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Population or Environmental Food Crisis?

The Potential of Organic Farming to Sustain Human Livelihood

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Bachelor Thesis

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Abstract

Denna kandidatuppsats är en närmare granskning på en debatt som har pågått i århundraden. Enligt överbefolkningsteorin så står världen inför en befolkningskris som redan har långtgående effekter på vårt samhälle och vår miljö. Populationisterna som driver denna tes menar att det ekologiska jordbruket inte kan försörja nuvarande eller större framtida populationsnivåer då det ger oss mindre skördar än vad det konventionella jordbruket erbjuder. Denna avhandling visar hur populationisterna har haft fel i sina domedagsvisioner och att de har missbedömt de teknologiska framstegen som gjort det möjligt att öka vår livsmedelsproduktion snabbare än befolkningstillväxten. Tyvärr har tekniken skapat miljöproblem som nu hotar vår resursbas och möjlighet att försörja fler människor. Avhandlingen driver därför tesen att vi behöver nya alternativa jordbruksmetoder för att kunna öka vår matproduktion på ett smartare och miljövänligare sätt.

Swedish titel: *Befolkning eller Miljömatkris? Potentialen för det ekologiska jordbruket att upprätthålla mänsklig försörjning*

Key-words: Population levels, organic farming, food security, Malthus, conventional agriculture, overpopulation, sustainable development.

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1 Introduction

In 2011 the world's population passed the seven billion mark. By 2050 the human family is expected to reach nine billion individuals. Many believe that we are in the midst of a population crisis that already has far-reaching effects on our society and our environment (Ehrlich, 2009:64). Globally, almost 900 million people are chronically undernourished today, and more than 1.4 billion people are estimated to suffer from malnutrition (FAO, 2012). Despite various UN goals to halve hunger in recent years there just seems to be no end in sight (Einarsson, 2010: 10). At the same time, ecological degradation is getting worse. We can see how important and unique ecosystems are being destroyed, we can see the alarming loss of biodiversity, we can see how desertification and soil erosion is spreading, we can see the worrying signs of depletion of freshwater reserves, and we can see the devastating effects from the increasing quantities of pollution and greenhouse gas emissions that we are spewing out (WWF, 2012:6). Our food production system and our agricultural practices play a central role in both worsening and lessening the effects of environmental degradation (FAO Statistical Yearbook, 2012:281). So it seems we are facing an environmental food crisis as well (Nellemann et al, 2009).

The main argument brought forward by populationists and Malthus-inspired thinkers is that we cannot feed a growing population and that, if we haven't already, we will soon reach our carrying capacity (Miller, 2007:163). War, pestilence and famine will follow and wreak havoc around the world, they warn (Ehrlich, 2009:67). Others believe that more alternative and environmentally friendly agricultural practices can help us sustain population numbers while at the same time safeguarding our environment from further degradation (Shiva, 2012). Populationists have always been pessimistic about our possibilities to sustain current and future populations let alone to do it from organic farming, which they argue will give us smaller yields than what we get from more conventional agriculture (Paarlberg, 2010). But which side of this debate is correct?

1.1 Purpose and Question

The purpose of this bachelor thesis is to take a closer look on this relationship between increasing human population levels and the food production system that sustains human livelihoods. Is it possible for us to convert to more environmentally friendly agricultural practices that can help stop, or at least slow down, ecological degradation while at the same time being able to feed a growing number of humans? Therefore, the question is as follows:

Is it possible for organic agriculture, in the face of intensifying environmental degradation and fears of rising population numbers, to reach global food security and sustain human livelihood?

1.2 Method and Materials

In this chapter the choice of method and materials to answer the thesis question will be explained and argued for. The chapter ends with a shorter discussion on the reliability of statistical population data. A presentation of the study's theories and a smaller explanation of some of the terminology used will be further clarified in the coming chapters.

This thesis tries to assess and answer a question which has been asked for centuries. Answers are reached by connecting age-old and modern-day population theories with an empirical study on agricultural methods, population and food levels. The thesis question revolves around three main areas: Populations, agriculture and environmental sustainability. They are all interconnected pieces to the puzzle, so to say. It's therefore vital that they are connected and researched using contemporary knowledge and data on the subject so that a larger and more complete picture can emerge. The thesis therefore closely follows the main theme of hermeneutics which says that the meaning of one part, say the demographic situation, can only be understood if it is associated with the whole circle, which in this case are the environmental and agricultural structures (Alvesson & Sköldberg 2005:193).

As the initial work on this paper progressed it quickly became clear that a more holistic and global approach was needed to be able to adequately answer the thesis question. The thesis is therefore not a qualitative case study of a select few analysis units. The population and environmental crisis affect us all and cannot just be pinpointed or blamed on a single region or country. After all, we are all responsible for rising population numbers and the continued degradation of our environment.

The fact that organic farming yields varies dramatically from region to region and because cropland under organic production is still small, as will be shown later in this thesis, complicates the use of qualitative case studies. That's not to say that a similar and purely qualitative case study wouldn't be possible to achieve under these circumstances. But a more global and mixed method approach that takes these realities into account felt more preferable. The thesis question is of a generalized nature which makes the use of a quantitative method desirable as it enables more general conclusions to be made. But the thesis does not use any purely quantitative research methods to reach a conclusion. Instead the quantitative empirical data is used alongside of qualitative content analysis so that a more complete view can be reached. Having a theory testing, mixed research method and deductive approach felt like a necessary first step before a more specific case study of a single country or larger region could be more satisfactory achieved.

It could be argued that this mixed methods approach is methodologically wrong and that quantitative and qualitative research paradigms should not be mixed in one study. But this is the wrong way to look at it. It's hard to see how one can sufficiently answer a question in human ecology by just looking at the numerical, statistical and quantifiable. Of course, that doesn't mean that quantitative research is irrelevant to human ecology. On the contrary, quantitative research excels at providing a comprehensive view of many variables and phenomena. But with a purely quantitative approach one will miss those variables that cannot just be counted or measured. Especially in a social field like human ecology where the individual human play such an important role. Therefore it's necessary, in order to achieve a fuller and deeper understanding of one's research to use a variety of methods, both qualitative and quantitative (Cloke et al, 2004:249) and to refrain from seeing these different research paradigms as somehow mutually incompatible.

Like hinted earlier, the thesis has two interconnected parts, the first one is the theoretical portion of the thesis and the second is the empirical study. The first part is an introduction to prominent population theories by scholars such as Malthus and Ehrlich. Malthus' theory of population is recognized as a basic theory from which other thinkers have been inspired to evolve their own population theories from. In an effort to provide a theoretical framework these theories are then used to reach a comprehensive understanding of the population crisis and to identify key variables which are of interest for the empirical study where the population theories are tested. The empirical study uses these identified variables in longitudinal studies to evaluate and examine the severity of the population crisis as well as the possibilities and realities of organic farming to sustain current and future population levels. The empirical study also provides an introduction to conventional and alternative agricultural practices and their environmental effects in order to provide a fuller context for the reader.

Some may argue that this descriptive research approach may seem simple compared to other more explanatory research methods (Teorell & Svensson, 2007: 22). But before one can undertake explanatory research one must first have a good idea of the realities of population levels and the possibilities of organic farming to sustain growing populations on a more generalized and global level. So again, this thesis can thus be seen as the groundwork for more precise and focused case studies.

The material that is used comes primarily from official and non-official secondary sources, such as scientific reports, statistics from various governmental and non-governmental organizations, as well as reports from different media sources. This mixture of sources is used to get a better sense of *zeitgeist* and context of the intellectual, cultural and political climate during the thesis timeframe. Extra effort has been made to keep the thesis as objective as possible, this has been accomplished by remaining critical of the sources used and by making sure that no particular ideological standpoint in this debate is favored over the other. The thesis therefore largely draws it conclusions from official demographic and agricultural reports and data. Potentially highly subjective data and opinions from various interest groups, such as the English think tank Population Matters, have therefore been avoided as much as possible.

The study's materials may not have any strict geographical limitations but they do have a temporal constraint. Even though the UN offers population projections that stretches all the way to 2300 this thesis doesn't use data and materials that reaches further than to 2050 and 2100 in their estimates. This temporal constraint is needed to avoid the scientific discussion to end up in pure speculation. After all, one cannot know or predict with a hundred percent certainty what will happen in the future (Teorell & Svensson, 2007: 33). But as long as the thesis conclusions are based and related to contemporary empirical research it should be fairly safe to make qualitative guesses about near future realities.

It's worth noting that all references to Malthus and his work in *An Essay on the Principle of Population* comes from an edited version by Antony Flew, first published in 1970. This edited version is by and large exactly what Malthus he himself originally published. What differs this version from the original work is that some of the spelling and punctuation have been changed and modernized for easier reading (Flew, 1970:58).

1.2.1 Reliability of Statistical Data

The thesis uses population data from FAOSTAT, which is the statistics division of the United Nations Food and Agriculture Organization, and the US Census Bureau, which is the governmental body responsible for collecting data for the official US

census. The former uses a plethora of data to estimate and project population levels around the world. To be able to estimate global population levels the Census Bureau uses survey and census data, official administrative statistics and vital statistics – which are government records of births and deaths of individuals in the country – from individual nations as well as information and data from various multinational organizations (US Census Bureau, 2010:38). Data from official UN population estimates prepared by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat are also used. This data has a longer outlook on the future and tries to project possible future population scenarios that extend to 2100. Similar to the US Census Bureau, the data incorporates the results of national population censuses as well as more specialized surveys from around the world (Population Division, 2011:xiii).

Early demographic statistics are often incomplete and they therefore tend to be unreliable, making it hard to correctly predict future scenarios (Ehrlich, 1968:18). Modern censuses and demographic data collection were not conducted for many less developed nations until the 1960-70s. The data which the 1950 populations are estimated on vary depending on the availability of reliable data from a country to country basis (US Census Bureau, 2010:38). The reliability of demographic data gathering and analysis has been improved over time. But even though there are many rigorous demographic and statistical techniques to estimate and project population levels these methods still have limitations. The confidence interval, which basically shows the statistical probability of errors in population projections, has a tendency to widen considerably after around 40 years or two generations. There is also the possibility that future population projections can turn out incorrect due to unforeseen changes in cultural norms and behaviors (Lee, 2009:6).

Unfortunately there is a lack of detailed organic statistics for many parts of the world. Most of the organic data available originates from Europe and USA. There is a risk because of this that the results will be somewhat skewed against organic farming. The general tendency is that in developed countries, where industrial agriculture is the norm, organic agriculture will reduce yields. But this might not be the case in many other regions of the world. Where Green Revolution practices are common, often in regions around Asia, the conversion to organic farming is expected to lead to almost identical yields. In developing countries, where the external inputs are low, the general notion is that organic agriculture has the potential to increase yields (FAO FAQ). This is of course an over-simplification on the topic, but one which is worth keeping in mind throughout the thesis.

1.3 Terminology

There are various forms of agriculture, such as the raising of animal livestock, cultivation of crops, and more. This thesis will focus on land-based agriculture, more specifically crop cultivation systems in mainly alternative farming systems. The term *alternative agriculture* refers to organic farming (Badgley et al, 2006:87), which is a practice in which no synthetic fertilizers or pesticides are used (Dabbert et al, 2004:xii).

The term *populationist* is used to label Malthus-inspired scholars and activists, as well as people who believe or supports some variation of an overpopulation theory, and/or advocates for strict population control measures in an effort to avert a population crisis or catastrophe.

2 A Theoretical Framework of the Population Crisis

As mentioned earlier, this is the start of the theoretical part of the thesis. The objective of this part is to create a theoretical framework which will guide this research by determining, from the presented population theories below, which variables will be measured and explored in the thesis empirical study. This will help make it possible to not just reach an understanding of the general outline of a population theory that has been popular for centuries, but also to evaluate it to see if the theory is strengthen or weakened when tested against empirical material and data.

Three theories and their scholars, Malthus, Ehrlich and Kaplan, are introduced in the coming chapters. What these theories have in common is that they played an important role in either reviving the overpopulation debate once again, which was the case with Ehrlich, or they helped influence the political discourse at the time, which was the case with Kaplan. These theories will not be explained in full, partly due to the word limit this thesis is under, but also because it brings nothing of value to this thesis if, for example, Malthus' arguments against relief and help for the poor and hungry (Malthus, 1798: 94) is discussed thoroughly. Hence only the parts which have been deemed essential and related to the thesis question will be highlighted.

These three, and many other authors, discusses in different ways how overpopulation is a threat to humanity and how we cannot avoid a devastating demographic overshoot. Their numbers on how many people the world can support strongly varies depending on what sort of progress they believe we have made and will do when it comes to technology and science, how much we have already degraded our water and food resources, and so on. But what they all have in common is a belief that a population catastrophe will happen once the natural limits are reached (Dalby, 1996:121). Though, some authors have managed to push this idea more successfully than others.

2.1 Malthus' Theory of Population

Thomas Robert Malthus, born in 1766, was a British reverend and a scholar. Today he is still widely known for his controversial ideas about population levels and their limits (Flew, 1970:1). Malthus's population theory can be said to be the starting point of a rather passionately demography debate among academics and ordinary people alike – a debate which is still very much alive today.

Malthus anonymously published *An Essay on the Principle of Population* in 1798 where he warned about the problems with a bigger and an ever increasingly growing human population. This first essay, or edition, was more of a polemic pamphlet where Malthus tried to debunk the optimistic and utopian visions on the future by contemporary writers and thinkers who were inspired by the ongoing revolution in France (Flew, 1970:9). Malthus later on made new and more detailed editions to his population theory. In fact, Malthus added a total of four subsequent editions to his theory. The first one was added in 1806, the second only a year after, the next one in 1817, and finally in 1826 the fourth edition was added. These four editions are often called the "second essay" (Ibid, 13). A summary view on his theory was also added later in 1830 (Ibid, 15). Even though Malthus added new editions to his population theory, the greater part of his finished work still consists of material stemming from the first essay (Ibid, 9). Despite being more of a polemic essay than a scientifically supported thesis – or perhaps because of that – Malthus's first essay was widely popular among fellow academics and the general public. Malthus work was more detailed and methodological in his later editions. For the second essay he made study tours in Scandinavia, Russia, France and Switzerland – all being countries who were at that time open to British tourists (Ibid, 12).

Malthus makes two hypothesizes about the nature of the world, which he both claim to be true: "I think I may fairly make two postulata. First, That food is necessary to the existence of man. Secondly, That the passion between the sexes is necessary and will remain nearly in its present state (Quoted from Malthus, 1798:70)."

According to Malthus, we humans have, and will always have, a very strong urge to copulate. Because of this, overpopulation of the human race will swiftly become fact. The problem then lies in our capacities to produce food, or more precisely our inability to feed ourselves. Malthus claimed that our fondness of breeding is stronger than our food production capabilities and technologies to feed such a large population (Dalby, 1996:119).

"Assuming then my postulata as granted, I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence for man (Quoted from Malthus, 1798:71)."

If left unchecked the human population will increase in a geometrical ratio while our food production can only increase in an arithmetical ratio, Malthus warned. In a geometrical ratio the growth effectively doubles every time (1, 2, 4, 8, 16, 32 etc) while an arithmetical ratio goes from 1, 2, 3, 4, 5 and so on. According to Malthus, these numbers clearly shows the immensity and power of the first variable in comparison to the second and much weaker variable (Malthus, 1798:71).

If the human population grows faster than the food production, various checks, such as famine or wars, will rebalance the situation so that the human population is kept on level with the means of subsistence. (Malthus, 1798:250). Malthus divides these population checks into two main categories: preventive and positive checks. Later on Malthus makes further distinctions between these two categories and adds the checks of vice, the checks of misery and the check of moral restraint. (Flew, 1970:27).

Moral restraint, which is defined by Malthus as abstinence from marriage, belongs to the preventive category. Malthus advocated for a strict moral conduct towards sex. While not approving of abortion he saw contraception as a preventive check, one which belongs to the vice category. Both the checks of vice and misery belongs to the positive category. These are population checks that prematurely shorten the human life span either through insufficient food and/or bad clothing due to poverty, "unwholesome occupations" (i.e. jobs where there is a high probability of dying from unhealthy activities), diseases and epidemics, wars and plague. All these various positive checks can be divided into either the vice or misery subcategory. Those checks that appear to arise from the laws of nature, such as epidemics and famine, belong exclusively to the misery category. The other checks, those that we bring upon ourselves, such as wars, are more of a mixed nature. According to Malthus, these are checks which could be in our power to avoid. Therefore their cause is vice and their consequences are misery (Malthus, 1798:250). If preventive checks are insufficient to rebalance the situation, then the "necessary work" will be done by war, pestilence and famine – the positive checks on overpopulation. War could therefore be seen as an "alternative" to moral restraint (Flew, 1970:28).

Malthus didn't see any way by which we humans could escape from the laws of nature and avoid this fate. No charity or "fancied equality" among people could help or lessen this fact. Extensive agrarian regulations would be of no help against the severe challenges that would come from unhindered human population growth, not "even for a single century" (Malthus, 1798:72). Throughout the essay one can unmistakably see how little faith Malthus has to agrarian regulations, new agricultural technologies and scientific advancements which could help improve yields. Malthus discarded agrarian controls and regulations from the state and advocated private property and ownership as the only viable solution to obtain large yields (Ibid, 245). Likewise Malthus saw the invention of new agriculture

machinery as a mere convenience or luxury for the farmers, instead of a method to improve yields and an escape from the laws of nature and the checks on population (Ibid, 244). Often when the topic of the potential for new technologies arises in the essay he points out the physical limitations which man, and other animals, is subjected to (Ibid, 225).

Malthus' population theory was not just popular among the general public, it also influenced, as well as provoked, many contemporary academics and scholars. Some of the more well-known of these were Charles Darwin, Karl Marx and Friedrich Engels (Flew, 1970:49). In various works, Darwin notes how Malthus and his population ideas had inspired him in his own development of the theory of evolution (Ibid, 50). Marx and Engels responses towards Malthus theory of population were a bit more resentful. Engels describes Malthus theory as "this vile, infamous theory, this revolting blasphemy against nature and man (Ibid, 51)." Marx was not kinder in his responses to the population theory, calling Malthus "a shameless sycophant of the ruling class" (Ibid, 52).

2.2 Modern Overpopulation Theory

As we could see in the previous chapter, Malthus both provoked and influenced many academics and scholars. His theory of population might have been proven wrong, but his work did inspire to a whole host of different Malthusian theories. In this chapter some of these more modern overpopulation theories are presented.

In a cover story, titled *The Coming Anarchy*, published in February 1994 in the distinguished *Atlantic Monthly* magazine, Robert Kaplan presented his gloomy and Malthusian inspired vision of a future world stricken by the horrendous effects of overpopulation (Kaplan, 1994). According to the article, the world is headed towards violent anarchy where states and societies will collapse and be replaced by private armies and organized criminals. This "downward spiral of crime and social disintegration" was blamed on the environmental degradation of our natural systems and a demographic explosion, i.e. overpopulation. Kaplan argued that the violence and chaos that were taking place in West Africa would spread to other regions of the world. As the violence and ecological problems spread, more and more people will be forced to seek shelter in urban environments. This in turn will create even more social disintegration, ecological degradation and violent conflicts. Kaplan therefore believed that the population crisis and the degradation of our environment would become the main national-security issue for the US and other developed countries in the coming century (Dalby, 1996:119).

Kaplan's article was written during some of the worst and bloodiest moments in the history of Africa. Less than two months after the publication of his article the

Rwandan genocide took place. So it's not that surprising that Kaplan's population theory was taken seriously by the US administration and former President Bill Clinton (Dalby, 1996:120), who himself specifically cited the article in a speech to the National Academy of Sciences in June 29, 1994 (ECSP Report, 1995:51). Later on Kaplan's article "became practically *de rigueur* citation for Cabinet members appearing before Congress (Levy, 1995:35)."

In 1968 Paul Ehrlich presented, with the publication of *The Population Bomb*, his own Malthusian inspired population theory. The book has significance, mostly because it helped revive the demographic debate once again. But also because, compared to many similar efforts at the time, this contribution dwelled deeper into not just overpopulation but also into the link between growing population numbers, overconsumption and environmental destruction. Ehrlich had been making the rounds in the US media trying to lift the population issue into the medial and political spotlight again. Because of this he was approached by David Brower, founder of the American environmental organization the Sierra Club Foundation, who suggested that Ehrlich should publish his theory in time to influence the upcoming presidential election. Paul collaborated with his wife Anne Ehrlich on the book and future revisions on their theory. But because the publisher insisted on a single author, only Paul Ehrlich was credited for the book (Ehrlich, 2009:63).

Their reasoning has many similar characteristics to Malthus's thinking on overpopulation. While acknowledging our genetic urge to copulate (Ehrlich, 1968:13), Ehrlich blamed the dramatic population growth on industrialization, and more importantly improvements in medical science. Medical science, especially its effective public health programs, has improved the lives of countless of people and drastically helped to increase birth rates. The Green revolution and the ever increasing industrialization have both played important roles in increasing human population levels. But "the development of medical science was the straw that broke the camel's back" (Ehrlich, 1968:15).

While recognizing the potential the Green Revolution has for increasing food production and staving off future famines, Ehrlich also warned about the environmental downsides of the Green Revolution (Ehrlich, 1968:98). Ehrlich believed that the Green Revolution would bring both developmental and socio-economic problems as well as potentially severe environmental consequences – especially when it comes to its heavy use of water, synthetic fertilizers and pesticides. Ehrlich warned that the implementation of the Green Revolution in developing countries would result in the same environmental disruptions that is the case today in more developed countries (Ibid, 99). Kaplan notes how much of India's economy and food production relies on dramatically shrinking natural resources and declining water levels, as well as the high levels of urbanization and violence among the different ethnic and religious groups. With all this, Kaplan says, "it is difficult to imagine that the Indian state will survive the next century." Kaplan

links the declining water levels with the Green Revolution. While having successfully increased India's yields, the Green Revolution also comes with severe environmental drawbacks. Moreover, Kaplan also warns about possible future effects that climate change can have on the country's agriculture sector (Kaplan, 1994).

According to Ehrlich there are only two solutions to the population problem, the first one being the "birth rate solution" where famine, wars or pestilence increases the death rate. This "solution" is similar to the positive checks that Malthus talked about. The second solution, and the one which the authors advocated for, is population control where we humans intentionally and actively take measurements to reduce global birth rate (Ehrlich, 1968:17). There would be no environmental or food crisis to speak of if the human population was reduced to around one or half a billion individuals. Sure, we would also need to make some minor changes in our technology usage as well as improving and making the distribution of the world's resources more just and fair. But population control would still be the only real solution in avoiding the "final collapse" (Ibid, 44).

When Paul and Anne Ehrlich wrote *The Population Bomb* their views on the future were bleak. They warned that the world was on the verge of a Malthusian style catastrophe (Ehrlich, 1968:45) and that the "battle to feed humanity" had already been lost (Ibid, 18). They proclaimed that the birth rate solution with its wars, famines and diseases would most likely be the agency most responsible for reducing human population levels in the coming decades (Ibid, 45). Several decades has passed since the book was released, but they are still confident that the collapse will come – any time now – especially considering the rising levels of consumption globally (Ehrlich, 2009:64).

Fears about an imminent population crisis has popped up into the spotlight now and then since Malthus introduced his theory in the late 18th century. The most recent appearance was in 2011 when the world population reached seven billion. Before then, the population problem was intensely debated during the food price crisis of 2008-2009. The causes to the food price crisis was also debated in Sweden. Here it was Marit Paulsen, the well-known Swedish politician, who connected the rising food prices to overpopulation and claimed that organic agriculture couldn't sustain the growing numbers of people. Only large-scale agro-industries and more pesticides could maintain a sufficient food production, Paulsen claimed (Paulsen, 2009).

3 The Circle of Population, Environment and Agriculture

The previous chapters has shown that the claim that population growth happens at an exponential rate is a common theme among populationists and Malthus-inspired thinkers. It has also showed how little faith Malthus and other populationists has on technology and scientific advancements as well as government regulations to increase our food production. Modern population theory has also seen a shift in focus. While Malthus and older scholars talked mainly about population levels and its relation to our agricultural food production system, modern populationists often has an environmental aspect to their arguments. Kaplan and especially Ehrlich can be used as examples of this as they often emphasizes the environmental damage which is caused by technologies such as the Green Revolution and an increasingly growing agriculture sector. The strength of these claims will therefore be tested in the following empirical study.

The figure below shows how population, agriculture and the environment interacts and affects each other and how they, if brought together, can help provide an answer to the thesis question. For example, population levels has a direct effect on the size of our agricultural food production system which in turn affects our environment. At the same time the health of our environment affects the output from our food system which in turn puts limits on how many people we can sustain, and so on. Hopefully now there is a clearer understanding of the interconnected bond between the three areas which are under focus in this thesis and why an empirical study is needed so that the full picture of the situation can emerge.

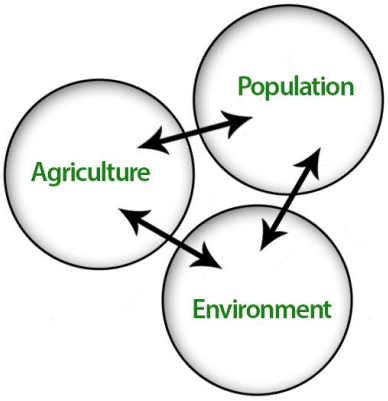

Figure 1: The interconnecting circles.
Source: Author's elaboration.

3.1 Population Levels: Today and Tomorrow

This chapter looks on how population levels have progressed historically till today and what kind of future population growth we might expect. This will help us evaluate the severity of the population problem.

In 1830, the global population had reached one billion. This is about 50 years after Malthus published his first population essay. Roughly 100 years later the global population had increased with another billion. By 1960, or about 30 years later, the human population had grown to three billion. 15 years later in 1975 the fourth billion was added. Global population numbers reached five billion people only 12 years later (Lee, 2009:6). And at the end of October 2011, the UN announced that we had reached seven billion people (UN News Centre, 2011). One can see how global population numbers have progressed since the 1950s and are projected to develop till 2050 in figure 2.

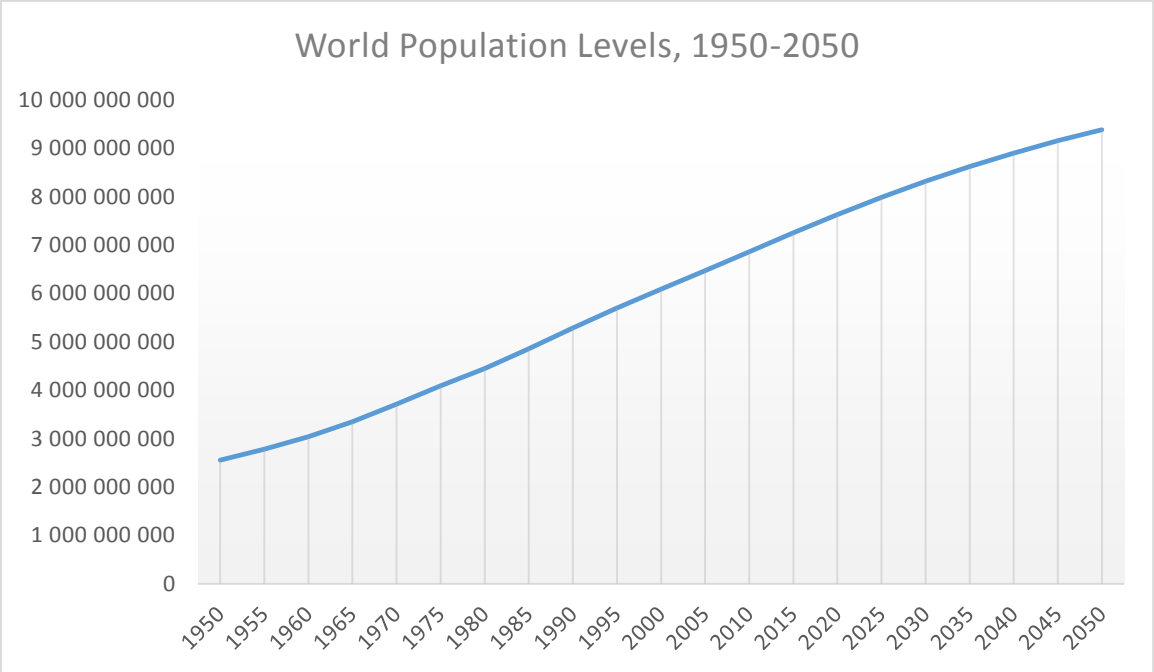

Figure 2: This graph shows the estimated and projected total midyear population levels for the world between 1950 and 2050. Source: U.S. Census Bureau, International Data Base, June 2012.

From a first quick look it might seem that global population levels are increasing. But a closer look reveals how global population growth is now starting to slightly decrease in speed. Malthus warned in his population theory that human population would increase in an exponential ratio (Malthus, 1798:71). Ehrlich also warned about the dangers of an exponentially growing population (Ehrlich, 2009:64). But

as we can see from the graph above, no exponential population growth has taken place. Instead we can see a more linear development.

Figure 3, which displays estimated and projected world population growth in percentage, shows a completely different picture than the previous graph. Here we can see a downward trend in global population growth. In fact, we can see how the world's population growth actually peaked and started to slow down around 1963 – five years before Paul and Anne Ehrlich published their population theory (Angus & Butler, 2011:66). Since around 1990 we can see a constant decrease in world population growth taking place. If this downward trend continues the population growth rate will have slowed down considerably by 2050 (Lee, 2009:2). Again, no exponential or geometrical growth is taking place. Joel Cohen, a leading expert in population sciences, even goes as far as saying that human population "probably never has and probably never will" grow exponentially (Angus & Butler, 2011:65).

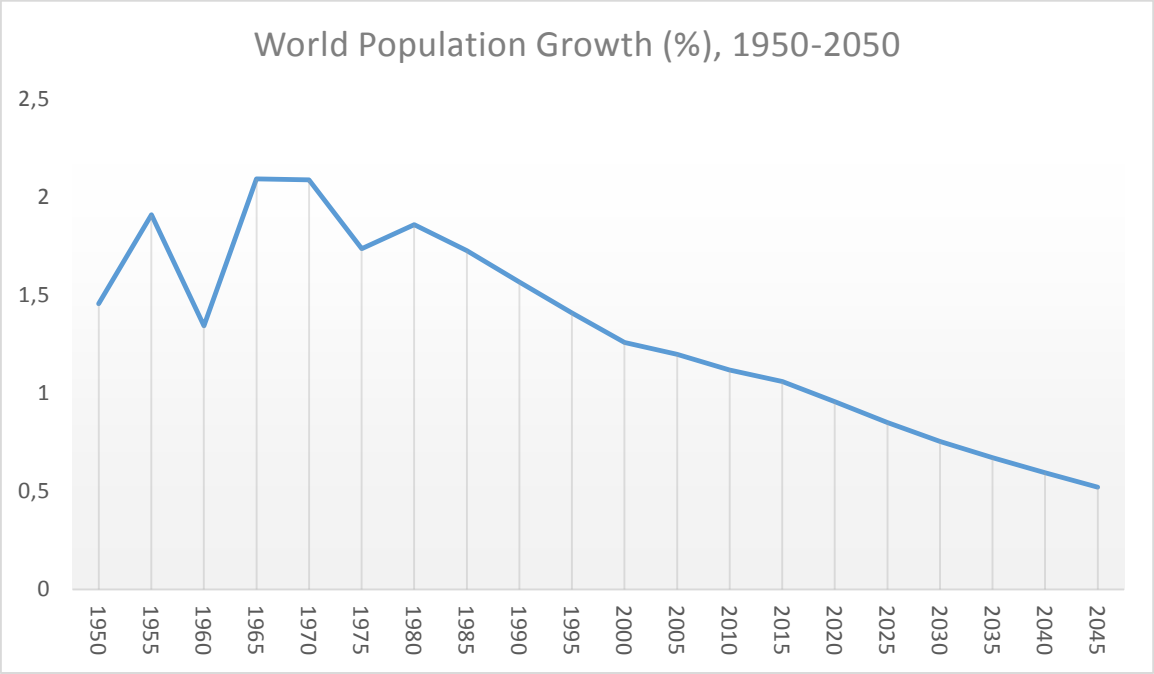

Figure 3: The world's estimated and projected population growth rate between 1950 and 2050 in percent. Source: U.S. Census Bureau, International Data Base, June 2012.

UN population data offer four different scenarios for the future depending on different projections, figure 4 shows these in more detail. One scenario, labeled constant fertility is the closest thing we get to an exponential population growth similar to what Malthus and other populationists have warned about. But this development is deemed unlikely and the UN predicts that the medium scenario is the most probable outcome. There's also a high and a low scenario connected to the medium projection, where population levels either increases more or less than anticipated (ESA, 2011:xvi).

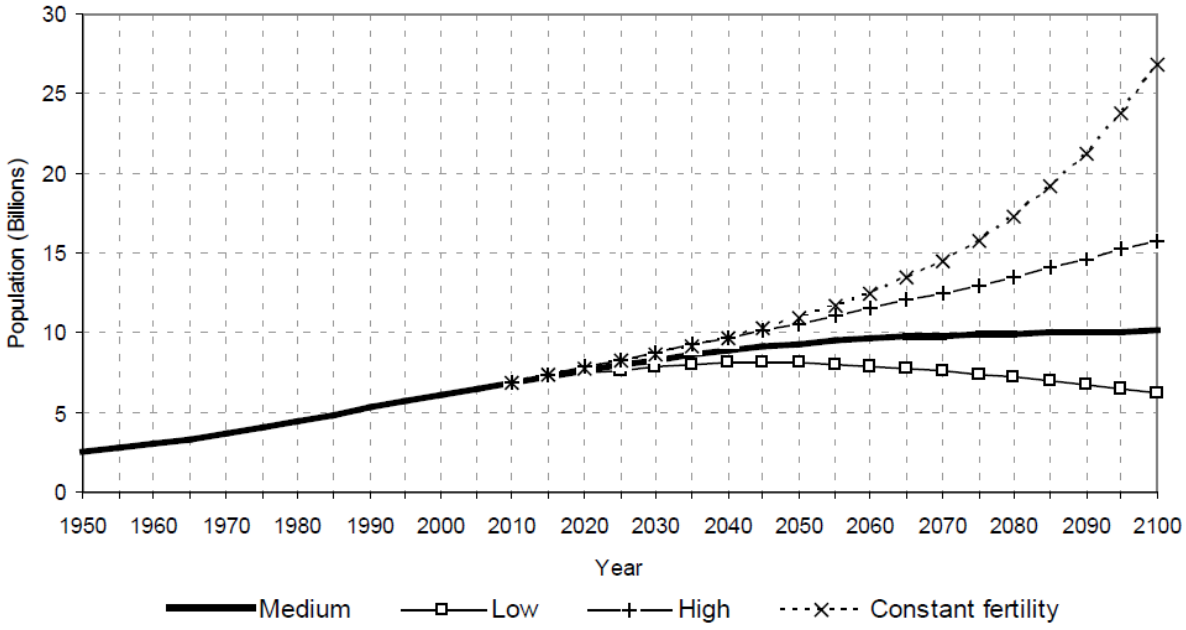

Figure 4: Future global population scenarios according to different projections and variants. Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2011). World Population Prospects: The 2010 Revision.

According to the medium scenario, global population is projected to increase with 2.3 billion to reach a total world population of 9.3 billion people by 2050. The majority of this population growth will take place in developing countries. 50 years later the global human population is projected to have reached 10.1 billion people. The majority of people, around 87 percent, will by 2100 live in the less developed regions in the world, while 27 percent of these will live in the least developed regions (ESA, 2011:1). Again, it's worth noting that these long-range population projections are extremely difficult to calculate correctly and in a reliable way. But if we are to trust the UN data, human population growth is expected to stabilize by 2100 (Angus & Butler, 2011:69) at around 10 billion people.

Another variable to look at is the total fertility rate, namely the number of living children each women will have during her lifetime. Globally, replacement levels average around 2.3. In rich countries, where child mortality levels are low, the replacement level is about 2.1. In poorer countries which lack proper medical facilities and systems the number is obviously higher (Angus & Butler, 2011:66). Population levels will increase if the total fertility rate is higher than the replacement levels and vice versa. In many often rich and developed countries today, the total fertility rate is actually below the replacement levels. But this does not mean that the country's population levels won't see any further growth. The population will continue to grow for decades even though the total fertility rate has fallen well below the replacement levels. In other words, a reduction in birth rates is a demographic momentum which won't have any short-term effects on

population levels. Many European countries today have fertility rates that are well below replacement levels. This has caused some demographers to project that by 2060 the total population in Japan could fall by nearly 50 percent and by around 25 percent in Europe (Ibid, 67).

This is why we recently could hear a lot of warnings about depopulation in the media, some even going as far as claiming that parts of Europe could become "almost deserted" in the years to come (Runner, 2008). Such cries rightfully seems alarmist but governments and institutions in developed countries are taking these warnings seriously. Just consider EU who recently issued a union-wide Blue Card, similar to the more well-known Green Card used by the US, in an effort to attract skilled workers from countries outside the union (Europa Portal, 2012). UN data shows that populations aged 60 or older is the group that is growing the fastest globally today. In the developing world this population ageing will drastically increase in the coming decades. It is projected that population aged 60 or over will increase at annual rates of more than 3 percent (ESA, 2011:xiv). Another indicative of global population ageing are the increases in median age around the world. In 2011, 22 countries had a median age higher than 40 years. Japan had the oldest median age of 45 years. Germany was a close second with a median age of 44.7 years (Ibid, 4). According to the UN, "the implications of population ageing cannot be dismissed (Ibid, xiv)."

3.2 The End of Cheap Food

In 2007, food prices increased dramatically and the world quickly ushered in a global food crisis that lasted until late 2009 (Einarsson, 2010:20). The global price increase mainly affected basic food commodities such as wheat, rice and corn, but not so much products such as coffee and cacao. The effects were felt fast and hard, especially in developing countries where much of the food was being imported and where people, who already spent half or more of their income on groceries, couldn't afford a doubling of food prices (Ibid, 21). Riots started to take place in many cities around the world by people who no longer could afford to buy enough food to themselves and their families. In the developing countries worst affected, the national governments tried to counter the food price crisis with various political and economic means. They reduced taxes on cereals and lowered the tariff on imports of food and/or introduced various food subsidizes for their citizens. Many developing countries, including China and India, also introduced export restrictions on their own agricultural and food products – sparking heavy criticism from the US and IMF (Ibid, 23).

Looking back at the events it's easy to see that it was just a bubble and that food prices, almost as quickly as they had come, went back to their previous levels again. But back then, in the middle of it, many people claimed that the crisis was a sign of things to come, and that overpopulation was the main culprit. In a discussion on Nightwaves on BBC Radio 3, Susan Blackmore, a neuroscientist, and Professor John Gray, from the London School of Economics, discussed overpopulation and its link to the then ongoing food crisis. Both agreed that the "fundamental problem" is that there are just "too many people", with Blackmore adding that she hoped, "for the planet's sake", that a global disease, such as the bird flu, would come and "reduce the population". In a TV interview, Britain's Prince Phillip said that it was the demand for food from "too many people" that had caused the food price crisis (O'Neill, 2008).

According to recent figures, around 870 million people were undernourished during 2010-2012. Those numbers equal 12.5 percent of the global population (FAO et al, 2012:8). The majority of these people live in developing countries in sub-Saharan Africa, Western Asia and Northern Africa (Ibid, 9). As can be see in figure 5, this number is a reduction since early 1990's levels when around 19 percent of the global population was undernourished (FAO Hunger Portal). So progress in food security has been made. But from the numbers one can also see that most of this progress was accomplished before the global food price crisis in 2007-2008. Since then, the reduction in undernourished people has slowed down and leveled off (FAO et al, 2012:11). Despite this, the actual increase in global hunger was less severe than previously expected (Ibid, 10). The FAO, WFP and IFAD concludes in their 2012 report on food insecurity that "it is clear" that the previous achievements in reducing hunger has "slowed considerably since 2007", and that it's doubtful that the Millennium Development Goals, as well as previously stated hunger targets and commitments in several regions around the world will be achieved in the near future (Ibid, 12). These failures in reducing undernourishment can be blamed on political instability due to wars and conflicts. But a lack of political will to prioritize hunger reductions, weak government structures and institutions such as the absence of proper transparency and food programs, both on a regional and global level, can also be blamed for the failure (Ibid, 22).

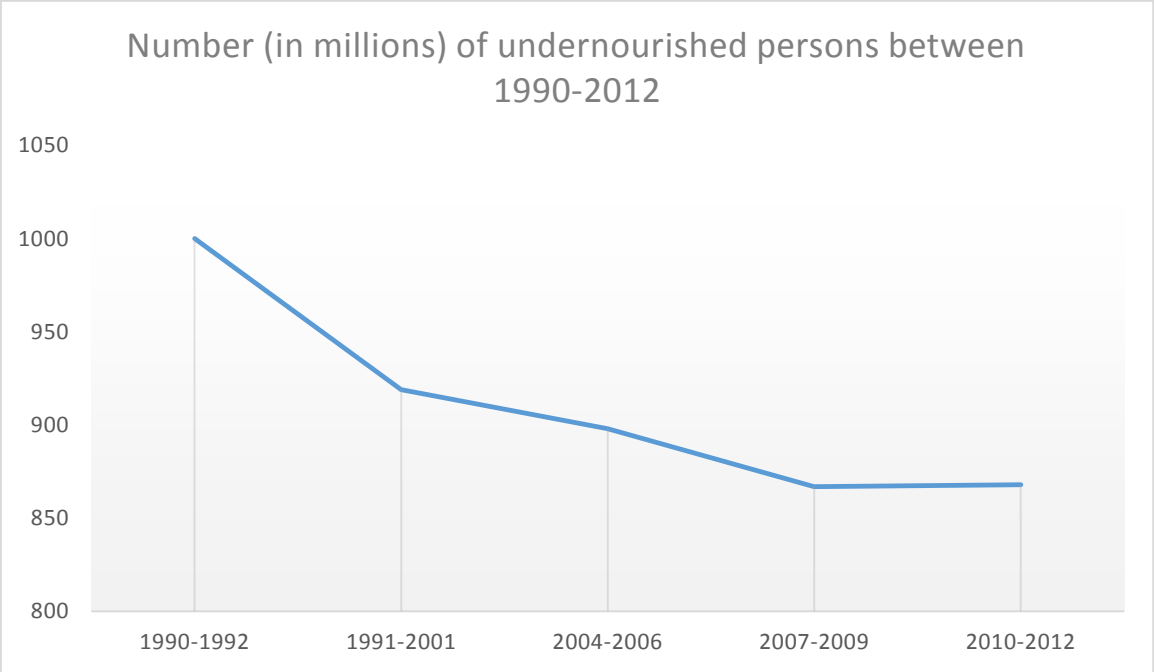

Figure 5: Number (in millions) of undernourished people between 1990 and 2012. Source: FAO Hunger Portal 2012.

The food price crisis, nor the halt in the reduction of global hunger, had nothing to do with overpopulation and inadequate food production – such as the scenario populationists are constantly warning about. In fact, both 2007-2008 were pretty normal years for farmers. Their yields varied no more than usual and the total world food production continued to grow by 1-2 percent per year – the same pace as it had done for the past decade (Einarsson, 2010:22). It's true that farmers had troublesome years during 2006-2007 in Australia due to drought, and that the EU and Ukraine produced much less wheat than estimated before 2007. But this reduction was offset by unusually good harvests in Russia, USA, Argentina and Kazakhstan. In fact, the total amount of wheat on the global market increased by around 5 percent which resulted in record yields in 2006-2007. Demands from large populous nations such as China and India had no effect on the rising food prices either as the two nations are both net exporters of cereals (Ibid, 26).

Instead, rising oil prices and growing productions of biofuels were to blame for the food price crisis. Fossil energy in the form of oil is an important component in the modern agriculture industry, so it's not surprising that changes in oil price will have effects on the price of food for consumers worldwide. In this case it was the increasing costs involved in the highly energy intense production of nitrogen fertilizers for agriculture that in turn resulted in increased food prices. The second reason was the growing production of biofuels from agricultural commodities. To put things into perspective and to show just on what massive scale global biofuel production is on let's take the US as an example: About 25 percent of the US corn

production is now used in producing ethanol - which is far more than the country's entire total corn export (Ibid, 23). Globally, biofuel production, which is based on agricultural commodities, has more than tripled 2000-2008. Today it accounts for more than two percent of the global consumption of transport fuels (FAO, 2009:31). Another example: In 2007-2008, roughly 10 percent of the total usage of coarse grains was used in the production of ethanol (Ibid, 32). Jean Ziegler, UN's independent expert on the right to food, has called the production of biofuels from food crops a "catastrophe for the hungry people" and a "crime against humanity" (Lederer, 2007). In light of the food price crisis the FAO convened a three-day meeting with experts in Rome, Italy, in June of 2009 (FAO, 2009:4). They came to the conclusion that the food price crisis was a result of increases in energy prices, and that it shows how energy and agricultural markets are becoming more intertwined with each other. In their report they warn that a further rise in biofuels production would be "a real risk" for global food security (Ibid, 31). They therefore urge that policies that promote the use of agricultural commodities for biofuels production "should be reconsidered" so that the competition between food and fuels can be mitigated (Ibid, 33).

These malnutrition numbers represents people who don't get their minimum energy intake, which FAO considers to be about 1900 calories per day/person, the exact amount of calories varies depending on region, age and gender. The human body needs a diet of enough variation between vitamins, fat, proteins and minerals. So just because one gets enough of calories doesn't mean one has a balanced and satisfactory diet. It's estimated that at least one billion people suffers from this "hidden hunger" which is characterized by various forms of nutrient shortages, which turns into deficiency diseases and often develops into chronic sickness (Einarsson, 2010:17). Here's the twist. We are currently experiencing a nutrition transition, characterized by overnutrition and obesity, which affects all societies around the world. As urbanization increases and people's incomes grow bigger, more people are gradually adopting a lifestyle which involves not just reduced physical activity but also a more energy-dense diet, which consists of semi-processed foods which are higher in saturated fats, sugars and cholesterol. Obesity has more than doubled since the 1980's and the majority of adult obesity can be found in developed countries, with the US being a prime example. As a result of this transition, the number of overweight people has reached more than 1.4 billion people worldwide. This surpasses the number of undernourished people in the world (FAO et al, 2012: 25).

3.3 The Environmental Food Crisis

We cannot ignore the basic fact that population growth, along with rising incomes and urbanization, is the main socio-economic factor for increasing global food demand (FAO, 2009:5). Even if the total demand for food is estimated to grow more slowly this century, substantial increases in the global food production is required. To be able to satisfy the projected food demand during this half of the century we need to increase global food production by 70 percent by 2050 (Ibid, 8). Preferably we need to do this without further degrading our already fragile ecosystems and natural resources.

Our planet has considerable land reserves which in theory could be converted to arable land to satisfy future demands from a growing population. But the extent to which this is possible, or even preferred, is limited. Most of these land reserves are situated in only a few countries in Latin America and sub-Saharan Africa where the lack of proper infrastructure could, at least in the short-term, limit their contribution to the global food production system. But more importantly, large parts of these land reserves have important ecological functions that will be destroyed if turned into arable land. Considering these limitations, FAO projects that the global area of arable land will be expanded by five percent, or around 70 million hectares, by 2050 (FAO, 2009:9). *The environmental food crisis* is a term that comes from UNEP and a report which the organization commissioned in 2009 in response to the food price crisis. The report concluded that food prices will increase and become more volatile from escalating environmental degradation (Nellemann et al, 2009:5).

3.3.1 Conventional Agriculture

Conventional agriculture has had both positive and negative effects for human society. Technological innovations since the 19th century have managed to completely transform rural landscapes, populations and agriculture productions in the developed world. The key element of this transformation was the change from "on-farm" to "off-farm" resources. Thanks to new technological advances it became more economically profitable to replace human labour with machinery. Equally profitable became it to enhance the farm's soil fertility by just buying chemical fertilizers. The use of pesticide allowed farmers to protect their crops from pests while making large-scale agricultural systems more easily managed. These technological advancements have increased the productivity of the agriculture sector which in turn has led to food becoming more abundant and cheaper for

consumers. The labour force which was replaced by machinery could also be employed in other production areas, and thus the total wealth of society increased (Dabbert et al, 2004:1). But this development has had socio-economic and environmental effects. The population decline in rural areas has led to major structural changes in which formerly agricultural regions now have unemployment levels above average and difficult social conditions (Ibid, 2). The technological transformations, in which agricultural systems have been detached from their natural roots, are especially evident in factory farms where livestock are involved. Just consider the housing of hens in battery cages and how little, if anything, it resembles the natural environment (Ibid, 1). As conventional farms are looking more like factories with industrial-like production systems, concerns for animal welfare and environmental health is becoming more and more significant in developed and affluent societies (Ibid, 2).

There is no denying that the negative effects of conventional agriculture are far reaching. Reports show that 15 out of 25 ecosystem services, such as water supply or various forms of food production like seafood, are already degraded or used beyond sustainable levels. Actions taken to further intensify the use of the natural resource base and these other ecosystem services will often cause the degradation of other areas and services. The intensification of our food production system has caused loss of tropical forest and biodiversity, soil nutrient depletion, erosion, desertification, and depletion of freshwater reserves (FAO, 2009:8). Considering that irrigated agriculture is an extremely productive food system, it covers only one fifth of arable land but contributes nearly 50 percent of global crop production, it's worrying that fresh water reserves are being depleted at an alarming rate (Ibid, 9). All in all, conventional agriculture is said to be responsible for 75 percent erosion in biodiversity, land degradation and water destruction (Shiva, 2012). Long-term projections do suggest that the world's natural resource base should be adequate to meet future demands, but only if the degradation of our ecosystem services are stopped, or at least significantly slowed down (FAO, 2009:9).

The conventional food system is also responsible for massive greenhouse gas emissions. In the US alone, the conventional food system is with its 19 percent just behind cars when it comes to total usage of fossil fuels. Globally, our food production system is responsible for around 37 percent of total greenhouse gas emissions in our atmosphere. In the 1940s our food production system produced 2.3 calories of food energy for every calorie of energy we invested. Today it takes 10 calories of energy to produce a single calorie of food. This transformation is not hard to imagine considering how much fossil fuels are required in every process of the industrial food production system. Conventional agriculture requires chemical fertilizers and pesticides which are made with the help from natural gas and petroleum, it also requires heavy farm machinery and the whole procedure involves

energy intense food processing and packaging, as well as fossil fuel-powered transportation systems to reach consumers worldwide (Pollan, 2008:1).

3.3.1.1 The Green Revolution

Despite its name, the Green Revolution should not be mistaken for an alternative or organic agriculture practice. It's quite the opposite. The Green Revolution can be seen as a neo-agricultural version of conventional farming practices of the 1960-1970s where the main aim is large-scale environmental modification (Ehrlich, 1968:29). The Green Revolution involves the development, practice and distribution of high-yielding varieties of cereal grains, chemical fertilizers, pesticides, genetically modified grains, and large-scale irrigation infrastructure – all being practices that requires a heavy and constant input of fossil fuels. Norman Borlaug, whom was considered to be the father of the Green Revolution, continuously advocated for the use of pesticides and chemical fertilizers as a solution to growing populations and environmental degradation. Borlaug rejected claims that organic agriculture would be better for the environment as "ridiculous". Because organic farming resulted in lower yields Borlaug predicted that more land and forests would be required to be cultivated if we wanted to be able to maintain the same yield levels for organic farming as the ones achieved from more conventional methods. If we intensify our farming practices we can leave more land for the rainforest, Borlaug's thinking went. There's truth to this. Thanks to the "seed and fertilizer" practices of the Green Revolution, global cereal production tripled between 1950-2000 while land use only increased by 10 percent during the same period (Leonard, 2006).

UNEP's assessment for the future development of our food production system states that any future system will be dependent on and "must contribute positively" towards the realization of "healthy ecosystems and resilient communities" (Nellemann et al, 2009:31). Clearly, the Green Revolution and conventional agriculture has no place in such a food system.

3.3.2 Alternative Agriculture

Organic farming is an agriculture system that has a more holistic approach in which it uses methods that are designed to be less damaging to ecosystem services and the natural resource base. Organic farming does this by emphasizing the overall health of the agro-ecosystem by promoting and enhancing local biodiversity and

biological activity in the soil (Dabbert et al, 2004:3), recycling its own waste from crops and livestock so that it can return valuable nutrients to the land, improving and maintaining soil-fertility, minimizing all forms of agriculture-related pollution and its impact on the environment, among other things. Instead of synthetic materials and off-farm inputs organic farmers are keener on using on-farm resources and management practices which involve cultural, biological and mechanical methods (Ibit, 4). This does not mean that organic farming is hostile towards technology. Organic farmers have no problems with utilizing modern technology selectively while avoiding those practices or technological elements which are risky and possibly harmful for the environment (Ibit, 2). While conventional agriculture is free to use various practices, organic farming is subject to both national and international regulations which limit them in their options and practices. These certification standards and regulations may differ depending on country and region, but they all restrict the use of pesticides, fertilizers and certain forms of genetically modified crops organisms (Letourneau & Bothwell, 2008:430).

As the demand for healthy food and environmental concerns are becoming more important for consumers around the world, alternative approaches to agriculture have become less alternative and more mainstream. Organic farming enterprises are emerging from the now profitable business and its products are no longer restricted to niche health food stores or farmers' markets (Letourneau & Bothwell, 2008:430). Despite this recent progress for alternative agriculture practices, the skepticism against organic farming is still strong. Ehrlich predicted that the use of pesticide and conventional practices would intensify, and that the ecological aspect of agriculture would be "ignored more and more" as population numbers increased and produce became scarcer (Ehrlich, 1968:29). Critics argue that organic agriculture isn't more environmentally friendly as it requires more land to be converted to farmland to be able to reach similar yields levels as conventional farming. Critics also argue that vegetables that have been organically grown in greenhouses around Europe are much less sustainable than their conventional counterparts from Africa. Many people are also skeptical to claims that organic food is healthier or that it would contain more nutrients. Most of the criticism against organic farming revolves around the smaller yields the alternative system produces compared to the more conventional methods (Johnston, 2008).

3.3.2.1 The Possibilities of Organic Farming

The UNEP report mentioned earlier forecasts that food will rise in demand as human population grows by about two billion more individuals, incomes increases and the growing consumption for meat continues unhindered. The report warns that

although global food production "rose substantially in the past century", mainly thanks to agricultural expansion as well as fertilizers and irrigation, yields have in the last decade nearly stabilized for cereals. According to their estimates it's "uncertain" that further yield increases can be achieved. If they are possible to achieve, they will most likely be too small and thus unable to keep pace with the growing food demand. UNEP blames the leveling of yield increases partly on a lack of investments in agricultural research and development. But more so they warn about the negative effects on future crop yield levels that urban expansions, soil and environmental degradation, increased biofuel production, and anthropogenic climate change will have (Nellemann et al, 2009:6). The combined effects of all these has the potential to reduce projected yields by 5-25 percent by 2050. This would cause food shortages, with food production being up to 25 percent short of demand, and prices that are 30-50 percent higher than today. This scenario could be averted if we manage, while increasing yields, to optimize our food chain system. This is possible to accomplish by minimizing the loss of food energy from each step of the food production chain - from harvest and process to consumption and recycling. But more importantly, we need a "major shift" towards "more eco-based production" (read: organic farming) that can help reverse soil degradation, conserve biodiversity and protect ecosystem services (Ibid, 6).

One study, which examines the relative yield performance between conventional and organic agriculture systems from 66 previous yield studies, shows that organic yields are on average 25 percent smaller than conventional ones. The results in the analysis ranged from 5 percent to 34 percent smaller yields, depending on contextual conditions, for organic farming (Seufert et al, 2012:229). This would indicate that organic agriculture requires additional land to be converted into farmland for it to reach similar yield levels as conventional agriculture.

A 13 year side-by-side comparison of organic and conventional corn-soybean systems, at the Iowa State University in the US, shows that organic farms can provide similar yields as conventional agriculture, while at the same time resulting in higher economic returns for the organic farmer (Masterson, 2011). Another similar study is the 30 year side-by-side trial of organic and conventional corn and soybean yields by the Rodale Institute. The Farming Systems Trial (FST) started in 1981 to study the transition from conventional to organic farming procedures as well as compare yield levels between the two agriculture methods. During the first few years of the transition there was a decline in yields for the organic crops. Later on the organic yield levels saw a rebound and today the yield levels match, or in some cases even surpasses the conventional crop yields. Especially interesting are the findings that organic yields will outperform conventional crop yields during years of drought (Rodale Institute FST). Studies done on data from the FST confirm this to be the case. A review of the FST by David Pimentel and others from the Cornell University shows that organic agriculture produces the same corn and

soybean yields as more conventional farms. During the drought years of 1988-1998, the organic crop yields were 22 percent higher than conventional yields in the trial (Lang, 2005). Organic farmers in the US say that they have fared better against the recent drought this past summer which severely damaged crops, reduced crop yields and drove up food prices (Hendren, 2012).

A 21 year study of organic and conventional farming systems in Switzerland may show what kind of performance we could expect to see from organic agriculture in Central Europe. The result from the study indicates that organic farming systems in Europe would see cereal crop yields that are on an average 20 percent lower than their conventional counterparts. But at the same time the nutrient input for the organic systems were 34-51 percent lower than in the conventional systems. That results in crops that require 20-56 percent less energy during their life-span, or 36-53 percent lower energy intakes per acre of farmland for organic crops. Therefore, the authors of the study still consider organic agriculture to be an "efficient production" method. The study could only find minor quality differences between the food systems. The organically managed soils showed a greater biological activity (Mäder et al, 2002:1695) and a better floral and faunal diversity than the conventional managed soils. Their conclusion is that organic farming is "a realistic alternative" to conventional agriculture (Ibid, 1697). Profits for the organic farm remained similar to its conventional equivalent (Ibid, 1695). This would indicate that organic farmers could see financial gains from converting to organic agriculture as they need to spend less money on expensive off-farm inputs.

Another study, which compiled data on the current global food supply as well as comparative yields between organic and conventional farming methods (Badgley et al, 2006:87), also suggest that its possible for organic agriculture to feed both current and future human populations (Ibid, 94). The purpose of the study was to try and estimate how much food could be produced after a hypothetical global shift to organic farming. From a plethora of various other studies comparing crop yields between organic and conventional farms, the authors of the study calculated a dataset of 293 examples of global yield ratios for all the major crops in both the developed and developing world (Ibid, 86). The results showed that organic farming would give smaller yields in the developed world while the organic yields in the developing world would be larger than their current conventional yields. Two different models were then constructed. The first model applied the yield ratio for developed countries to the entire world, the model assumed that regardless of location all farms would only get the lower developed-country yield levels. For the second model the authors applied the lower organic yield ratios from the developed world to developed countries, the higher organic yield ratios which were measured earlier for the developing world was then applied to those respective countries (Ibid, 88). The results from the first conservative model indicated that organic farming would generate 2641 kilocalories per person/day. This is a good result, especially

considering that the current food supply provides 2786 kilocalories per person/day and that the average caloric requirement for adults is between 2200-2500 kilocalories. The result from the second model was even more promising. It showed that organic farming on a global scale could generate 4381 kilocalories per person/day. This would result in a 75 percent increase in food availability for the world's current population. The results from model two would also result in a food production that could sustain a much larger human population (Ibid, 92). This increase in food quantity would be possible to achieve while maintaining the current agricultural land base. Organic farming methods could even have the potential to reduce total agricultural land base. If properly intensified, organic agriculture "could produce much of the world's food" and improve food security in developing countries. But for this transition, from conventional to alternative, to be possible we need to overcome numerous agronomically and economically challenges. The authors of the study calls for increased investments in agricultural R&D. Considering that for the past 50 years most agricultural research has been focused on conventional methods there is huge potential for comparable improvements in yield increasing procedures and pest management methods for organic farming (Ibid, 94). This is especially the case in developing countries which only spend US$0.55 for every US$100 of agricultural output on public agricultural research and development. This can be compared to US$2.16 for developed countries (Nellemann et al, 2009:81).

Small farms are being highlighted in many of these studies as an important way to reach global food security. Both in developed and developing countries the production per unit area is greater on smaller farms. Therefore an increase in small farms would have positive effects for global food availability (Badgley et al, 2006:94). In fact, and despite the large modern industrial-like farms of today, around 70 percent of the world's food comes from small farms (Shiva, 2012). The widely held belief that the large monocultural farms are the most efficient and productive is a myth; it's actually the smaller farms, many of whom are located in developing countries that are the most efficient in their production. Small farmers manage to maximize the use of their land by using integrated farming systems which involve using a wide variety of crops as well as livestock on the farm. This combination helps provide a range of food and animal products to the local economy as well as supplying the farmer with manure for improving soil fertility. Larger farms might have higher yields per acre of a single crop, but overall the total production per acre of all crops and animal products combined is much higher on smaller farms. This way small farms helps to strengthen the local economy and environment while also improving food security worldwide (Vasilikiotis, 2000).

3.3.2.2 The Realities of Organic Agriculture Today

Despite these promising possibilities for organic farming the reality is that organic farming still plays a very insignificant role in our global food production system.

Total global arable land, which include both crop cultivation and pastures for livestock, is around 13 805 000 km² (FAOSTAT, 2010). Of this only 0.9 percent, or around 370 000 km², are organic. In 2010 only seven countries had more than a total of ten percent organic agricultural land (Willer, 2012:4). In the beginning of the 21st century, some 17 million hectares of land (nearly 170 000 km²) were dedicated to organic farming globally. In North America around 1.3 million hectares of farmland were farmed organically. The majority, around 45 percent, were located in Oceania, mainly Australia. Europe had 25 percent and Latin America shortly followed with 22 percent. The highest share could be found in the EU with more than three percent of total agricultural land area dedicated to organic farming (Dabbert et al, 2004:8).

When it comes to organic farming policy, the "EU leads the world." Various policies and political mandates in support of organic development have been in place in the EU since late 1980. In 1991, ten years before the equivalent US legislation came (Dabbert et al, 2004:2); the EU introduced consistent labeling of agricultural products and food across all member states (European Commission [1]). In the past two decades the amount of EU land dedicated to organic agriculture has seen a dramatic increase (Letourneau & Bothwell, 2008:430). Organic farmland increased five-fold just during 1993-2000 (Dabbert et al, 2004:2). This development is expected to continue thanks to continued growth in consumer demand for organic products and various government incentives and mandates (Letourneau & Bothwell, 2008:430). Total organic land area, i.e. fully converted land area as well as land area under conversion from conventional to organic farmland, in EU27 increased from 3.6 to 4.1 percent 2005-2007 (Rohner-Thielen, 2010:5). In 2008, organic farmland covered a total of 7.8 million hectares (European Commission [2]). The total organic area continues to show an upward growth trend in the union. During 2006-2007 the increase was 5.9 percent. 2007-2008 organic farmland increased with 7.4 percent (Rohner-Thielen, 2010:2). The five member states with the largest organic area for EU27 is Spain (1.3 m/ha), Italy (1.0 m/ha), Germany (0.9 m/ha), UK (0.7 m/ha) and France (0.6 m/ha) (European Commission [2]). Figure 6 shows how the size of organic farmland varies greatly from one member state to another with some states making more progress than others. The graph shows how Sweden's farmland has increased from 5.9 percent to 14.3 percent during 2000-2010. Other countries haven't seen a similar development during this period. The UK increased their share with less than one percent, going from 3.3 to only 4.1 percent (Rohner-Thielen, 2010:2).

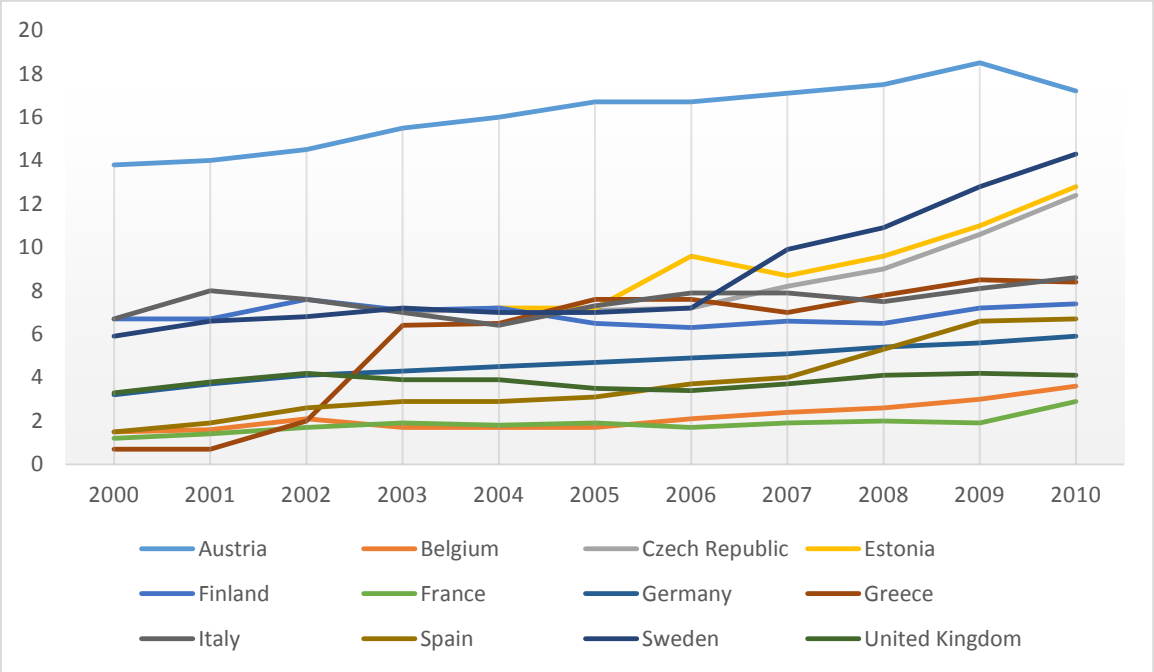

Figure 6: 12 EU member states and the share of total organic crop area out of total utilized agricultural area (%) in their respective nations. Data from the Czech Republic and Estonia are not available until after 2002 and 2003 respectively. Source: EUROSTAT.

3.4 Food Levels: Today and Tomorrow

Despite the predictions from populationists, the global agricultural production has grown and even exceeded the population growth rate (FAO Statistical Yearbook, 2012:174). Global crop production has had an average annual growth rate of one percent for the past 20 years (Ibid, 178). This can be exemplified in the slow, although steady, increase in average food per capita availability, which has increased from around 2220 kilocalories per person/day to about 2790 kilocalories between early 1960 and 2006. The largest increase can be seen in developing countries where food availability has jumped from 1850 kilocalories per person/day to over 2640 kilocalories. In 2010, the global food system produced more than 13 quadrillion calories; on a per capita daily basis this equals 5359 kilocalories (Ibid, 174).

Globally, food production has increased by 18 percent over the past two decades (Ibid, 176) and for the past 50 years crop production growth has seen a threefold increase (Ibid, 178). Interestingly, arable land has declined, at an accelerating rate, with about 40 million hectares since the 1980s in developed countries. At the same time arable land has increased with around 107 million hectares in developing

countries. This has resulted in a global increase of 67 million hectares of arable land. Therefore, the increased growth in crop production in the developed world can be attributed to yield improvements and more intensive farming methods. Only a smaller part of the increase can be attributed to an expansion in arable land (Ibid, 178). FAO believe that the potential to increase crop yields further is substantial and that a future peak yield seems unlikely (Ibid, 176). FAO's future predictions are hence more positive than the estimates from UNEP earlier. According to FAO there remain significant opportunities to increase food production in developing countries. Especially in Africa which is far behind other regions in its food production capacity (Ibid, 174). But they also stress the importance of "considerable" public intervention and investment to be able to reach the required yield increases. The majority of these investments are needed in agricultural research, but more are also required to mitigate environmental damage and prevent further environmental degradation (Ibid, 176).

With all this talk about yield levels and ratios it's easy to forget that yields aren't everything when it comes to increasing global food availability. There are other ways that can help improve global food security.

Because overall population growth is slowing down FAO predicts that total global food demand will decrease (FAO Statistical Yearbook, 2012: 174). Unfortunately, deep-rooted poverty plays a large part in this slowdown in global food demand (Ibid, 182). However, FAO expect that the demands from the bio-based economy, such as the production of biofuels, will continue to increase. This development is a double-edged sword. The further expansion of the bio-economy will offer "considerable growth potential" for the agricultural sector and supply farmers with new income possibilities. But it will also create rising food prices and put pressure on an already strained environment and natural resource base (Ibid, 174). The topic of biofuels has been covered in previous chapters, so it won't be delved into further here. But another large part of our total cereal production is being diverted away from our plates. While only having around 18 percent of the world's population, OECD countries in the rich world consumes 37 percent of the total global production of cereal (Einarsson, 2010:41). The reason for this large share is mainly due to the high levels of meat consumption in these countries (Ibid, 51). More than half of the total amounts of cereals consumed are being used to feed our livestock and animals in the meat industry (Ibid, 41). So by reducing our consumption of meat and biofuels we could increase the availability of food worldwide. But the production of biofuel is estimated to expand and the demand for meat shows no slowing down. Current models show that by 2050 an additional 550 million tonnes of cereals are needed to just feed our livestock. That same amount could have instead fed as many as 3.4 billion people (Ibid, 51).

Another way is to reduce food losses and waste. It's estimated that approximately one-third, or about 1.3 billion tonnes every year, of the food

produced for human consumption is being wasted or lost in the production process. Consumers in Europe and North-America waste between 95-115 kg per year/capita, while consumers in Asia and sub-Saharan Africa only waste around 6-11 kg per year/capita. In developed countries with medium- and high-incomes most food is wasted at the consumer level. This is food that is being wasted even though it is still suitable for consumption. In low-income countries in the developing world most of the food is lost in the production process before it even reaches the market. FAO takes this matter seriously. The UN agency considers food losses to be a "significant cost" to the world economy and serious threat to global food security and availability (FAO Statistical Yearbook, 2012:216).

4 Summary and Conclusions

This thesis asked if it's possible for organic agriculture, in the face of intensifying environmental degradation and fears of rising population numbers, to reach global food security and sustain human livelihood. As the figure below shows, an answer to this question has been attained by connecting population theories with an empirical study on agricultural methods, population and food levels. The previous chapters has shown that Malthus and other populationists have been wrong in their doomsday predictions and that they have misjudged the possibilities of technological advancements to increase our food production. But just as the thesis has shown, this technology has unfortunately created environmental problems that now threatens valuable ecosystems, our resource base and our very ability to sustain more people. It's clear that a different approach to agriculture is needed so that a smarter food production increase can take place.

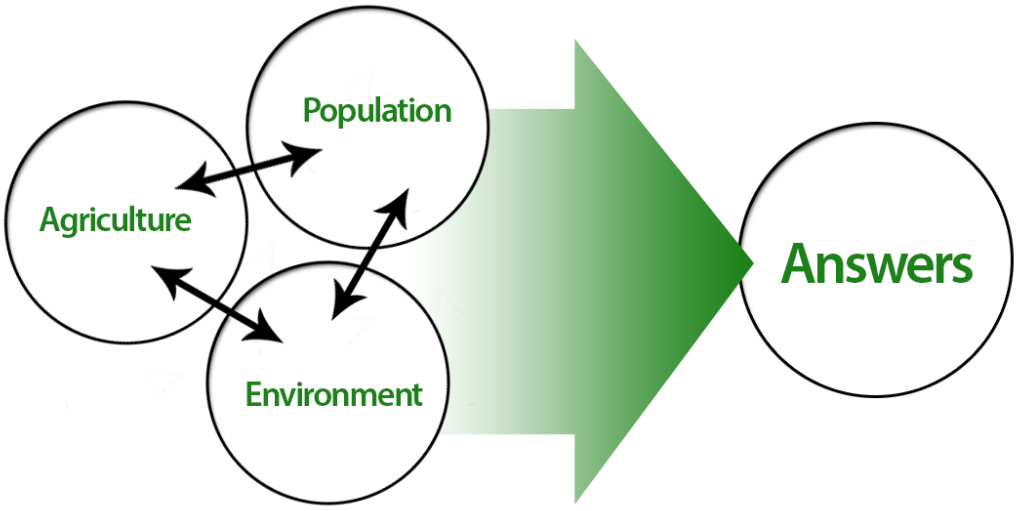

Figure 7: The interconnecting circles forms an answer. Source: Author's elaboration.

This thesis has been able to conclude that the claims from populationists that we would somehow face a population crisis to be unfounded and excessive. Demographic data shows that global population levels are increasing, but they aren't increasing exponentially and nowhere near those levels that populationists are warning about. The data compiled in this thesis shows how human population growth is actually starting to slow down and that the growth is expected to stabilize

by 2100 with around 10 billion people. In fact, this development has sparked fears about a potential ageing crisis with severe implications for developed countries such as Japan. If the population theories from Malthus-inspired thinkers like Ehrlich were to be true we would see a global population that is just getting younger and younger. But instead the global median age is increasing and data shows that people aged 60 or older is the group that is growing the fastest today.

The food price crisis of 2008-2009 has been explained as the result of an energy crisis and that it didn't take place because of uninhibited population growth, like populationists have claimed. A closer look was also taken on undernourishment and malnutrition. While large portions of people around the world are still undernourished we are now experiencing a nutrition transition characterized by overnutrition and obesity. Overweight people has now actually surpassed the number of undernourished people in the world.

The thesis has shown how global food production is growing and how it has even exceeded population growth rate. But if we are to satisfy the projected food demand from a growing population we need to increase our global food production with 70 percent by 2050. This is no easy task, and it doesn't help that food prices are expected to rise and become more volatile from escalating environmental degradation. To avoid this we need to make changes to our food production system as well as re-thinking our own consumption patterns.

Theoretically it's probably possible to increase yields and make the global food system more productive by further intensifying the use of external inputs such as pesticides and chemical fertilizers, which Borlaug among other advocates. But this could potentially have devastating effects on our environment, food prices and population levels. Even populationists, such as Kaplan and Ehrlich, warn that such practices could do more harm than good. Instead organic farming has been put forward as the solution to our growing environmental problems and broken food system. But populationists are opposing this alternative agriculture method as they believe it will be unable to adequately sustain human livelihood on a global scale.

In an effort to answer this question several studies on organic and conventional yield levels have been explored in the thesis. The result is far from unanimous, but a large part of the studies shows promising results for proponents to organic agriculture. Several side-by-side studies seem to support the claims that it's possible for organic farming to sustain current and even future population levels. Considering the findings in this thesis, it's no surprise that national and international bodies are now seeing organic agriculture as a viable option in food security discussions (Letourneau & Bothwell, 2008:430). It's obvious that the potential for conventional agriculture to be converted to organic farmland around the world is vast. As can be seen from developments in Europe, this conversion is taking place, albeit to a varying degree and speed, with a few countries having done more progress than others. Despite this, organic farming still plays a shockingly tiny role

in the global food production system. It's clear that the easiest way to safeguard food availability for current and future generations is to reduce the production of biofuels and our consumption of meat – both being responsible for taking away considerable farmland from crop cultivation.

The answer to the thesis question, if it's possible for organic agriculture to sustain human livelihood, is a probable yes. Organic farming seem to be capable of sustaining global human population levels while lessening the negative effects the agricultural sector has on our environment. It also seems that organic agriculture can withstand the effects of climate change much better than their conventional counterparts. But organic farming has a long and difficult road ahead. Considerable conventional farmland need be converted to organic land. Furthermore, a substantial increase in investments into research and development of alternative agricultural practices and yield increasing methods are also needed. But there's no question about it, we need to increase our food production in a smart way, with or without an imminent population crisis. Luckily for us, this seems to be possible.

References

Alvesson, Mats & Sköldberg, Kaj (2009). *Tolkning och Reflektion: Vetenskapsfilosofi och Kvalitativ Metod.* Second edition. Lund: Studentlitteratur.

Angus, Ian & Butler, Simon (2011). *Too many people? Population, immigration and the environmental crisis.* Chicago: Haymarket Books.

Badgley, Catherine; Moghtader, Jeremy; Quintero, Eileen; Zakem, Emily; Chappell, M. Jahi; Avilés-Vázquez; Katia; Samulon, Andrea & Perfecto, Ivette (2006). "Organic agriculture and the global food supply." In *Renewable Agriculture and Food Systems*, Vol. 22, No. 2, pp. 86–108.

Cloke, Paul; Cook, Ian; Crang, Philip, Goodwin, Mark; Painter, Joe & Philo, Chris (2004). *Practising Human Geography.* London: SAGE.

Dabbert, Stephen; Häring, Anna Maria & Zanoli, Raffaele (2004). *Organic Farming – Policies and Prospects.* London: Zed.

Dalby, Simon (2006). "The Environment as Geopolitical Threat: Reading Robert Kaplan's Coming Anarchy." In Haenn, Nora & Wilk, Richard (edited), *The Environment in Anthropology: A Reader in Ecology, Culture, and Sustainable Living*, pp. 118–135. New York: University Press.

ECSP Report (1995). *Environmental Change and Security, Project Report 1*.

Ehrlich, Paul (1968). *The Population Bomb*. Cutchogue: Buccaneer Books.

Ehrlich, Paul & Ehrlich, Anne (2009). "The Population Bomb Revisited." In *Electronic Journal of Sustainable Development*, Vol. 1, No. 3, pp. 63–71.

ESA (2011). *World Population Prospects: The 2010 Revision, Highlights and Advance Tables.* ESA/P/WP.220. New York: UN.

FAO (2009). *How to Feed the World in 2050. High Level Expert Forum. Executive Summary.* Rome: FAO.

FAO Statistical Yearbook (2012). *World Food and Agriculture.* Rome: FAO.

FAO; WFP; IFAD (2012). *The State of Food Insecurity in the World 2012. Economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition.* Rome: FAO.

Lee, Mary E (2009). "Trends in Global Population Growth." In *Research Starters Sociology*, pp. 1–8. Great Neck Publishing.

Letourneau, Deborah & Bothwell, Sara (2008). "Comparison of organic and conventional farms: challenging ecologists to make biodiversity functional." In *Front Ecol Environ*, Vol. 6, No. 8, pp. 430–438.

Levy, Marc (1995). “Is the Environment a National Security Issue?” In *International Security*, Vol. 20, No. 2, pp. 35–62.
Malthus, Thomas (1798). *An essay on the principle of population.* Edited by Flew, Antony (1970). Harmondsworth.
Miller, G. Tyler (2007). *Living in the Environment: Principles, Connections, and Solutions.* Fifteenth edition. Thomson Learning.
Mäder, Paul; Fliessbach, Andreas; Dubois, David; Gunst, Lucie; Fried, Padruot & Niggli, Urs (2002). “Soil Fertility and Biodiversity in Organic Farming.” In *Science*, New Series, Vol. 296, No. 5573, pp. 1694–1697.
Nellemann, Christian; MacDevette, Monika; Manders, Ton; Eickhout, Bas; Svihus, Birger; Gerdien Prins, Anne & Kaltenborn, Bjørn (2009). *The environmental food crisis – The environment’s role in averting future food crises. A UNEP rapid response assessment.* United Nations Environment Programme, GRID-Arendal.
Rohner-Thielen, Elisabeth (2010). “Agriculture and fisheries. Area under organic farming increased by 7.4% between 2007 and 2008 in the EU-27.” In *EUROSTAT – Statistics in Focus*, October Issue.
Seufert, Verena; Ramankutty, Ravin & Foley, Jonathan (2012). “Comparing the yields of organic and conventional agriculture.” In *Nature*, Vol. 485, No. 7397, pp. 229–U113.
Teorell, Jan & Svensson, Torsten (2007). *Att fråga och att svara. Samhällsvetenskaplig metod.* Malmö: Liber.
Vasilikiotis, Christos (2000). *Can Organic Farming “Feed the World”?* University of California: Berkeley.
Willer, Helga (2012). *Organic Agriculture Worldwide: Current Statistics.* Research Institute of Organic Agriculture, BioFach Congress 2012, Nürnberg, Session, The World of Organic Agriculture.
WWF (2012). *Living Planet Report.*

Online Sources

Angus, Ian (2012). “Attenborough asks corporations to protect wilderness from poor people”. Retrieved 2012-12-16, accessible from here: http://climateandcapitalism.com/2012/01/20/attenborough-asks-corporations-to-protect-wilderness-from-poor-people
European Commission [1]. “Legislation - Organic Farming”. Retrieved 2012-01-04, accessible from here: http://ec.europa.eu/agriculture/organic/eu-policy/legislation_en

European Commission [2]. “Data and statistics - Organic Farming”. Retrieved 2012-01-04, accessible from here: http://ec.europa.eu/agriculture/organic/eu-policy/data-statistics_en

Europa Portal. ”Entry and residence of highly qualified workers, EU Blue Card”. Retrieved 2012-12-18, accessible from here: http://europa.eu/legislation_summaries/internal_market/living_and_working_in_the_internal_market/l14573_en.htm

EUROSTAT. “Certified organic crop area [food_in_porg1]”. Retrieved 2013-01-05, accessible from here: http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database

FAO (2012). “Globally almost 870 million chronically undernourished - new hunger report”. Retrieved 2013-01-26, accessible from here: http://www.fao.org/news/story/en/item/161819/icode/

FAOSTAT (2010). “FAO Statistical Yearbook 2010 - Land Use”. Retrieved 2013-01-29, accessible from here: http://www.fao.org/economic/ess/ess-publications/ess-yearbook/ess-yearbook2010/yearbook2010-reources/en/

FAO Hunger Portal (2012). Retrieved 2012-12-28, accessible from here: http://www.fao.org/hunger/en

FAO FAQ. “Organic Agriculture Frequently Asked Questions”. Retrieved 2013-01-16, accessible from here: http://www.fao.org/organicag/oa-faq/en/

Hendren, John (2012). “Organic farmers beat US droughts”. Retrieved 2013-01-20, accessible from here: http://www.aljazeera.com/video/americas/2012/09/2012930181750198689.html and here: http://www.youtube.com/watch?v=3HhyBcPbI-U

Johnston, Rob (2008). “The great organic myths: Why organic foods are an indulgence the world can't afford”. Retrieved 2013-01-19, accessible from here: http://www.independent.co.uk/environment/green-living/the-great-organic-myths-why-organic-foods-are-an-indulgence-the-world-cant-afford-818585.html

Jones, Paul (2013). “David Attenborough: “Humans are a plague on the Earth””. Retrieved 2013-01-29, accessible from here: http://www.radiotimes.com/news/2013-01-22/david-attenborough-humans-are-a-plague-on-the-earth

Kaplan, Robert (1994). “The Coming Anarchy”, in Atlantic Monthly, February issue. Retrieved 2012-12-06, accessible from here: http://www.theatlantic.com/magazine/archive/1994/02/the-coming-anarchy/304670/?single_page=true

Lang, Susan (2005). “Organic farming produces same corn and soybean yields as conventional farms, but consumes less energy and no pesticides, study finds”. Retrieved 2013-01-20, accessible from here: http://www.news.cornell.edu/stories/july05/organic.farm.vs.other.ssl.html

Lederer, Edith (2007). “Production of biofuels 'is a crime'”. Retrieved 2012-12-28, accessible from here: http://www.independent.co.uk/environment/green-living/production-of-biofuels-is-a-crime-398066.html

Leonard, Andrew (2006). “Save the rain forest — boycott organic?”. Retrieved 2013-01-22, accessible from here: http://www.salon.com/2006/12/11/borlaug/

Masterson, Kathleen (2011). “Organic makes economic sense for grain farmers, study finds”. Retrieved 2013-01-20, accessible from here: http://harvestpublicmedia.org/article/887/organic-makes-economic-sense-grain-farmers-study-finds/5

O’Neill, Brendan (2008). “Malthusian snobs pray for cure for overpopulation”. Retrieved 2012-12-18, accessible from here: http://www.theweek.co.uk/25209/malthusian-snobs-pray-cure-overpopulation

Paarlberg, Robert (2010). “Attention Whole Foods Shoppers”. Retrieved 2013-01-26, accessible from here: http://www.populationmedia.org/2010/10/31/attention-whole-foods-shoppers/

Paulsen, Marit (2009). ”Dags att slakta den heliga ekologiska kossan”. Retrieved 2013-02-10, accessible from here: http://www.newsmill.se/artikel/2009/03/26/dags-att-slakta-den-heliga-ekologiska-kossan

Pollan, Michael (2008). “The Food Issue: Farmer in Chief”. Retrieved 2013-01-19, accessible from here: http://www.nytimes.com/2008/10/12/magazine/12policy-t.html?pagewanted=1&_r=0&ei=5070&emc=eta1

Rodale Institute FST. “Farming Systems Trial”. Retrieved 2013-01-20 and is accessible from here: http://rodaleinstitute.org/our-work/farming-systems-trial/

Runner, Philippa (2008). “Europe Regions Face Depopulation”. Retrieved 2012-12-18, accessible from here: http://www.businessweek.com/stories/2008-08-22/europe-regions-face-depopulationbusinessweek-business-news-stock-market-and-financial-advice

Shiva, Vandana (2012). “Myths about industrial agriculture”. Retrieved 2013-01-20, accessible from here: http://www.aljazeera.com/indepth/opinion/2012/09/2012998389284146.html

UN News Centre (2011). “As world passes 7 billion milestone, UN urges action to meet key challenges”. Retrieved 2012-12-14, accessible from here: http://www.un.org/apps/news/story.asp?NewsID=40257#.UMs3Om-qmX4

U.S. Census Bureau (2010). “International Data Base - Population Estimates and Projections Methodology”. Retrieved 2012-12-16, accessible from here: http://www.census.gov/population/international/data/idb/estandproj.pdf