified the present and projected population numbers in the Low Elevation Coastal Zone (LECZ)—the area less than 10 m above sea level. In 2000 a 10th of the world's population lived in this zone as did 13% of the urban population. Fig. 9 shows how large cities in Asia are strongly concentrated in the coastal areas. It is apparent too that the world's coastal areas are growing faster than the inland population (McGranahan et al., 2007). Moreover, McGranahan et al. (2007) show that while 10% of the total MDC population and 11% of the MDC urban population live in the LECZ, the proportions are higher for LDCs (14 and 21%).

6. Interactions between environmental change, demographic change and migration

It is important to appreciate the complexity of the causes of migration. One of the reasons why environment has been neglected as a factor driving migration is that it has rarely been the only, or even the main, cause of migration in the past. As is depicted in Fig. 10, environmental factors as a cause of migration can be the key factor in migration but more often they are contributory causes and are located along a continuum of degree of significance. The extent to which environmental change is a cause of migration varies from not being significant at all to being the overwhelming cause of migration such as when an agricultural area is inundated and people are forced to move. Environment has been identified as a mostly 'proximate' cause of migration. This means that distinguishing 'environmental migrants' from others is quite difficult except at the extreme end of the continuum in Fig. 10. It is at this forced end of the continuum that a designation of migrants as 'environmental migrants' is most applicable.

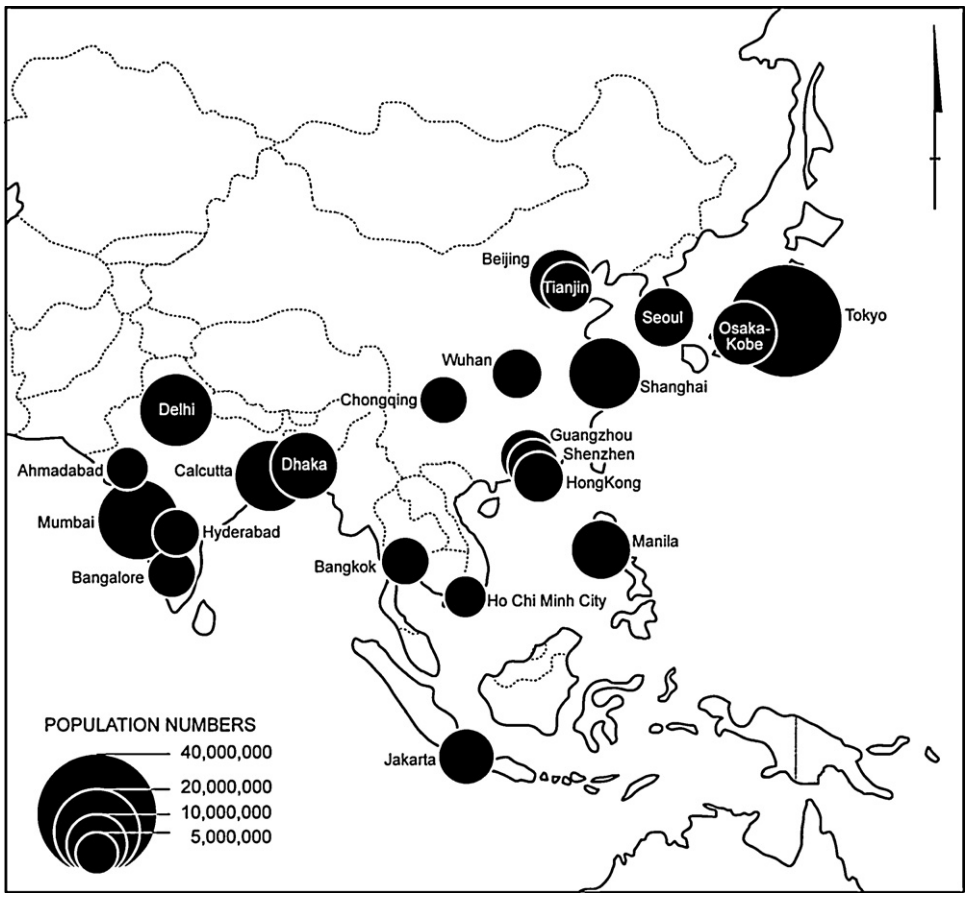

Fig. 9. Asia and the Pacific: location of cities with a population of 5 million and over, 2005.
Source: United Nations (2008).

Hence the relationship between environmental change and migration is much more complex than an environmental deterioration equals population displacement nexus, which is often assumed. Fig. 11 is an attempt to show the complexity of interactions in the relationship between environmental change and migration. Environment as a cause of migration usually interacts with a range of other economic, social and demographic factors. This will also be the case where the environment is affected by climate change. Hence it is important to conceptualise environmental change, demographic change and population movement as part of a complex multidirectional interacting system.

One of the key issues here is that both environmental change and demographic change can cause migration independently but demographic changes may influence the environment which in turn causes migration. In Java in Indonesia, for example, Hugo (1978) showed that continued population growth in rural areas placed considerable pressure on the ability of the environment to absorb all of the increase in agriculture which led to outmigration. In some especially fragile areas (steep hill slopes, coastal plains) clearing and overuse led to deterioration of the environment through erosion and leaching of soils which further reduced the capacity to provide a sustainable living to people in the area. It should also be noted, however, that there were a number of *in situ* adjustments which allowed the environment to be modified to absorb more people through agricultural involution (Geertz, 1963).

Fig. 10. Environment as a cause of migration.

These *in situ* adjustments included intensification of agriculture, adoption of new types of economic activity, reducing fertility and even reduction in body size (stunting). The key implications for the present study are:

- Population increase can lead to the carrying capacity of an area being exceeded so that outmigration results;
- However, outmigration does not necessarily occur as a result of population increase because a range of *in situ* adjustments are often also made in response to environmental change.

The latter point is especially important. *In situ* adaptations are by far the most common responses to demographic and environmental changes. There is not a simple deterministic relationship of the type:

population increase → environmental deterioration
→ outmigration.

Assuming such a relationship exists has led to unrealistic predictions of massive population displacement by climate change.

Keeping this very important caveat in mind it is useful to identify the areas of most rapid global population growth and relate this to anticipated spatial patterns of climate change. As was indicated earlier future population growth will be limited largely to less developed regions of the world and that while Asia is the main contributor to global population growth currently, increasingly Sub-Saharan Africa will become the primary contributor. The other main areas of growth are South Asia, the Middle East and the Pacific. While there are some high population growth nations outside of these regions (e.g. Philippines in Southeast Asia), these

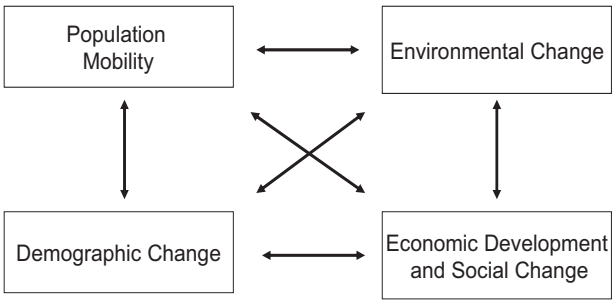

Fig. 11. A complex interrelationship: migration, environment, resources and development.

are the 'hotspots' of most rapid global population growth over the next four decades. It is of importance, therefore, to note that these areas also are likely to experience some of the most substantial impacts of climate change. Of the top ten countries (based on land area at risk) which are at high risk of experiencing three or more hazards, eight are in the identified rapid population growth regions while of the top 60 experiencing two or more hazards most are in high population growth regions (Dilley et al., 2005, pp. 4). Moreover, there is a strong correlation between the areas currently at most risk of experiencing environmental hazards and those at greatest risk of being most influenced by climate change. Rapid population growth in these areas is a significant factor to add to this vulnerability as is the case that all of the four regions have low levels of development and capacity to cope with environmental hazards. This does not suggest that there is a causal or deterministic relationship between climate change and population growth but simply that there is a pattern of areas of most rapid population growth including some of the areas identified as facing considerable risk of significant climate change impact.

In considerations of both climate change and demographic change it must be recognised that there are substantial intra-national variations. Different parts of countries are experiencing different levels of population growth and are at different levels of risk of experiencing negative climate change impacts. There are five main types of area that climate change is anticipated to have a negative impact upon:

- Coastal areas are vulnerable to inundation and the effect of storm surges associated with sea level rise (McGranahan et al., 2007);
- River valleys and deltas (Ericson et al., 2006) will be influenced by increased riparian flooding;
- Low lying island states, especially atolls, are at risk from the effects of sea level rise, surface warming and extreme weather events (Barnett and Adger, 2003);
- Semi-arid and low humidity areas where drought and availability of water are already problematic are likely to experience an exacerbation of those water shortage problems;
- Some other areas likely to be impacted by extreme weather events.

In fact, several of these types of regions are precisely the areas which are currently experiencing very rapid population growth. This is especially the case, for example, in coastal areas (McGranahan et al., 2007). For example, the portion of the Mekong Delta in Vietnam is home to almost a quarter of the total Vietnamese population. A World Bank study (Dasgupta et al., 2007) found that for a 1 m sea level rise, Vietnam would be the developing nation most affected in terms of:

- Percentage of population affected (10.8%);
- Percentage of GDP affected (10%);
- Percentage of wetlands inundated (28%).

Much of this impact would be in the Mekong delta. Ho Chi Minh City has become a major focus not only of permanent rural to urban migration within Vietnam (Gubry, 2002, Nguyen Thi, 2008), but also massive seasonal temporary inmigration (Grace, 2002). A qualitative study in the Mekong region has established that

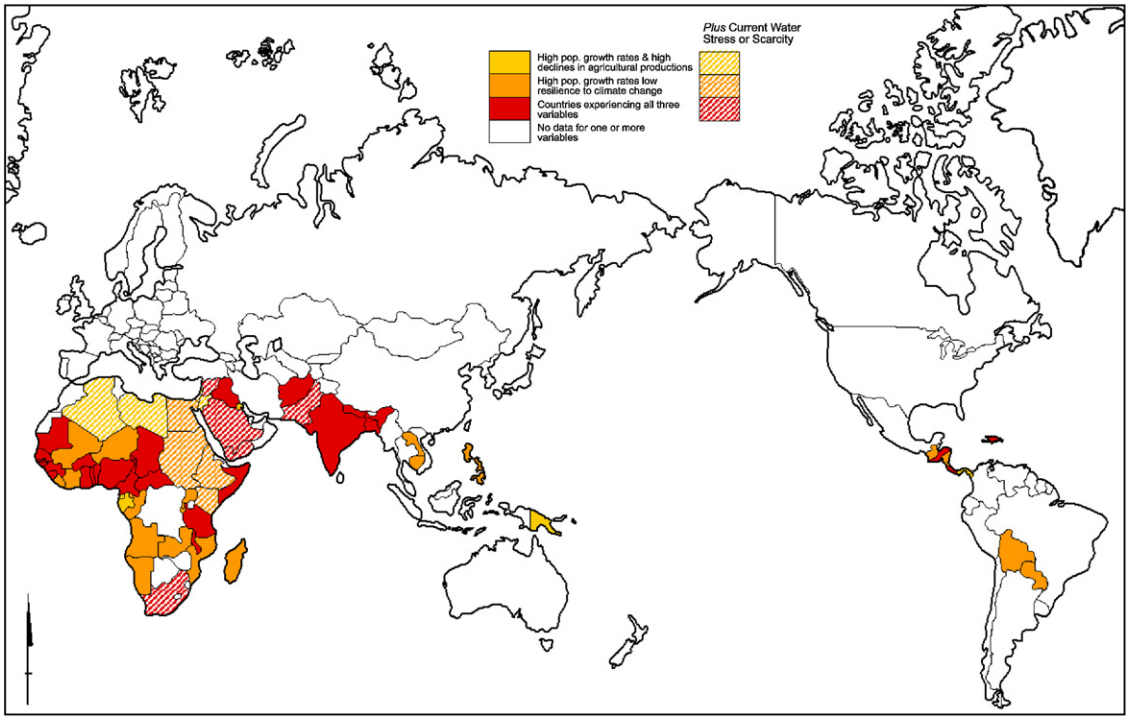

Fig. 12. Population and climate change hotspots.
Source: www.populationaction.org/Publications.

Table 4
Correlation coefficients between population growth and development and environment variables for countries.

Independent variable	Annual population growth rate 2010	Total fertility rate 2010	Number of countries (*n*)
GNI per capita	−.345[a]	−.528[a]	167
GDP per capita	−.342[a]	−.446[a]	159
Incidence of corruption	.322[a]	.403[a]	125
Population affected by disasters	.148	.163[b]	160
Percent population on degraded land	.237[a]	.289[a]	150
Percent urban	−.466[a]	−.627	167

Source: UNDP (2010).

[a] 99% level of confidence.
[b] 95% level of confidence.

environmental factors are already an important element driving migration in the region (Dun, 2009).

The key issue here is that there is a strong pattern of climate change hotspots also being areas of rapid population growth. Population Action International have analysed measures of four variables for all countries of the world:

- Population growth rates in 2005;
- Projected changes in agricultural production 1990–2010 due to climate change
- Reliance to climate change as measured in 2000;
- Water scarce or water stressed countries in 2005.

The overlaid distribution of these four variables is provided in Fig. 12. They were able to designate 33 countries as *population and climate change hotspots* and it is clear they are concentrated in Africa, South and Southeast Asia, Central America and the Pacific, although the small island nature of the last group prevents them showing up on a global map.

This section has demonstrated that there is a strong spatial coincidence between hotspots of continued rapid population growth and climate change hotspots. It is probable then that population increases are likely to exacerbate the impacts of climate change in low income countries. In fact it is the case that there is a 'triple jeopardy' situation in these areas because it is not only that they are population growth and climate change 'hotspots' but they also are some of the world's poorest areas. Poverty is often associated with high levels of vulnerability and low levels of resilience.

To further investigate the relationship between population growth, on the one hand, and development and environment on the other a correlation analysis of countries was conducted drawing on data from the Human Development Index (UNDP, 2010). The results are provided in Table 4 and show a striking pattern. For both rate of population growth and total fertility rate there are strong significant negative correlations with development and urbanisation and negative correlations with percentage of the population on degraded land and population affected by disasters. This adds further fuel to the contention here that there is a strong spatial correlation between population and environmental 'hotspots'.

7. Some policy implications

There are a number of implications for policy which emerge from the present study. One is certainly the imperative of reducing global population growth as quickly as possible. In this respect it is disturbing that there has recently been a slowing down in fertility reduction in high growth countries (United Nations, 2011). A recent careful analysis (O'Neill et al., 2010) has used an energy-economic growth model which accounts for a range of demographic dynamics to indicate that slowing population growth would provide between 16 and 29% of the emissions reductions suggested to be necessary by 2050 to avoid dangerous climate change. Bongaarts and Sinding (2011) have demonstrated that where there is sufficient political will, well-run voluntary programs which provide ready access to, and information about, contraception and reproductive health have brought about sustained declines in fertility and population growth across much of Asia, the Middle East and Latin America. They argue that such programs represent a cost-effective approach to relieving population pressure, stimulating economic development, improving health and enhancing human health. They could well have added that such programs are also critically important to help in adapting to the potential negative impacts of climate change.

However, it is also necessary for this effect to be especially concentrated in particular areas where rapid population increase continues. There is a continuing urgency of targeting inclusive and equitable reproductive health and family planning initiatives in hotspot areas of low income and low levels of development. This is especially the case in Sub-Saharan Africa, South Asia, the Middle East and the Pacific. One of the important, but neglected, dimensions of such initiatives is that they can help reducing the vulnerability of populations living in these areas and enhance local capacity while also bringing down population growth rates. The results of the study underline the necessity of concentrating efforts in poverty reduction, capacity building and enhancing resilience in these hotspot areas. The effects of climate change will be to exacerbate the problems in these areas and lend an additional dimension of urgency to the need for action. On the other hand, bring down population growth can be part of the necessary package of initiatives to build resilience and facilitate adaptation.

A second implication relates to the demographic reality and certainty regarding the patterns of ageing. There is no doubt about the fact that there will be a steepening of demographic gradients between high income countries with declining numbers in the workforce ages and low income countries with continued growth in those age groups. While we must avoid demographic determinism, there can be no escaping that there *will* be increasingly stark contrasts between labour shortage and labour surplus countries. There is an urgent need for an international migration regime which recognises this reality and provides a basis for safe, effective and equitable migration from low income countries to meet the needs of high income countries. Effects of climate change may be factored in to the development of such a regime. The fact is that demographic differences, quite apart from other drivers, mean that there will be significant labour shortages in high income countries. In providing this labour, can low income areas and countries which are facing the greatest threat of negative climate change impact be given special consideration as source areas for migrants?

A third implication relates to the need for increased efforts in planning the future settlement system and associated population distribution in countries to be impacted by climate change. To

what extent does the existing settlement system and population distribution match the economic, social and environmental reality of the next 40 years? The last 40 years has seen a massive redistribution of population between and within countries largely in response to economic and demographic change. This study has demonstrated the huge shift which has occurred from rural to urban areas over the last few decades. It is not unrealistic to consider a similar scale of redistribution over the next four decades toward a pattern of human settlement in line with environmental constraints, climate change and new economies. In the last 40 years the driving force of population redistribution has been overwhelmingly structural economic change. In the next 40 years will there be a similar shift but in this case part of the driving force be environment and climate change? To what extent are existing settlement systems in low income countries an artefact of colonisation centred around large coastal and entrepot centres? To what extent can new natural settlement plans and strategies facilitate the development of more sustainable, ecofriendly, economically dynamic cities? The current overwhelming focus of migration, internal and international, on coastal cities should be re-examined, especially where the long term sustainability of those cities is under significant threat due to climate change. Should national settlement policy be increasingly identifying inland cities for investment? There is greater ability to develop sustainable ecofriendly urban environments in new cities than retrofitting older ones. The last two hundred years has seen a global inland to coastal migration, perhaps the next century will see a reversal.

Another policy implication relates to morbidity and mortality. There is a new awareness of the significance of the complex relationship between migration and health (WHO-IOM, 2010). However, the agenda in this research area currently does not include implications of climate change. While the WHO is investigating in some detail the potential effects of climate change on health (McMichael et al., 2006), the implications for migration have received less attention (McMichael et al., 2010).

8. Conclusion

While there is great uncertainty regarding future patterns of both climate change and migration, there can be no doubt that the impacts of climate change will add to already increasing levels and complexity of population mobility. We cannot be specific about the scale and scope of those impacts but they will be significant. Moreover, it is possible to not only cope with these changes but also to harness that population mobility to reduce poverty and enhance economic and social development. In order to do this, however, there will need to be major improvements in many areas—more effective migration management, strengthening governance, developing appropriate funding mechanisms to facilitate adaption to climate change, enhancing international cooperation on climate change issues, expanding and improving development assistance mechanisms and in developing sound economic development policy and practice throughout the region. Moreover there is an *urgency* in making these changes to accommodate the effects of climate change on mobility. This urgency derives from two things. Firstly some of the impacts are already in evidence, and secondly because the changes which are required involve substantial institutional, structural and cultural change which will take time to achieve. Many of the impacts of climate change are likely to be felt hardest several decades into the future, but if those impacts are to be dealt with in a way which does not lead to increased poverty and suffering but facilitates reductions in inequality and improvements in well-being, policy intervention across multiple levels is required now.

References

Barnett, J., Adger, W.N., 2003. Climate dangers and atoll countries. Climatic Change 61, 321–337.

Bin, H., 2010. Employment Challenge and Policies Response in China. China Enterprise Confederation, People's Republic of China.

Bongaarts, J., Sinding, S., 2011. Population policy in transition in the developing world. Science 333 (July).

Boserup, E., 1966. The Conditions of Agricultural Growth: the Economics of Agrarian Change Under Population Pressure. Aldine, Chicago.

Cocks, K.D., Foran, B.D., 1995. Quality of life as a discretionary determinant of Australia's long-term population. In: Population 2040: Australia's Choice, Australian Academy of Science, Canberra, pp. 63–78.

Dasgupta, S., Laplante, B., Meisner, C., Wheeler, D., Yan, J., 2007. The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis. World Bank Policy Research Working Paper 4136, February.

Dilley, M., Chen, R.S., Deichmann, U., Lerner-Lam, A.L., Arnold, M., 2005. Natural Disaster Hotspots: A Global Risk Analysis. The World Bank, Washington DC.

Dun, O., 2009. Viet Nam: EACH-FOR Case Study Report. Bonn, United Nations University–Institute for Environment and Human Security (UNU-EHS) for European Commission.

Ericson, J.P., Vörösmarty, C.J., Dingman, S.L., Ward, L.G., Meybeck, M., 2006. Effective sea-level rise and deltas: causes of change and human dimension implications. Global and Planetary Change 50, 63–82.

Friedlander, D., 1969. Demographic responses and population change. Demography 6, 359–381.

Geertz, C., 1963. Agricultural Involution: The Process of Ecological Change in Indonesia. University of California Press, Berkeley.

Gibbs, J.P., 1963. The evolution of population concentration. Economic Geography 39, 119–129.

Grace, J., 2002. Female Labour Migration: Rural–Urban. Book Review of Ha Thi Phuong Tien and Ha Wuang Ngoc, 2001.Women's Publishing House, Hanoi. Intersections, Issue 8, October, http://wwwsshe.murdoch.edu.au/intersections/issue8/grace_review2.html.

Gubry, P., 2002. Ho Chi Minh City: A Future Megacity in Viet Nam. Paper presented at the IUSSP Southeast Asian Regional Conference, Session 19, Megacities, Bangkok, 10–13 June.

Hugo, G.J., 1975. Population mobility in West Java, Indonesia. Unpublished Ph.D. Thesis. Department of Demography, Australian National University, Canberra.

Hugo, G.J., 1978. Population Mobility in West Java. Gadjah Mada University Press, Yogyakarta.

Hugo, G.J., 1991. Changing famine coping strategies under the impact of population pressure and urbanisation: the case of population mobility. In: Bohle, H.G., Cannon, T., Hugo, G., Ibrahim, F.N. (Eds.), Famine and Food Security in Africa and Asia: Indigenous Response and External Intervention to Avoid Indigenous Response and External Intervention to Avoid Hunger. Bayreuther Geowissenschaftliche Arbeiten, Bayreuth, West Germany, pp. 127–148.

Hugo, G.J., 1996. Environmental concerns and international migration. International Migration Review 30 (1), 105–131.

Hugo, G., Bardsley, D.K., Tan, Y., Sharma, V., Williams, M., Bedford, R., 2009. Climate Change and Migration in the Asia-Pacific Region. Report prepared for Asian Development Bank.

Leete, R., Alam, I., 1993. The Revolution in Asian Fertility: Dimensions, Causes and Implications. Clarendon Press, Oxford.

Long, J.F., 1985. Migration and phases of population redistribution. Journal of Development Economics 17, 29–42.

Lutz, W. (Ed.), 2007/08. Population Network Newsletter (No. 39, Winter).

Malthus, T., 1798. An essay on the principle of population. J. Johnson, St. Paul's Church-Yard, London.

Martin, P., 1993. Trade and Migration: NAFTA and Agriculture. Institute for International Economics, Washington DC.

Martin, P., 1994. Migration and trade: challenges for the 1990. Work and Family Life of International Migrant Workers 4 (3), 1–21.

McGranahan, G., Balk, D., Anderson, B., 2007. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. Environment and Urbanization 19 (1), 17–37.

McMichael, A.J., 2006. Carrying Capacity: Environmental Constraints (National and Global) on Population Size. Presentation to The Population Debate, University of Adelaide.

McMichael, A., Woodruff, R., Hales, S., 2006. Climate change and human health: current and future risks. Lancet 367, 859.

McMichael, A., McMichael, C., Berry, H., Bowen, K., 2010. Climate-related displacement: health risks and responses. In: McAdam, Jane (Ed.), Climate Change and Displacement: Multidisciplinary Perspectives. Hart Publishing, Oxford.

Newman, J.L., Matzke, G.E., 1984. Population: Patterns, Dynamics and Prospects. Prentice-Hall, New Jersey.

Nguyen Thi, H.X., 2008. Adaptation of Young Migrants in Ho Chi Minh City, Vietnam. Unpublished Ph.D. Thesis, Department of Geographical and Environmental Studies, The University of Adelaide.

O'Neill, B., Dalton, M., Fuchs, R., Jiang, L., Pachauri, S., Zigova, K., 2010. Global demographic trends and future carbon emissions. Proceedings of the National Academy of Sciences of the United States of America 107 (October (41)), 17521–17526., In: http://www.pnas.org/content/107/41/17521.

Population Reference Bureau, 2007. World Population Data Sheet, Population Reference Bureau, Washington DC.

Ravenstein, E.G., 1889. The laws of migration. Journal of the Statistical Society 52 (2).
Rogers, A., 1979. Migration patterns and population redistribution. Regional Science and Urban Economics 8, 1–36.
United Nations, 2003. World Population Prospects: The 2002 Revision, vol. II, Sex and Age Distribution of the World Population. United Nations, New York.
United Nations, 2007. World Population Prospects: the 2006 Revision. United Nations, New York.
United Nations, 2008. World Urbanization Prospects: the 2007 Revision. United Nations, New York.
United Nations, 2009. World Population Prospects: the 2008 Revision. United Nations, New York.
United Nations, 2011. United Nations Press Release—World Population to Reach 10 Billion by 2100 if Fertility in All countries Converges to Replacement Level. United Nations, New York.
United Nations Development Programme (UNDP), 2009. Human Development Report 2009. UNDP.
United Nations Development Programme (UNDP), 2010. Human Development Report 2010. 20th Anniversary Edition—The Real Wealth of Nations: pathways to Human Development, UNDP.
Wang, F., Mason, A., 2007. Population Aging in China: Challenges: Opportunities and Institutions. In: Zhao, Z., Guo, F. (Eds.), Transition and Challenge: China's Population at the Beginning of the 21st Century. Oxford University Press, pp. 177–196.
WHO-IOM, 2010. Health of Migrants—The Way Forward. Report of a Global Consultation, Madrid, Spain, 3–5 March, WHO.
World Bank, 2006. Global Economic Prospects 2006: Economic Implications of Remittances and Migration, World Bank, Washington, DC.
Zelinsky, W., 1971. The Hypothesis of the Mobility Transition. The Geographical Review, LXI, 2, 219–249.