CHAPTER

13

Food: population rise and sustainability

OUTLINE

Fears of the adverse effects of unchecked population growth are not new. In fact, they go back millennia to at least 200 AD Rome and to a particular Quintus Septimius Florence Tertullianus (Freen, 1996). Indeed, in his paper on population growth and agriculture, Johnson (2000) quotes Quintus Septimius Florence Tertullianus as suggesting that populations had in fact (even back then) become "burdensome to the world" (Johnson, 2000, pg1). Not only this, the foresighted Tertullianus also touched on many of the complexities and causes of overpopulation which remain relevant in today's society; these include urbanization, biodiversity, deforestation, and farming marginal and unsuitable lands among others. Such concerns were raised in an era when population was a mere fraction of today's figures. Indeed, during this particular period, global population has been estimated at a mere 200 million. Furthermore, according to Johnson, the growth rate of the population at that time (revised in 2000) stipulated that from about 200 AD forth, the rate of growth—until about 1000 AD—was a steady 0.04% per annum after which rates increased to 0.12% annually until about 1700 AD—after which, for the next 100 years or so, a noticeable annual increase of around 0.41% meant that population levels had reached the world's first "one billion" around 1800 AD (Zhang, 2008). From this point, various regions grew at differing

Food and Society
https://doi.org/10.1016/B978-0-12-811808-5.00013-1

rates with the resultant world population growing to 2 billion over the next 130 years to 1930. From here, each additional one billion people were added to total global population in ever shorter cycles reaching 3 billion in 1960; 4 billion in 1975; 5 billion in 1987; 6 billion in 2000; and 7 billion in 2011, which is 130, 30, 15, 12, 13, and 11 years, respectively (Zhang, 2008). In terms of future extrapolations, Zhang (2008) further suggested that populations would increase to between 7.94 and 8.33 billion by 2030 and 9.5 billion by 2050. This is in line with the United Nations and US Census Bureau's as well as the UN estimates to 2050 (UNDP, 2006; USCB, 2008a).

13.1 Population trends

Johnson (2000), when considering the initial slow population growth before 1800 AD, hypothesized that the slow growth was in large part due to restrictions in available calories per capita of approximately between 1600 and 2000 Kcal per person. These figures were based on two sets of statistics; the first were estimated accounts of calorific availability in England and France before the rise of the industrial revolution—a period purported to be a time of underdevelopment. Secondly, Johnson factored in the figures from developing countries between the years 1934–38 (being the earliest available records); these were used to extrapolate the 1600–2000 Kcal per person mentioned above (Johnson, 2000). Johnson (2000) in his work also noted that contemporary life expectancy in early civilization remained at a continual average of 25–30 years. That was, until after about 1650 AD, at which time longevity noticeably increased, likely, in no small part, to the increased availability of greater per capita nutrition.

As population began its marked increase after about the 17th century (Fig. 13.1), concern mounted over real or imagined threats of excessive population growth and by extension pressures on both the social fabric and the sustainable resources of the day (Malthus, 1798; Chalmers, 1852). Over time two separate but related hypotheses emerged; the first was the theory espoused by Thomas Malthus's that resources of food would ultimately become the limiting factor in population growth; while tentatively similar, a second concept was that of an optimum population—a measurable and sustainable carrying capacity of the Earth. Collectively, both occupied the minds of leading thinkers of the day. In fact, the debate is so important; it has been, and continues to be, central to the Earth and its population capacity debate today. In this regard it has become one of the most prominent and dominant discourses vis-à-vis the Earth's capacity to sustain human life. So, what of current population growth estimates? The next sections take a brief look at the current situation.

So, what of population trends? Well, latest figures (as of 2015) show that the number of total human inhabitants tops out at just over 7.34 billion and is growing at about 80 million people per year. With growth at this rate, the global population is set to increase to about 7.94–8.33 billion by 2030 before trailing off at around 9.2–9.5 billion by 2050/60 (ESA, 2007; GEO, 2007; Zhang, 2008). Within these figures, the demographic makeup will more likely see the lesser developed regions accounting for the bulk of this growth, from 5.4 billion in 2007 to an estimated 7.9 billion in 2050. Compare this to the more developed areas and regions of the world, which are forecast to remain stationary or static at around 1.2 billion during the same period of growth (ESA, 2007). The population profile, more properly the

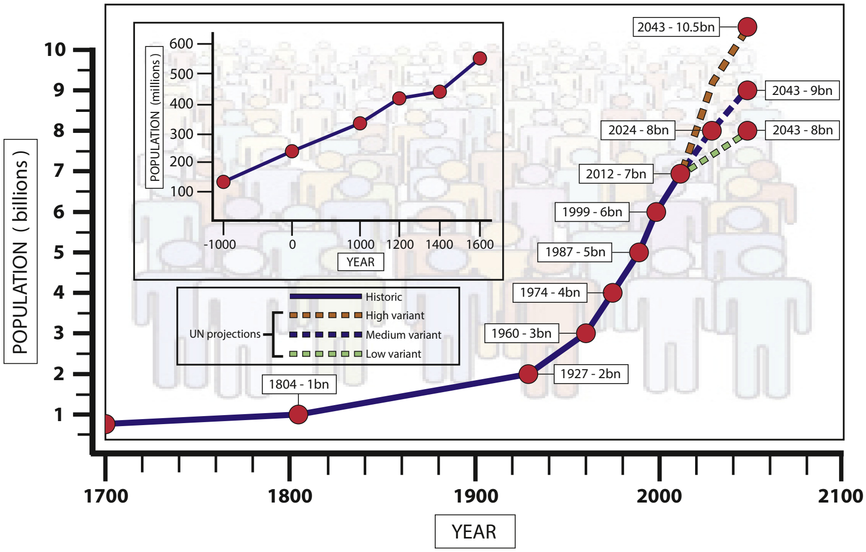

FIGURE 13.1 Population: historical and projected trends. *Source: Courtesy of Pat Newsham based on averages of past trends offered by multiple sources (UN, 1973; McEvedy and Jones, 1974; Tomlinson, 1978; Biraben, 1980; Johnson 2000; Haub, 2002; USCB, 2008a,b; Zhang 2008) and future figure based on UN medium, high and low variant projections (Johnson, 2000; UNPP, 2009).*

demographic, is also likely to be transformed. This is illustrated by the Institution of Mechanical Engineers that, based on characteristics of current and projected economic development stages, identifies three principal emerging groups of societies (IMechE, 2013). These are identified as mature or fully developed; postindustrial societies characterized by stable or declining populations whose age profile would be high; late-stage developing nations (those currently industrializing) as in the likes of China for example, characterized by decelerated population growth rates, increasing affluence, and an increasing age profile; and lastly the newly developing countries in the early stages of industrialization, as in Africa, whose population demographic is likely to be characterized by high growth rates and a predominantly young age profile (IMechE, 2013). For some, this apparent two/three track affair raises significant concerns when it comes to the food supply. Others, like the FAO, however, feel these forecasts are somewhat overstated (FAO, 2011). In the eyes of FAO, the reason is simple and they cite the adequate quantities of present-day global food production as an example of just how efficient and innovative humankind can be when called upon out of necessity. However, how such notions pan out is one of the future challenges that face both the agricultural and biotechnological industries of the present and future.

13.2 The Malthusian hypothesis

As mentioned, the most notable and indeed the most vocal of the Earth's inability to sustain unchecked population growth was the influential 18th/19th[th] century, political economist and demographer Thomas Robert Malthus. Compellingly, Thomas's work, published in 1798 called "Essay on the Principle of Population," later revised and elaborated on in 1803; he reasoned against the "perfectibility of man" (Malthus, 1798, 1803). Indeed, together the publications combined to formally outline, perhaps for the first time, one of the most quoted and well-debated theories concerning the Earth's ability to provide for ever-increasing population numbers and moreover how it ultimately comes to adversely affect society in the end (Grigg, 1982; Abramitzky and Braggion, 2009). Malthus's central tenet was the notion that population growth and the food supply would increase or grow at different rates. Populations, it was posited, grew exponentially (at ever-increasing percentage intervals), while it was suggested that food supply could only increase arithmetically or by fixed amounts periodically. This meant that in Malthus's prediction, if left unchecked, population growth would eventually outstrip the ability of the food supply to cater for the masses with predictable results, i.e., leaving many hungry and at risk of famine (Malthus, 1798, 1803). This basic notion is illustrated in Fig. 13.2, which shows how the exponential population growth curve (the "s" curve) overwhelms the ability of the food supply (the straight line) to cater for the population at the intersection "A." It is at this cross section, in Malthus' view, that the food supply departs and is unable to keep up with a growing population's food requirement.

While this formed the mainstay of Malthus's central theme, he also understood that since population appeared, for the most part to be in equilibrium at the time and was not running away vis-à-vis the food supply; so, he postulated that certain checks and balances had to be in play aiding or regulating the situation as it were. A few checks in particular, both preventative and positive were in Malthus's view seen to be acting as key gatekeepers of unsustainable population growth. The first couple of preventative checks were attributed to things like sensible population decisions such as moral restraint in the forms of marriage deferment of

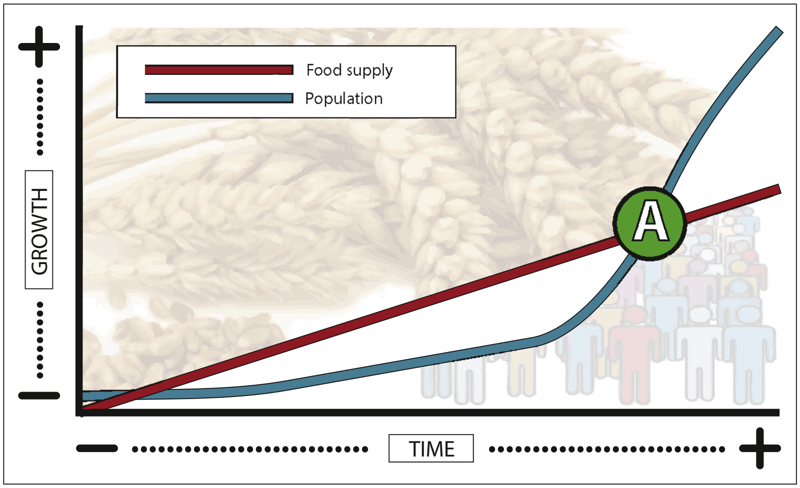

FIGURE 13.2 Predictions of comparative population and food growth rates according to Thomas Malthus. *Based on Thomas Malthus's ideas from "An Essay on the Principle of Population." (London, Printed for J. Johnson, in St. Paul's Church-Yard, 1798). Courtesy of Pat Newsham.*

having kids until such times as food and social structures were in place to feed and look after a growing "needy" population. Secondly, Malthus considered certain events - as positive checks or measures that effectively shortened life expectancy. Principally in Malthus' view these came in the form of war, famine and disease (Malthus, 1798, 1803). Cumulatively, Malthus' theory led to what became known in later times as the Malthusian Cycle or "oscillating" population numbers. Simply put, populations would increase as incomes rose, which in turn allowed for earlier marriages and more children. This growth was then halted or decreased as the food supply was not enough to keep up with demand, leading once again to lower fertility rates and/or deferred marriages (Grigg, 1982). Fundamentally, in Malthus' view, population could or would not proliferate without adequate means of nutritional sustenance and the two forces, he contested, should at all times be kept in equilibrium. Malthus was also vocal on his ideas and presented certain outcomes to his argument. Most notable was the idea that much of the fault of overpopulation lay at the feet of the "reproductive and productive" nature of the less well-off. This, he pondered, was often in excess of their ability to provide for themselves and their families (Vorzimmer, 1969; Ross, 2003). Malthus went further too, controversially regarding famine, mortality, and environmental degradation as natural occurrences of overpopulation. From this perspective, Malthus viewed this as an almost necessary means of keeping the population numbers in check (Malthus, 1798, 1803; Ross, 2003; ÓGráda, 2009).

It did not stop there either; Malthus theories were also populated with more examples of potential runaway population scenarios. In this, it was opined that population could grow out of control by growing grains and legumes to maximize agricultural efficiency; together with the free labor market; the freedom to work wherever it was available; the establishment of workhouses reducing or at least negating the need for public assistance, especially for the poor. This went hand in hand with the idea that seemed to only encourage the poor to conceive children they could not feed. Furthermore, rather than aiding an already provocative problem, Malthus was fervently against the idea of the redistribution of wealth. He did so in the belief that by increasing incomes this would only encourage the poor to have yet more children (Malthus, 1798, 1803).

Even despite this, Malthus was a man of vision and remains a controversial figure of both contemporary and of current times. In this, irrespective of one's own current view, Malthus was no doubt well ahead of his time, bringing to the fore a debate that has lasted, with no clear-cut resolution, to today's debate. Indeed, while there are many advocates of Malthus's theory, there are equally as many critics − some just as prominent. Among early detractors were Karl Marx and Friedrich Engels who were severe critics of what they saw as Malthus's bourgeois attempts to cement the status quo in terms of existing social strata by disregarding the exploitation of the wage-workers (Gimenez, 2008). On top of this Engels was particularly against the notion of the denigration of the poor and hapless, as unavoidable outcomes of universal natural laws. Engels also maintained in 1843/4, that Malthus's promoted more negative ideas concerning population growth than remedial solutions. In response to the poor, Engels cited Malthus in the area of the poor and the food supply in which the poor would:

> … multiply in excess of the available means of subsistence … [as] the root of all misery and all vice. And as a:
> … vile, infamous theory, …[a] hideous blasphemy against nature and mankind ***Engels (1844)***.

Others too were just as taken aback, cynical almost of Malthus's ability to make such charges. Patten (1912) for instance, perceived Malthus's as completely lacking of awareness of economic influences on populations choices. Equally, author of "The Dynamics of Agricultural Change: The Historical Experience" Grigg (1982), regarded Malthus's notion that increased populations were restrained by subsequent growth in food supplies; was simply wrong, as Malthus seemingly ignores agricultural production's technical advances that has thus far increased to keep pace with ever-increasing population growth. Johnson (2000) too convincingly puts forth the argument that during the mid-19th century, major population increases in the developed world had come about more so through advances in knowledge and technologies that had successfully reduced mortality rates, rather than increasing fertility (Davis, 1956; Johnson, 2000). It does not stop there, indeed, contrary to Malthus's opinion that food was a major controlling factor of unrestricted population growth Boserup (1965), Woodruff (1909) and Johnson (2000) as well as others suggested that it was in fact the other way around. That is to say, increased population numbers are pivotal in increasing or spurring growth within the agricultural industry as well as in the wider economy in general. This advancement of the agricultural industry, it was considered, was forced on mankind more through necessity than as an act of social responsibility i.e., − supply and demand.

Grigg (1982), on the other hand, had slightly different views vis-a-vis population growth and food supply. Griggs balanced view, while observing many flaws in the Malthusian theory, fell short of accepting this notion, conceding instead that growth in agricultural output was more likely a result of a multitude of factors beyond just population numbers. Nonetheless, the core precept still remains the subject of much conjecture both today and in the past. Indeed, in the words of Weisdorf (2005), he suggests population and agricultural output was in fact a:

> "… 'chicken-and-egg issue' [which] remains unresolved; did human societies domesticate plants and animals as an adaptive response to population pressure or did domestication give rise to a larger population?" ***Weisdorf (2005)*, pg566.**

While the proponents and followers publicly debated the phenomenon, one man, in particular quite possibly Malthus's most vocal critic, was writer and philosopher William Hazlit. In a series of open letters rejected not only much of Malthus's doctrine (particularly in Malthus's view of the poor) but also his fundamental contribution to science in general. In fact, Hazlit, while describing Malthus's views on population, openly offered:

> "… I have no hesitation in saying that his work is the most complete specimen of illogical, crude and contradictory reasoning … Argument threatens argument, conclusion stands opposed to conclusion …" ***Hazlit (1807)*, pg15.**

Further adding:

> "There is hardly a single statement in the whole work, in which he seems to have a distinct idea of his own meaning. The principle is neither new, nor does it prove anything new; least of all does it prove what he meant it to prove … His whole theory is a contradiction; it is a nullity in the science of political philosophy." ***Hazlit (1807)*, pg16.**

As an aside, one interesting observation regarding the Malthusian prophecy and the food supply—at least from the historical perspective—is worthy of note. The Malthusian prophecy essentially stipulated that the population growth and the potential of the food supply were on divergent trajectories. Yet the true nature of attempts over the years to feed our growing populations more likely resembles a sigmoid curve than that of a straight arithmetic line proposed by Malthus. Building on this and in answer to the charge of a limited food supply, Malthus clearly did not factor in man's ability to innovate in times of need. Of course, this does not render the debate moot far from it; as populations grow, the question still remains, just how far can humankind innovate to feed the masses.

Yet for all Malthus's verbiage, another vociferous detractor of his hypotheses, Engels did not completely discount the fact that Malthus's ideas did in fact possess some modicum of truth (Benton, 1996).

13.2.1 A lasting legacy

Despite the above continuous and often vocal opposition, Malthus also enjoyed much commendation among his peers. Indeed, with all the criticisms of the Malthus's concept, one thing cannot be denied; and that is the fact that simply by raising the profile of the debate, Malthus's work has without doubt contributed to the ongoing discourse on population pressures and the food supply. This is best summed up in the commemoration of the centenary of his death in which Bonar et al. (1935) praised the work of Malthus:

> Is he [Malthus] worthy of remembrance?.Yes … If only for the impulse he gave to the serious study of a branch of economics which before him, hardly a branch at all … [Although] I do not say it was universally well received, but it [certainly] excited universal attention. ***Bonar et al. (1935), pg222.***

Furthermore, John Maynard Keynes, economist and co-author of the commemoration, was also mindful of Malthus's indelible contribution to the ongoing debate, when he summed up Malthus's canniness for intellectualizing the population problem.

In sum, at its core, the notion of finding a balance between that of natural resources versus population growth is without doubt a pertinent and valid point in the food population versus agricultural output debate of both then and now. Yet, difficulties arise for others as Malthus attempts to qualify his point of view with seemingly inconsistent and unsupported opinion rather than empirically based evidence. Having said that, however, with all things considered, it cannot be denied that by simply elevating the debate to the level of both the public and his peers, Malthus's work undoubtedly continues to contribute to the ongoing discourse of population growth and food supply challenge. Indeed, such compelling, provocative, and emotive arguments marshaled the seed of a popular and well-researched debate whose dominant dialogue began in the late 19th and early 20th centuries and one which has contributed significantly in the preoccupations of laymen, philosophers, and policymakers alike (Prentice, 2001; Sulistyowati, 2002; Ross, 2003; Brentano, 1910; Patten, 1912; Flugel, 1915; Wolfe, 1928; Hiller, 1930; Spengler, 1949; Meade, 1961; Ehrlich, 1967; Galor and Weil, 1999; Kögel and Prskawetz, 2001; Trewavas, 2002; Lagerlöf, 2003).

13.3 Population sustainability and the carrying capacity of the Earth

Continuing in parallel to Malthus' debate is the notion of the carrying capacity of the Earth. While some might be confused by the similarities in both arguments, it is not surprising, as they have indeed very similar issues. Having said that, they are, however, tackled from opposing perspectives. Also, as with the population debate, the carrying capacity theory is equally controversial. Called the "optimum population capacity" or the "sustainable carrying capacity of Earth," the debate came to the front in the early part of the 17th century but did not really attain traction or critical mass until the early part of the 20th century where, just like the population debate, it began to be seen as a challenging issue.

First off, it must be said that the optimum capacity in terms of population that the Earth can support is not quite the same concept as the maximum number of people that can live on the Earth. Instead, optimum capacity is regulated by the notion of a sustainable "carrying capacity." This idea hinges on the concept that there is an unmistakable relationship between population numbers and Earth's natural resource base, upon which it relies for sustenance, shelter, health, and numerous other resources (Roughgarden, 1979; Daily et al., 1994). The idea proposes a fundamental limit to population numbers, which is oftentimes, but not always, related to limiting factors of natural resources—the keyword here is sustainability (Lidicker, 1962; Grigg, 1982; Van Den Bergh and Rietveld, 2004; Gilland, 2006).

As one can see from this, the concept of a sustainable carrying capacity is in principle fundamentally similar to Malthus' population and food theory. However, by contrast, the carrying capacity argument attempts to analyze the equation from the flipside of the argument—that of a limited or finite natural resource base. And, as has been mentioned, just like Malthus' theory, notions of the Earth's carrying capacity has had a long history. It has often been quoted that one of the first to tackle this idea head on was Anton van Leeuwenhoek, an eminent microbiologist, in the 17th century who, in a letter to the Royal Society of London, made the first real calculation of optimum population numbers in 1679 (Leeuwenhoek, 1686; Neill, 1926; Egerton, 1968; Van Den Bergh and Rietveld, 2004; Gilland, 2006). Leeuwenhoek's simple calculation extrapolated a global maximum population figure of 13,385 million based on the density of the Netherlands at the time (Leeuwenhoek, 1686, pg14–16). In reality, however, this calculation was more an exercise in its metaphoric inference on his groundbreaking spermatozoa studies than it was any real attempt at offering any viable contribution to the carrying capacity deliberation. However, he did whet people's appetite for the debate, and after sporadic interest throughout the 17th and 18th centuries, it was in the late 19th and early 20th centuries that the idea resurfaced with any great fervor. Indeed, by the middle of the 20th century and gaining momentum on the back of the Malthusian debate, population growth, the food supply, and the limiting natural resource debate were already becoming more pertinent to contemporary society. In fact, the awareness of the potential detrimental relationship had, by this time, crept out of the realms of theory and was fast becoming a point of policy for government and institutions alike. Unfortunately though, during this period, few institutions outside of the FAO, the USDA, and the World Bank were conducting globally representative surveys on the state of the food supply and other natural resource supplies in regard to population pressures (Ruxin, 1996; Gibson, 2012). There were several issues at play: the first required knowledge of population numbers, distribution, and trends; the second required thought to be given to the maximum potential resources that the Earth could sustainably use to support its inhabitants; while thirdly, consideration was needed in respect of the potential of the food system to cope with these emerging challenges. As mentioned, however, few surveys were carried out during this period and consequently many relied heavily on the data and statistics contained within just a few limited publications (Ruxin, 1996). The reading was grim, and by the 1950s and 1960s, numerous reports emerged claiming new global Malthusian catastrophes and that the world was ultimately on the brink of mass starvation. Hunger and malnutrition became buzzwords in the popular press, although the specter of doom was not confined to the media either. Indeed, many academic authors, it seemed, were also convinced of humanities inability to feed itself under present population trajectories. Such was the growing fear, and amid the obvious gap in research, that a task force was set up by the White House in 1967 to look into the situation. The task forces report downplayed existing fears of imminent food shortages at the time suggesting instead that the problem's

> … size and significance tend[ed] to be obscured by rhetorical overkill. ***SAC (1967)*.**

This downplaying of the situation was in part, according to Thomas Poleman, promoted by the few global reports on the subject and which incidentally were biased toward exaggeration and sensationalism (Poleman, 1972). However, the fears would not subside and during the 1970s and 1980s many more surveys were conducted, reports published, and theories postulated.

During this time, many diverse limiting factors were cited as being the pivotal component in the restraint of population growth. Ravenstein in 1891, for instance, thought that limiting factors of cultivatable land would ultimately constrict population growth, while Swedish economist Knut Wicksell opted for economic and technological resources in defining limits of optimum population figures (Felkin, 1891; Gottlieb, 1945; Uhr, 1951; Spengler, 1983; Ravenstein, 1990). Others, like Woodruff (1909), proposed that:

> "The saturation point for population closely corresponds to the mean annual rainfall … the more there is the more grass and grain …" ***Woodruff (1909)*, pg21.**

These early salvoes were the opening shots in a phenomenon that has paralleled the food-population debate during many decades of the 20th century. Indeed, building on these early proposals, a plethora of studies followed, each convincingly perceived as defining limiting factors backed by much compelling evidence. Many, like the FAO, saw agricultural land as the limiting factor; the FAO, in their calculations based on current and future potentially available agricultural land, determined that the Earth could in fact support nearly 9 billion people. Another, later study maintained that available freshwater would eventually surface as the most likely restrictive force (AEZ, 2000). However, within this debate, one study really stands out from the rest—that of Van Den Bergh and Rietveld (2004). This study is of specific interest as it metaanalyzed 69 historic studies, many also previously explored by Cohen (1995).[1] Based on metaanalysis of studies covering research from 1679 to the present,

[1]Cohen's carrying capacity study of the Earth in 1995 determined a median sustainable value of 12 billion people.

Van Den Bergh and Rietveld (2004) stripped out any wild outlying figures and determined a median value of 7.7 billion—a number incidentally which Van Den Bergh and Rietveld cautioned might itself not even be properly sustainable (Van Den Bergh and Rietveld, 2004). Their studies also showed that the two most often quoted limitations—as indicated by the research studied—were spatial extrapolation (land) and limited resources (food) which collectively accounted for 71 of the 94 collected estimates. However, while these two factors received the most attention, it was cautioned that actual limiting factors of the future might just as likely be those more stringent or inflexible resources such as water, forest, and other nonrenewable resources (Van Den Bergh and Rietveld, 2004). Yet in spite of this "reasonable" estimate and with so many other wildly varying figures (0.5 billion to 1021 billion) based on equally divergent limiting factors inter alia: food; water; natural ecological and geophysical constraints; photosynthesis; carbon cycle, etc., and with no likelihood of convergence in estimates in the foreseeable future, many feel that it is a debate that is set to continue for a long time to come (Constantino and Constantino, 1988; Murai, 1994; AEZ, 2000; Gilland, 2006; Cao et al., 2007; Ferguson, 2008; OPT, 2009).

Another important driver of the food supply chain (FSC) change is the relentless move toward globalization and urbanization.

13.3.1 Urbanization: the Rural–Urban dynamic

In later sections it will be seen that agriculture remains an important sector in terms of global employment; however, the trend is one of contraction. Coinciding with this reduced reliance on an agricultural workforce is a concomitant increase in urbanization (cities with more than 5000 inhabitants). Today, some 50% of the world populations now live in urban environments (Parfitt et al., 2010). This rural–urban shift has only recently become, over the last few centuries, a cultural phenomenon or dynamic. Indeed, urbanization between 1300 and 1800 AD, according to Johnson, remained largely unchanged at about 10%–12% in Europe (excluding Russia), India, China, and much of the developed world (Johnson, 1997, 2000). Incidentally, by 1800 AD, there was only one city in the world with a population of over 1 million inhabitants—Beijing. However, by the end of the 19th century, urbanization was drastically reshaping the world demographic with Europe's urban population then reaching approximately 37.9%. During the same period, there were over 16 cities worldwide that had increased their population figures to over 1 million (Johnson, 1997, 2000). This trend continued with urbanization increasing throughout the world—going from an approximate 67/33% rural/urban split in 1962 to the 50/50% milestone in 2008. This will undoubtedly not stop there either—as the figure is set to increase over the next two decades or so with urbanization ultimately accounting for approximately 4.72–5 billion by 2030 (about 57.8% of projected population numbers). It is also said that much, if not most of this, is set to take place in Asia and sub-Saharan Africa where urban populations are expected to double over the said period. By contrast, the rural population is expected to remain static or perhaps fall slightly, accounting for around 3.12 and 3.41 billions over the same time period (FAO, 1995; von Braun, 1995a; Cohen, 2006; UNFPA, 2007; USDA/ERS, 2008; Zhang, 2008).

It has been suggested that increasing poverty, hunger, and malnutrition were some of the principal accelerants of this migration in developing countries. Exacerbating this drive seems to be several factors. For one, rising agricultural productivity through applied technologies and greater intensification, for example, has led to concomitant decline in demand for rural agricultural labor. Furthermore, strong "pulls" of urbanization include apparent higher standards of living; better social mobility; diversity of employment and to higher wages; improved access to education; and increased opportunities as well as greater inherent choices associated with urban living. Importantly too, urban dwellers typically have improved access to things such as health care, clean water, and sanitation, which all together act as very powerful motivators of urbanization (Food Summit, 1996; Ericksen, 2008; USDA/ERS, 2008).

Urbanization, it must be cautioned, also has a double impact on the food economy; on the one hand, higher wages often mean greater food choices and dietary diversity, often leading to more meat and dairy consumption. While on the other hand, the local agricultural economy is often negatively affected in terms of rural sector employment, as well as questions regarding whether or not the rural landscape has adequate time to develop alternative strategies to cope with such, often speedy, drastic changes (von Braun, 1995b; King and Elliott, 1996; Ravallion et al., 2007). Furthermore, as a larger share of the population comes to live in urban centers, urbanization is creating the need for new or extended existing FSCs to feed this growing segment. For these new and extended FSCs to operate with efficiency, many countries, particularly developing countries, need real improvements in transportation, storage, and marketing infrastructures to keep food affordable for all, including the lower income groups (Parfitt et al., 2010).

That said, while the dynamics of the collective "push and pulls" of urbanization is a complicated matter, the perceived benefits are strongly identified as improvements all round. However, this reality ignores the fact that while, in absolute terms, rural poverty outstrips urban poverty, the urban poor population, as a group, is increasing more rapidly—in some cases by as much as 30%—than those in rural areas. Adding to the fact is that 90% of the world's urban slums are located in developing countries; there is mounting concern that issues of food, particularly food security, in such areas are set to worsen (USDA/ERS, 2008).

References

Abramitzky, R., Braggion, F., 2009. Malthusian and Neo-Malthusian Theories: Malthus' Legacy.

AEZ, 2000. Inventory of Land Resources. Retrieved 2nd June 2019, 2019, from: http://www.fao.org/ag/AGL/agll/gaez/index.htm.

Benton, T. (Ed.), 1996. The Greening of Marxism. The Guilford Press, New York.

Biraben, J.-N., 1980. An essay concerning mankind's evolution. J. Hum. Evol. 9 (8), 655–663.

Bonar, J., et al., 1935. The commemoration of Thomas Robert Malthus. Econ. J. 45 (178), 221–234.

Boserup, E., 1965. The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. G. Allen and Unwin, London.

Brentano, L., 1910. The doctrine of Malthus and the increase of population during the last decades. Econ. J. 20 (79), 371–393.

Cao, S., et al., 2007. Disharmony between society and environmental carrying capacity: a historical review, with an emphasis on China. Ambio. J. Hum. Environ. 36 (5), 409–415.

Chalmers, C., 1852. Notes, Thoughts, and Inquiries. John Churchill, Princes Street, Soho: London.

Cohen, J.E., 1995. How Many People Can the Earth Support?. W.W. Norton, New York and London.

Cohen, B., 2006. Urbanization in developing countries: current trends, future projections, and key challenges for sustainability. Technol. Soc. 28 (63).

Constantino, R., Constantino, L., 1988. Distorted Priorities, the Politics of Food. Foundation for Nationalist Studies, Quezon City, Philippines.

Daily, G.C., et al., 1994. Optimum human population size. Popul. Environ. 15, 469–475.

Davis, K., 1956. The amazing decline of mortality in underdeveloped areas. Am. Econ. Rev. 46, 305–318, 2 Papers and Proceedings of the Sixty-eighth Annual Meeting of the American Economic Association.

Egerton, F.N., 1968. Leeuwenhoek as a founder of animal demography. J. Hist. Biol. 1 (1), 1–22.

Ehrlich, P., 1967. Paying the piper: there is no longer any hope of feeding the population of the world. New Sci. 36, 652–655.

Engels, F., 1844. Umrisse Zu Einer Kritik der Nationalokonomie. In: Milligan, T.M., Struik, D.J. (Eds.), Outlines of a Critique of Political Economy, vol. 3. Collected Works, London, Lawrence and Wishart, pp. 418–443, 1975.

Ericksen, P.J., 2008. Conceptualizing food systems for global environmental change research. Glob. Environ. Chang. 18 (1), 234–245.

ESA, 2007. World Population Prospects: The 2006 Revision. UN Department of Economic and Social Affairs:Population Division, New York.

FAO, 1995. Report of the First External Programme and Management Review of the International Irrigation Management Institute (IIMI). Food and Agriculture Organisation, Rome.

FAO, 2011. Website of the Food and Agriculture Organisation of the United Nations. Retrieved 15th Feb 2019, from: http://www.fao.org/themes/en/.

Felkin, R.W., 1891. On acclimatisation. Scott. Geogr. J. 7 (12), 647–656.

Ferguson, A.R.B., 2008. Food and Population in 2050. Optimum Population Trust, p. 8.

Flugel, J.C., 1915. Ethics and the struggle for existence. Int. J. Ethics 25 (4), 518–539.

Food Summit, 1996. Rome Declaration on World Food Security World Food Summit. Food and Agriculture Organisation, Rome.

Freen, R.H., 1996. Ancient Greek philosophical concerns with population and environment. Popul. Environ. 17 (6), 447–458.

Galor, O., Weil, D.N., 1999. From Malthusian stagnation to modern growth. In: The American Economic Review, vol. 89, pp. 150–154, 2 Papers and Proceedings of the One Hundred Eleventh Annual Meeting of the American Economic Association.

GEO, 2007. Global Environment Outlook 4: Environment for Development. United Nations Environment Programme, Malta.

Gibson, M., 2012. The Feeding of Nations: Re-defining Food Security for the 21st Century. CRC Press, Boca Raton, Florida.

Gilland, B., 2006. Population, nutrition and agriculture. Popul. Environ. 28 (1), 1–16.

Gimenez, M.E., 2008. The Population Issue: Marx vs Malthus.

Gottlieb, M., 1945. The theory of optimum population for a closed economy. J. Political Econ. 53 (4), 289–316.

Grigg, D., 1982. The Dynamics of Agricultural Change: The Historical Experience. St Martin's Press, New York.

Haub, C., 2002. How many people have ever lived on earth? Popul. Ref. Bur. 30 (8), 3–4.

Hazlit, W., 1807. A reply to the essay on population. In: Malthus, R.T.R. (Ed.), A Series of Letters to Which are Added, Extracts from the Essay; with Notes Paternoster Row. Longman, Hurst, Rees and Orme, London.

Hiller, E.T., 1930. A culture theory of population trends. J. Political Econ. 38 (5), 523–550.

IMechE, 2013. Global Food Waste Not, Want Not: Feeding the 9 Billion: The Tragedy of Waste. Retrieved 30 January, 2019, from: https://www.imeche.org/policy-and-press/environment-theme.

Johnson, D.G., 1997. Agriculture and the wealth of. Nations. Am. Econ. Rev. 87 (2), 1–12.

Johnson, D.G., 2000. Population, food, and knowledge. Am. Econ. Rev. 90 (1), 1–14.

King, M., Elliott, C., 1996. Education and debate: averting a world food shortage: tighten your belts for CAIRO II. Br. Med. J. 313, 995–997.

Kögel, T., Prskawetz, A., 2001. Agricultural productivity growth and escape from the Malthusian trap. J. Econ. Growth 6 (4), 337–357.

Lagerlöf, N.-P., 2003. From Malthus to modern growth: can epidemics explain the three regimes? Int. Econ. Rev. 44 (2), 755–777.

Leeuwenhoek, A.v., 1686. Ontledingen en ontdekkingen van levende dierkens in de teel-deelen van verscheyde dieren, vogelen en visschen; van het hout met derselver menigvuldige vaaten; van hair, vlees en vis; alsmede van de groote menigte der dierkens in de excrementen. Cornelis Boutesteyn, Leydon.

Lidicker Jr., W.Z., 1962. Emigration as a possible mechanism permitting the regulation of population density below carrying capacity. Am. Nat. 96 (886), 29–33.

Malthus, T.R., 1798. An Essay on the Principle of Population. As It Affects the Future Improvement of Society with Remarks on the Speculations of Mr. Godwin, M. Condorcet, and Other Writers. Printed for J. Johnson, in St. Paul's Church-Yard, London.

Malthus, T.R., 1803. An Essay on the Principle of Population. Or, a View of its Past and Present Effects on Human Happiness; with an enquiry into our Prospects respecting the Future Removal or Mitigation of the Evils which it occasions. Printed for J. Johnson, in St. Paul's Church-Yard, London.

McEvedy, C., Jones, R., 1974. Atlas of World Population History. Facts on File, New York.

Meade, J.E., 1961. Mauritius: a case study in Malthusian economics. Econ. J. 71 (283), 521–534.

Murai, S., 1994. Global environment and population carrying capacity. In: Uitto, J.I., Ono, A. (Eds.), Population, Land Management, and Environmental Change. U.N. University, Tokyo.

Neill, R.M., 1926. Microscopy in the Service of Man. Williams & Norgate, London.

Ó Gráda, C., 2009. Famine: A Short History. Princeton, University Presses of California, Columbia and Princeton.

OPT, 2009. Earth Heading for 5 Billion Overpopulation? Optimum Population Trust.

Parfitt, J., et al., 2010. Food waste within food supply chains: quantification and potential for change to 2050. Phil. Trans. R. Soc. 365 (1554), 3065–3081.

Patten, S.N., 1912. Theories of progress. Am. Econ. Rev. 2 (3), 61–68.

Poleman, T.T., 1972. Food, Population, and Employment: Ceylon's Crisis in Global Perspective. Staff Paper. Cornell University: Department of Agricultural Economics, New York, p. 31.

Prentice, A.M., 2001. Fires of life: the struggles of an ancient metabolism in a modern world. Nutr. Bull. 26 (1), 13–27.

Ravallion, M., et al., 2007. New Evidence on the Urbanization of Global Poverty. World Bank, Washington D.C.

Ravenstein, E.G., 1990. Ravenstein on global carrying capacity: originally published in: proceedings of the royal geographical society, new monthly series, Vol. 13, 1891. Popul. Dev. Rev. 16 (1), 153–162.

Ross, E.B., 2003. Malthusianism, capitalist agriculture, and the fate of peasants in the making of the modern world food system. Rev. Radic. Political Econ. 2003 35, 437–461.

Roughgarden, J., 1979. Theory of Population Genetics and Evolutionary Ecology: An Introduction. Macmillan, New York.

Ruxin, J.N., 1996. Hunger, Science, and Politics: FAO, WHO, and Unicef Nutrition Policies, 1945 –1978, Chapter II the Backdrop of UN Nutrition Agencies, by Joshua Nalibow Ruxin. University College London. PhD, London.

SAC, 1967. The World Food Problem: A Report of the President's Science Advisory Committee, Volume lll Report of the Panel on the World Food Supply. The White House: ThePresident's Science Advisory Committee (PSAC), Washington, p. 1.

Spengler, J., 1983. Knut Wicksell, father of the optimum. Atl. Econ. J. 11 (4), 1–5.

Spengler, J.J., 1949. The world's hunger: Malthus, 1948. Proc. Acad. Political Sci. 23 (2), 53–72.

Sulistyowati, C., 2002. Can Gmo ensure food security amid the population growth. In: Institute of Development Studies and Technological Assistance. BIC News.

Tomlinson, H., 1978. 'Not an instrument of punishment': prison diet in the mid-nineteenth century. Int. J. Consum. Stud. 2 (1), 15–26.

Trewavas, A., 2002. Malthus foiled again and again. Nature 418, 668–670.

Uhr, C.G., 1951. Knut Wicksell: a centennial evaluation. Am. Econ. Rev. 41 (5), 829–860.

UN, 1973. The Determinants and Consequences of Population Trends: New Summary of Findings on Interaction of Demographic, Economic and Social Factors, Vol. I, Population Studies, No. 50. United Nations, New York, Sales No. E.71.XIII.5.

UNDP, 2006. Human Development Report 2006 – Beyond Scarcity: Power, Poverty and the Global Water Crisis. United Nations Development Programme, New York.

UNFPA, 2007. State of the World's Population: Unleashing the Potential of Urban Growth. U.N. Population Fund.

UNPP, 2009. World Population Prospects: The 2008 Revision Population Database. United Nations Population Fund.

USCB, 2008a. Historical Estimates of World Population. U.S. Census Bureau, Washington, D.C.

USCB, 2008b. Total Midyear Population for the World: 1950–2050. U.S. Census Bureau.

USDA/ERS, 2008. Food and Consumer Price Index (CPI) and Expenditures. Food Security Assessment. USDA/Economic Research Service, Washington, DC.

Van Den Bergh, J.C.J.M., Rietveld, P., 2004. Reconsidering the limits to world population: meta-analysis and meta-prediction. Bioscience 54 (3), 195–204.

von Braun, J. (Ed.), 1995a. Employment for Poverty Reduction and Food Security. International Food Policy Research Institute, Washington D.C.

von Braun, J., 1995b. A New World Food Situation: New Driving Forces and Required Actions. International Food Policy Research Institute, Washington, D.C. The International Food Policy Research Institute.

Vorzimmer, P., 1969. Darwin, Malthus, and the theory of natural selection. J. Hist. Ideas 30 (4), 527–542.

Weisdorf, J.L., 2005. From foraging to farming: explaining the neolithic revolution. J. Econ. Surv. 19 (4), 561–586.

Wolfe, A.B., 1928. The population problem since the world war: a survey of literature and research. J. Political Econ. 36 (5), 1928.

Woodruff, C.E., 1909. The Expansion of the Races. Rebman Company, New York.

Zhang, W., 2008. A forecast analysis on world population and urbanization process. Environ. Dev. Sustain. 10 (6), 717–730.