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WORLD POPULATION GROWTH AND ITS IMPLICATIONS ON FOOD SECURITY AND ENVIRONMENT: ONLINE EDUCATIONAL RESOURCES ON VOLUNTARY FAMILY PLANNING[i]

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Abstract:
The article presents educational and informative resources that can be downloaded for free from the internet. They consist of text, images, graphs, and videos that can be of interest to general readers and for teachers. These latter can use the resources with the method felt as most appropriate. As a consequence of the growing world population, by 2050, in South Asia and Sub-Saharan Africa, a 112% increase in food production will be required to meet the caloric requirements. In this latter region, water availability per capita declined by 40% over the past decade, agricultural land decreased from 0.80 to 0.64 ha/capita between 2000 and 2017, and the fertility level is 4.6 births per woman. The agricultural land available per capita is decreasing on a global scale, and a *slower population growth might give the time to take measures aimed at meeting the needs of the people, while protecting the environment.* Family planning is a basic human right, but nowadays it is seriously underfunded by donors and developing countries. Several documents deal with the unmet needs of *257 million women who want to avoid pregnancy, but cannot use safe and modern contraception methods. Every year 121 million pregnancies are unintended.* Some documents quoted deal with the influence of religious and socio-cultural factors on family planning, and child marriage. These are associated with health risks for both children and adolescent mothers. Several documents presented in this article deal with contraceptive methods. Some documents describe the strategies adopted in several countries to improve the availability and affordability of contraceptives for low-income people. Family planning and a slower population growth may provide countries with a window of opportunity for a faster economic growth, thanks to savings in education, maternal and child health care, and other services. Such savings far surpass the expenditure for birth control.

[i] CRESCITA DELLA POPOLAZIONE MONDIALE E SUE IMPLICAZIONI SU SICUREZZA ALIMENTARE ED AMBIENTE: RISORSE DIDATTICHE IN RETE SULLA PIANIFICAZIONE FAMILIARE VOLONTARIA

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Keywords: Educational Resources, Growing Population, Family Planning, Contraceptive, Soil Loss, Declining Water Resources, Food Security, Migration

Riassunto:
L'articolo presenta risorse educative ed informative scaricabili gratuitamente da internet. Queste consistono in testo, immagini, grafici e video che possono interessare vari lettori ed insegnanti. Questi ultimi possono usare le suddette risorse con il metodo sentito come il più appropriato. In conseguenza della crescita della popolazione mondiale, nel 2050, per soddisfare il fabbisogno calorico nell'Asia meridionale e nell'Africa subsahariana sarà necessario un aumento del 112% della produzione di cibo. Nell'Africa subsahariana, la disponibilità pro capite di acqua è diminuita del 40% negli ultimi 10 anni, i terreni agricoli sono diminuiti da 0,80 a 0,64 ettari a persona tra il 2000 ed il 2017. Il livello di fertilità è 4,6 figli per donna. I terreni agricoli disponibili pro capite stanno diminuendo su scala globale. Una crescita della popolazione più lenta concederebbe il tempo necessario a prendere provvedimenti volti a soddisfare i bisogni delle persone, proteggendo l'ambiente allo stesso tempo. La pianificazione familiare volontaria è un diritto umano di base, ma adesso è sottofinanziata dai donatori e dai paesi in via di sviluppo. Vari documenti parlano dei bisogni insoddisfatti di 257 milioni di donne che vogliono evitare la gravidanza, ma non hanno a disposizione contraccettivi moderni e sicuri. *Ogni anno ci sono 121 milioni di gravidanze indesiderate.* Alcuni documenti citati parlano della influenza dei fattori socio-culturali sulla pianificazione familiare e sui matrimoni precoci. Questi ultimi sono associati a rischi sanitari, sia per i bambini che per le giovani madri. Vari documenti presentati in questo articolo parlano dei metodi contraccettivi. Altri documenti descrivono le *strategie adottate in taluni paesi per rendere i contraccettivi più disponibili, anche economicamente, per le persone con basso reddito*.

Parole chiave: Risorse Educative, Crescita della Popolazione, Pianificazione Familiare, Contraccettivi, Consumo di Suolo, Calo delle Risorse Idriche, Sicurezza alimentare, Migrazione

1. Aims of the teaching unit

This paper, based exclusively on the quoted documents, presents online educational resources aimed at motivating and facilitating the study of contraception methods.

2. Materials and methods

The educational resources quoted in this article, downloadable for free from the internet, consist of text, videos, graphs, and images. They are in English and can be used with the method felt by the teacher as most appropriate.

3. Introduction

According to FAO estimates, by 2050 agriculture will need to produce at least 50% more than in 2012, with certain areas such as South Asia and Sub-Saharan Africa where a 112% increase will be required to meet caloric requirements. According to "The state of the world's land and water resources for food and agriculture – Systems at breaking point" there is an alarming trend in resource use, and the situation has much deteriorated during the last decade (3).

The best agricultural soils are lost to an uncontrolled urbanisation, and options to expand cultivated areas are limited. As a consequence of the population increase, between 2000 and 2019, despite a 4% increase in croplands, the agricultural land available per capita decreased by 22%. In Sub-Saharan Africa, water availability per capita declined by 40% over the past decade and agricultural land declined from 0.80 to 0.64 ha/capita between 2000 and 2017. (3).

"The State of World Fisheries and Aquaculture 2022" is an FAO Report that, inter alia, provides information on marine capture production by country (25> Download Report > Page 14, Table 2). We can observe that the world's total marine capture production remained constantly around 80 million tonnes per year between the 1990s up to 2020.

The number of undernourished people rose from 604 million in 2014 to 768 million in 2020 (3).

While rich countries generate waste and degrade soil and water at an alarming rate, the poorest countries with high fertility rates contribute to the depletion of natural resources (60). *According to the United Nations Population Fund, a slower population growth might give countries the time to take measures aimed at meeting the needs of the people, while protecting the environment*.

4. A growing world population

"Countries in the world by population - 2023" provides information on, e.g. the number of inhabitants by country and the yearly change (1). The document deals with, e.g. current world population, *net population growth this year*, economics, society, environment, food, water, public military expenditure, energy, and health (1> W).

According to "Population Growth", in 1800 one billion people were living in the world (2). *In 2050, the world population is projected to be about 9.7 billion people* (1> Population> Population Projections).

A document provides the population projections by country for 2050, 2075, and 2100 (12).

According to demographers, the world population, after a rapid increase is expected to peak by the end of this century. The document contains several graphs, including interactive charts on population growth (2).

According to the document retrieved in 2023, nowadays the global fertility rate is 2.3 children per woman; in the pre-modern era it was much higher but a high mortality rate at a young age maintained a low population growth. The improvements in the health systems resulted in decreased mortality and a consequent acceleration in population growth. Several interactive charts on fertility rate are available, including average age at marriage - women, and average numbers of children vs. child mortality (2> Fertility Rate). An interactive graph shows the differences in life expectancy across the world. A section is entitled: What drives improvements in life expectancy? (2> Life Expectancy).

A graph shows the decreasing number of children dying before reaching the age of five. A section is entitled: Child mortality in the past. The document also deals with its major causes (2> Child Mortality).

4.1 Unmet needs of contraception

According to a press release of the United Nations Population Fund, as many as *257 million women who want to avoid pregnancy cannot use safe and modern contraception methods* (26). Several factors are involved, they include lack of both information and contraceptive options. Sexual violence and some kinds of formal and informal social control are also involved. This latter is particularly true in the case of crisis; for instance, more than 20% of refugees will face sexual violence, which may result in unintended pregnancies.

Even the Covid-19 pandemic caused disruptions in contraceptive supplies and services.

Every year as many as *121 million pregnancies are unintended*. This *human rights neglected crisis has profound consequences for society*; over 60% of pregnancies lead to abortion, while an estimated 45% of these latter are unsafe and cause 5-13% of all maternal deaths (26).

"State of world population 2022 - Seeing the Unseen - The case for action in the neglected crisis of unintended pregnancy" is a document of the United Nations Population Fund on this subject (27).

According to "Unwanted Pregnancies: Outcomes for Children" unintended pregnancies can be mistimed or unwanted. These latter are associated with, e.g. maternal anxiety and depression, authoritarian parenting style, insufficient interaction with the child. Unwanted children are likely to face, e.g. behavioural and psychological issues in adolescence (53).

According to "World Population Prospects 2022", more than half of the global projected population increase will occur in eight countries (28). *Many countries, among the least developed, are projected to double in population between 2022 and 2050*, thus putting additional pressure on the resources. The document contains a lot of tables and graphs.

At the 1968 International Conference on Human Rights, family planning became a basic human right but, nowadays, *after such a long time is under attack*. The paper discusses the standards necessary to confirm and support the right to family planning (59).

Since the 1960s, fertility in developing countries has been considerably reduced thanks to contraceptives. *But nowadays, family planning is seriously underfunded by donors and developing countries*. Adequate and consistent access to contraception and pertinent information, inter alia, is necessary (60).

"Family planning financing" deals with the most important financial sources, such as countries, international organisations, individuals, foundations, and companies (61). As for the donors, the future is uncertain, while domestic financing may require more engagement of ministries of finance and ministries of health. In particular, serving hard-to-reach populations in low-income countries may require an integrated approach. In health, prevention is much cheaper than treatment, and contraception cost is much lower than providing care as a consequence of unintended pregnancies.

4.2 Influence of religion and other socio-cultural factors on family planning

"Religious and Cultural Influences on Contraception" outlines the teachings of the predominant religions found in Canada regarding contraceptive usage and acceptability (64). The study considered Christianity, Judaism, Islam, Hinduism, Buddhism, and Chinese religious traditions.

A study analyses the role that socio-cultural inhibitions play in the use of modern contraceptives in rural Uganda. Here, 30% of married women use contraceptives, the fertility rate is 6.2 children per woman, under-5 and maternal mortality rates are high (37). Several socio-cultural beliefs and practices promote births. These include the reliance on traditional family planning practices and fears about modern contraception. Polygamy may generate competition in having many children among co-wives. This is particularly true where bigger families are most preferred and a woman can be chased from the marital home if she does not bear as many children as the man wishes (37 / 38). In some countries, having a male heir is considered important, consequently, women without sons would insist on having births until a son is born (37 / 39 / 40).

In "Fertility and infant mortality trends in Nicaragua 1964–1993. The role of women's education" (49), figure 2 shows the fertility rates among adolescents by education level, in different periods of time. Table 2 compares the infant mortality rates among children born from mothers formally educated and not. Figure 3 shows the improvements in infant mortality.

The paper discusses the several mechanisms believed to be involved in fertility. A higher education level of girls raises the level of aspirations, self-esteem, goals, and independence (49). Educated women may get married later in life and decide to pursue a profession while having fewer children.

"Female Literacy Rate is a Better Predictor of Birth Rate and Infant Mortality Rate in India" (48) confirms the importance of women's education level as a determinant of infant health and lower population growth rate. Table 1 compares Literacy Rates, Crude Birth Rates, and Infant Mortality Rates of the states and union territories of India.

The graphs of "Female Education and Childbearing: A Closer Look at the Data" show the relationship between Female Education and Fertility in Ethiopia, Ghana, and

Kenya (50). Again, we can observe that the higher the education level of a woman, the lower the number of children she is likely to bear.

For instance, in Ghana, a woman who has not received formal education expects to have over her lifetime 6 children. Whereas in Ethiopia, a woman with a high school education can expect to have over her lifetime 1.3 children. In this latter country, the percentage of women having a child before turning 20 is 61 among those not educated, and 16 among girls with 8 years of schooling. A graph shows the male-female education gap in Sub-Saharan Africa (50).

As for age at marriage, delayed fertility, and population stabilisation, the education level of women is more important than male literacy (48 / 50).

4.3 Child marriage, adolescent mothers and associated risks

According to "Family Planning and Reproductive Health", having children too early or too late in life or too closely spaced, may imply health risks for both mother and child. Enabling people to determine whether and when to have children is important for both safe motherhood and a healthy family (29 text and video).

A World Health Organisation document deals with adolescent pregnancy, which in 2019 involved 21 million adolescents aged 15-19 years in low- and middle-income countries. As many as 50% of these pregnancies were unintended because of barriers that prevent adolescents from getting contraceptives and they often ended in unsafe abortions. *Adolescent mothers face higher risks of systemic infections, eclampsia, and puerperal endometritis. Their babies face an increased risk of low birth weight, severe neonatal conditions, and preterm birth* (30). The document discusses geographical and social contexts where this phenomenon is more common. *There is, however, a growing commitment in an increasing number of countries to prevent child marriage and adolescent pregnancy*.

A document deals with healthy timing and spacing of pregnancies. Fig. 3 compares the *perinatal mortality by age of mothers; a more favourable situation can be observed in mothers aged 20-29, as compared to adolescents* (32). Another key message of the document is that *after a live birth, it is better to wait at least 24 months before attempting a new pregnancy*. Fig. 1 shows under-5 mortality risks according to the length of the interval between birth and pregnancy. Fig. 2 shows the higher risk of having an underweight newborn after a short spacing of pregnancies.

"Towards ending child marriage: Global trends and profiles of progress" is a UNICEF document. *Child marriage, despite being widely recognised as a violation of human rights and a limitation to the development of a country, still affects 650 million girls and women in the world* (31).

"Child marriage - Frequently Asked Questions" explains several reasons, often economic, involved in this practice. *When a choice is possible, the majority of young people would prefer to marry later* (52). In countries where pregnancy outside marriage is seen as shameful, a girl may even be forced to get married to the rapist.

Child marriages take place among several communities, ethnicities, and religions, with the main driving factor being poverty. Child marriage occurs all over the world, and particularly in South Asia and Sub-Saharan Africa (52).

Limited wealth typically encourages families to marry off their daughters during childhood. Progress in the elimination of child marriage depends on poverty reduction, and improvements in education and employment. *The report analyses the situation of 9 countries that made strides in reducing the level of child marriage* (31).

4.4 Some effects of population growth rate on economy, and the demographic dividend

In Uganda, the current 46 million population is expected to reach 104 million by 2060 (45). In order to ensure shared prosperity in the long term, this country needs to improve access and quality of education, health, electricity, water, and sanitation infrastructures. For instance, given the quick population growth, 41 more general hospitals and a five-fold increase in the number of secondary school teachers would be necessary to achieve the United Nations 2030 Sustainable Development Goals. This requires expenditures 2-3 times higher.

Again, according to the World Bank document, *under a low fertility rate such costs could be substantially lower, thanks to less people demanding education, health, and access to basic infrastructures* (45 figure 3). This might allow large savings and, inter alia, better job opportunities would become available.

According to a governmental document of Mozambique (46), the quick population growth is increasing the pressure on various sectors, such as education, agriculture, health, and the economy. Between 1997 and 2011, for instance, the number of children in lower primary grades rose from 1.7 to 4.4 million. Under a high-fertility scenario, by 2040, this number is projected to reach 13.8 million, which implies a high cost.

On the contrary, a slower population growth may allow this country to invest in, e.g. universal education, better quality health services, and food security (46). *In the health sector, a decrease in fertility rate may result in US$4 billion saved by 2040; conversely, for instance, the total cost for family planning programs between 2014 and 2019 was US$32.1 million*.

Interestingly, a drop in fertility may result in an increased share of the population at working age, which provides a time-bound opportunity for faster economic growth; this is known as a demographic dividend (28 / 62).

According to "Understanding the Demographic Dividend", in the Republic of Korea, as fertility fell in the mid-1960s, elementary school enrolments declined. The funds previously allocated to elementary education, were used to improve the quality of education at higher levels. Increased income also creates the opportunity for providing better food for infants (62). The demographic dividend is a limited window of opportunity that does not last forever, and not all countries take advantage of it in the same way. The document discusses the policies needed to take advantage of the demographic dividend.

Figures 1 and 2 (62) show the population pyramids for Korea and Nigeria; we can observe that in the former most people are of working age, while in the latter there are many people too young for work.

According to "China - The Economic Miracles and Demographic Dividend in China – Abstract", in this country, the demographic dividend is estimated to have contributed more than a quarter to the economic growth (67).

4.5 Improving availability and affordability of contraceptives for low-income people

"How Social Marketing Contributed to Expanding Size of Overall Condom Markets in Ethiopia, Brazil, and Indonesia" provides information on strategies used and results obtained in the protection from both HIV and unwanted pregnancy (33).

In Ethiopia the condom market was virtually non-existent; in 1990 a program started with a highly subsidised product for a broad public. The demand creation mostly consisted in radio advertising in Amharic and local languages of the different ethnic groups. Promotional events were also organised, aimed at targeting high-risk venues. Since pharmacies were rare, condoms were sold in non-traditional markets, such as kiosks and vegetable vendors (33).

Table 1 shows the different levels of subsidy for different brands, targeted for the diverse income level. Fig. 1 shows the Ethiopian condom market in millions of male condoms between 2002 and 2020. *In this country, new HIV infections dropped sharply. A non-profit organisation sold 1.4 billion condoms and estimated that this averted, between 1990 and 2020, 16.6 million unintended pregnancies* (33).

In Brazil, during the early 1990s, *locally produced condoms were sold at a price between 60 cents and $1.00, which was considered too expensive for the average Brazilian*. In addition, their availability was mostly limited to pharmacies. Then, high-quality Asian condoms became available at 15 cents and, at the same time, the Brazilian mass media started promoting the use of condoms. In addition, some states decided to suspend the tax on this item, which increased the interest for their utilisation. This led to the growth of the Brazilian condom market, as shown in Fig. 2 (33).

According to a registered non-profit organisation, *thanks to the sale of 2.2 billion condoms, in Brazil between 1991 and 2020, an estimated 161,000 HIV infections and 3.2 million unplanned pregnancies were averted* (33).

Up to 1987, in Indonesia, condoms were not popular as they were associated with commercial or extra-marital sex. When the first HIV case appeared, condom education, availability and use became more important. A campaign included the introduction of subsidised condoms at affordable prices for lower- and middle-income couples. *A pilot project increased the availability of high-quality and affordable condoms to commercial sex workers; the program was expanded after the positive results that it exhibited* (33). Fig. 3 shows the growth of the Indonesian condom market between 1995 and 2020.

The document provides recommendations for the Social Marketing Practice that include providing an affordable product for low-income people. Sometimes high-priced

condoms have been introduced, and the revenues from these latter are used to subsidise lower-price products (33).

Figure 3 (63) shows the relationship between condom sales per capita, and percent of GNP per capita required to purchase 100 condoms. The *conclusion of the document is that the price of condoms should be low if a satisfactory prevalence of condom use is to be achieved*.

In Brazil, certain condom variants were making money while 100 condoms, considered as a year's supply, costed no more than 0.25% of the Gross Domestic Product per capita (33).

While quality family planning methods are often too expensive in Sub-Saharan countries, a link provides information about a strategy used to provide contraceptives *at an affordable price to Sub-Saharan women*. The project also included training of pharmacists on family planning methods and counseling (29> PRH Success stories> Engaging the Private Sector to Accelerate Progress on the Journey to Self-Reliance).

According to the United Nations Population Fund, despite a doubling in the number of women using modern contraception between 1990 and 2018, *contraception continues to be unavailable to many women wishing to avoid pregnancy*. The *investment needed to make accessible to all women the modern methods of family planning is approximately $68.5 billion between 2020 and 2030. This is a proven and cost-effective intervention. In fact, the reduced requirements in maternal and child health care, education, and other services, far surpass the expenditure on family planning* (35> Chapter 2: Costing for ending unmet need for family planning).

The "2023 Global Contraception Policy Atlas" provides information about sexual and reproductive health and rights on 7 main world regions. This includes country rankings, and situation by country (44).

Some health centres, family planning clinics, and schools give male and female condoms for free (54).

4.6 Integration of family planning, food security, health and environment

A registered charity, in partnership with the United Nations Population Fund, supports villagers in safeguarding the marine ecosystem on the south western coast of Madagascar. *Here, the traditional fishing practices are ineffective at feeding the growing population of this area, where a family has an estimated 6.7 children*. Before the project, the people had to walk as much as 50 km through a spiny forest in order to access contraceptive services (34).

Now, a local family planning clinic is available for the villagers. *Importantly, this project recognises the links between marine resource sustainability and population growth* (34).

According to "Population, Health, Environment and Livelihoods", family planning, food security, women empowerment, health, and environmental conservation are interconnected (65 Figure 1). According to studies, women having their own income are accorded more respect; this implies the ability to negotiate the use of contraceptives with their partners, thus reducing unintended pregnancies and having safer sex.

The document describes some activities aimed at strengthening livelihoods, and some issues successfully addressed or being addressed by integrated projects. They include family planning, better health, and land rehabilitation in areas threatened by climate change, population pressure, biodiversity loss, and land degradation (65).

A website deals with unmet needs for essential sexual and reproductive health services, by country. The document, inter alia, provides information on the benefits arising from meeting such services, in terms of reduced unintended pregnancies, safe and unsafe abortions, maternal and newborn deaths. The document provides *information on the cost* of meeting women's service needs, *and the savings* generated by the consequent reduction in unintended pregnancies (51).

"Companies reach more than 1 million with family planning information in Philippines" deals with the cooperation between companies and the United Nations Population Fund (55). A trained staff provides family planning information in the workplace. Contraceptives are also available at the company; the employees decide voluntarily to use these services, which are kept confidential.

The private sector is proving an effective partner in expanding access to voluntary family planning. *A company may suffer a significant number of employee absences consequent to unplanned pregnancies.* Workers are enabled to make informed choices while making healthier decisions for themselves and for their family, *provide benefits for the businesses* (55).

"The need for family planning" provides several graphs. Figure 1 shows the percentage of women using contraception from 1960 to the late 1990s. Figure 2 of this 2007 document shows the current contraceptive use by region. Figures 3 and 4 show contraception use, respectively according to wealth and education (57).

4.7 Contraceptive methods

A document by the World Health Organisation summarises the mechanisms of action and effectiveness of contraceptive methods. *The effectiveness is reported for both consistent and correct use of contraceptive methods, as well as for their use as commonly occurs* (41).

"Your contraception guide" provides a lot of information on contraceptives, including their side effects, who can use them, and who cannot according to, e.g. age, health conditions, and lifestyle. *Emergency contraception is also included* (42).

The effectiveness also may greatly differ according to the contraceptive method selected. Certain methods may imply incorrect use, such as missing a pill, whereas others have no user failure. The website provides answers to many questions, such as: *Which is best for me?* Or *Worries and questions* (42).

According to a document from the Centers for Disease Control and Prevention, *condoms are the only contraceptive that may reduce the risk of getting sexually transmitted diseases*; this protection is not complete for all of them, however (43). The document provides information on the correct use of condoms. This latter can be used simultaneously with another type of birth control for dual protection but, *two condoms cannot be used simultaneously*.

A document deals with the correct use of male and female condoms (54 / 58).

Spermicide is one of the least effective contraceptive methods and, if frequently used may increase HIV infection risk consequent to vaginal irritation (58).

"Family Planning - A Global Handbook for Providers" provides additional information and answers to many questions, for instance, side effects of contraceptive methods, if any (58). *The vasectomy for male sterilisation is considered simpler, safer, easier, and less expensive than female sterilisation*.

Chapter 20 (58) deals with the lactational amenorrhea method. This is a family planning method based on breastfeeding that, at the same time, provides both contraception for the mother and the best feeding for the baby. This document analyses the conditions that must be satisfied for it to work.

Inter alia, the document (58) provides tips for new users of female condoms, which is of crucial importance to the effectiveness of this contraceptive method (page 267). Chapter 24 deals with reproductive health issues, including violence. The document deals with special family planning considerations for people affected by sexually transmitted diseases, including HIV (page 338).

According to "UK Medical Eligibility Criteria for Contraceptive Use", certain contraceptive methods are associated with higher health risks for subjects with particular medical conditions or personal characteristics. The document offers guidance to providers of contraception for the safe use of contraceptive methods that consider medical conditions or treatments (56).

For example, in case of potential risk factors for thromboembolism, women can be better advised to consider a contraception method that does not further increase this threat. Whereas, in the face of a medical condition or a treatment prescribed for it, the efficacy of the contraceptive might be reduced. For instance, some anti-epileptic drugs may affect the bioavailability of steroid hormones in hormonal contraception (56).

5. A planet with declining soil resources

According to "Implications on food production of the changing water cycle in the Vietnamese Mekong Delta", this area is sinking and shrinking as a consequence of groundwater withdrawal and reduced flow of sediments (7). *Today 200 million people rely on the food supply originating from this fertile cropland but, loss of emerged land, salinization, and depletion of aquifers are making agriculture increasingly difficult.* Here, dramatic impacts on food security are already expected by 2050; in addition, this flat and fertile land may completely disappear under the sea by 2100.

Table 1 and Figure 1 of "Review: Advances in delta-subsidence research using satellite methods" provide information on the largest and most populous deltas in the world (8). *In river deltas where fluid extraction occurs, we can observe sinking rates even a hundred times faster than the global average rate*. This may imply, inter alia, *aquifer salinization, increased vulnerability to flooding, and permanent inundation* of these economically and environmentally important areas.

5.1 Land degradation and desertification

Water-scarce regions are globally degrading as a consequence of climate change combined with land mismanagement and unsustainable water use. The ability of soils to support crops, livestock, and wildlife is decreasing (11). The document provides images and discusses processes and causes involved in land degradation; this includes forest fires, overgrazing, and reduction in vegetation cover. Even ploughing may contribute to exacerbating land degradation.

A historical document deals with drought and severe dust storms suffered by the over-plowed farmland southern plains of the US in the 1930s, which forced 2.5 million people to migrate (47).

According to an IPCC Special Report on Climate Change and Land, land degradation may occur anywhere across the world; when this happens in drylands, it is considered desertification (16> FAQ).

In certain areas, as a *consequence of increased population and a limited land availability*, the fallow period has been shortened. Consequently, the natural restoration of soil fertility is no longer occurring (11> video).

According to an FAO document, *the main cause of desertification is overpopulation, which results in intense and sometimes destructive use of fragile ecosystems* (14> 3.3 Desertification - Rethinking forestry strategy in Africa: Experience drawn from USAID activities).

According to a 2015 study reviewed in this document (11), *by the end of this century the drylands now covering around 38% of the Earth's land surface are projected to expand up to 50-56%*. The document and the video that it contains deal with mitigation of this problem. The food security of people living in areas affected by land degradation is threatened and, in extreme conditions, they are forced to migrate (11).

Many of the people entering the US from Mexico are, at least in part, driven by the declining ecological conditions of a severely degraded land (19).

In the Aral Sea basin, *as many as six million hectares of agricultural land in this arid area underwent desertification* as a consequence of salinization, extensive use of agrochemicals, loss of vegetation cover, intensified winds, and dust storms (20).

Most plants cannot grow well in salty soils. Figures 102 and 103 show two common mechanisms involved in soil salinization (69> 7.1 Salinization). Winter rains may remove the salt contained in the irrigation water that accumulates in the soil, but this does not occur in low-rainfall areas, or in low-rainfall years (70).

5.2 Declining water resources

The decision to use large amounts of water from the rivers feeding this lake for growing water-intensive crops, such as cotton and rice, inter alia, resulted in lowering the level of the Aral Sea by 20 metres. The lake slowly desiccated in four decades, *which caused the complete loss of commercial fishing catches*. In the past, the Aral Sea was the fourth-largest saline lake in the world (20). The shrinkage started in the 1960s, and nowadays the Aral

Sea basin *is a heavily polluted desert, unhealthy for a population, that grew from 13.8 to 34 million* between 1950 and 1990.

In some areas, climate change may imply higher temperatures and more rainfall, which results in increased harvests, but growing periods may shorten in the areas affected by extended drought periods. In addition, extreme events such as floods, droughts, and heat domes may result in predicted, and sometimes surprising, changes that may affect all the producers. *This is particularly true where resources are limited and the population is growing* (3).

According to a document from the Intergovernmental Panel on Climate Change, while warming accelerates soil drying, more precipitation is expected to fall as rain rather than snow. This results in reduced snowpacks and consequently a decreased water availability in summer when it is most needed. *Heavy precipitation events have been seen to increase, even where total amounts have decreased* (13).

A video shows a simple experiment showing how long it takes water to soak into parched ground (10). We can observe that after a heatwave, the water infiltration rate into a dry soil is slower than in normal conditions. For this reason, after a drought, a heavy rainfall can lead to dangerous flash floods.

According to "Water and Climate Change", extreme weather events make water more scarce, or more unpredictable, or more polluted, or all three. Glaciers and snowfields, whose meltwater feeds important rivers, are shrinking. In the meanwhile, water-intensive agriculture aimed at producing meat and biofuels may further exacerbate water scarcity (5).

According to documents reviewed in "Glacier shrinkage driving global changes in downstream systems", by 2100, only 4-13% of the 2003 European Alps ice area will remain. The ice losses are also heavy in the Himalayas. Again, according to the document, more conflicts may occur in the future between neighbouring countries competing for water resources that decrease as a consequence of a lowered glacial runoff (6).

According to a document of International Organization for Migration, melting glaciers may reduce dry-season water supply for one-sixth of the global population, mostly in the Indian subcontinent, parts of China, and the Andes. In the meanwhile, *sea level change is threatening large coastal areas* (19). In the Sahel, some women have to walk as much as 25 kilometres a day to fetch water; if such distances become even longer, they may have to decide to move permanently.

This suggests that climate change is compromising the ability of many ecosystems to provide the necessary resources for human populations living there (19).

Droughts and wildfires trigger migration in many areas. Wildfires intensify soil erosion and reduce groundwater recharge as a consequence of the fire-induced soil water repellency, which contributes to a decrease in water resources and food security (5 / 15).

A document describes the environmental and economic problems that justify immediate international attention. Agriculture accounts for nearly 80% of the water use on a global scale and at least half of it is groundwater. Further declines in groundwater availability may trigger conflicts (22).

A document deals with sustainable and affordable water solutions (5).

5.3 Declining groundwater resources

"Groundwater Decline and Depletion" (36) is a US document whose content is summarised by the title.

According to "Groundwater depletion the world over poses a far greater threat to global water security than is currently acknowledged" (22), on a global scale groundwater resources are poorly managed. *As a response to drought, more groundwater is pumped than is available on a renewable basis, which implies aquifer depletion*; this is exacerbated by significant population growth in some regions.

Groundwater depletion leads to streamflow depletion. An excess of streamflow diversions limits groundwater recharge (22).

5.4 Loss of global reservoir storage capacity and shrinking lakes

The Mississippi River Delta has lost 4,800 square kilometres, largely because the sediment supply is trapped in upstream reservoirs (9). *Reservoirs trap sediment, which implies a loss of their water storage capacity and a reduced sediment supply downstream*.

According to "Sustainable sediment management in reservoirs and regulated rivers: Experiences from five continents", *the existing global reservoir storage capacity will be halved by 2100*, which threatens the sustainability of water supply (9).

Trapping of sediment can often be avoided by an appropriate dam design and/or management. The documents analyse several strategies aimed at correct sediment management, both in the reservoir and upstream, *but this approach is not as widely used as it could be* (9 / 68 text, video, animations).

According to "Shrinking Lake Chad humanitarian impacts", this lake has shrunk from 25,000 square km in 1963 to less than 1,500 in 2001 as a consequence of both climate change and population pressure (17). Again, according to the document, 30 million people living there now compete for water, while this situation may lead to migrations and conflicts.

"Satellites reveal a widespread decline in global lake water storage - Climate change, human consumption, and sedimentation led to decline" provides information on the global situation including reservoirs and natural lakes (21).

5.5 Deforestation and emerging infectious diseases

A World Health Organisation document deals with the links between tropical deforestation and emerging infectious diseases (24). In South-East Asia, forest conversion to plantations and wildfires caused habitat loss and food reduction for the fruit bats. This caused the displacement of these animals, while the stress they suffered may have altered their viral load. Their migration is linked to the bat-borne Nipah virus outbreak in Malaysia, occurring among pigs eating fruit contaminated by contact with bats.

In Malaysia, the Nipah virus disease, besides proving to be highly transmissible among pigs, caused 105 fatalities among pig industry people. Here, about *1.1 million animals were culled* between 1998 and 1999 (66).

Ebola and Marburg viruses may also cause forest-associated diseases (24).

5.6 Disasters, resilience, and migration

According to documents reviewed in "Migration and Climate Change", the disaster resilience of the diverse countries may differ (19). For instance, while a hurricane in Florida caused 65 victims, a comparable event in Bangladesh killed at least 138,000 people.

"Cuba Weathering the Storm: Lessons in Risk Reduction from Cuba" analyses the well-organised civil defence system existing in this country, poor and at the same time highly exposed to hurricane risk (18). When Hurricane Georges hit Cuba six people lost their life, while in the rest of the Caribbean, 597 people were killed. *In Cuba, disaster preparedness and prevention are part of all school curricula*.

The 2008 document of the International Organisation for Migration (19) hypothesises three different climate migrant scenarios. They are related to climate evolution, the effectiveness of adaptation strategies, and the rate of *future population growth and distribution.* Each of them may result in different levels of climate-induced migration.

Conflict of Interest Statement

The author declares no conflicts of interest.

About the Author(s)

The author is a former middle school teacher, and wrote about 70 educational papers starting 36 years ago. Areas of interest: Health Education, Environmental Education and Prevention of Natural Disasters. The author has a University Degree in Biology.

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