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PAPER

Environmental Impacts of the Nutrition

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Abstract This paper explores the connection between the nutrition transition towards the North American dietary style and environmental depletion phenomena. Due to socio-economic dynamics, such as population growth, urbanization, globalization, and income levels, developing countries are undergoing a dietary shift towards a higher consumption of energy-dense foods, typical of the western diet. However, energy-dense foods are currently produced through industrial agriculture processes, causing noticeable stress on the environment. In particular, conventional agriculture methods result in heavy climate changing gas emissions, threats to biodiversity conservation, and depletion of natural resources. Developed countries have already experienced the nutrition transition, recording a certain spread of North-American dietary habits among their population since the 50s. Developing countries are undergoing the same process now, but it seems that this nutrition transition is occurring at a much faster pace than in the past. Moreover, it involves a huge percentage of the world population. As a consequence, there is growing concern on environmental depletion phenomena caused by industrial farming in the production of typical North American foods. If the demand for energy-dense food keeps increasing according to its current trend and no shift towards sustainable production systems occur, conventional farms activity will become more and more unsustainable for the planet, threatening seriously food security. After a general introduction to the topic, we examine the existing evidence of the nutrition transition and explain its main characteristics. Then, we explore the major causes of this trend. After that, we will focus on conventional agriculture practices and their environmental impact, given the characteristics of the nutrition transition. Last, we conclude by drawing a comprehensive picture of the issue.

Keywords Nutrition transition - Sustainable diet - Environmental depletion - Intensive agriculture - Sustainable farming - Food security

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1. Introduction

It is a widely known fact that the world population has grown quite remarkably in the last decades, particularly in poor and developing countries. Population dynamics have led to an increased demand for food that, thanks to the development of new technologies and agrochemicals, resulted in the so-called green revolution. Thus, agricultural practices became increasingly characterized by intensive single-crop plantations, agrochemicals, and mechanization. In the short run, the green revolution has improved productivity and reduced food prices. Yet, single-crop plantation and use of agrochemicals are counterproductive in the long run, as they are responsible for environmental depletion, resulting in decreasing production and increasing food prices in many areas of the world[1]. Due to the globalization of agricultural practices, the green revolution has spread in developing countries, where demand for food was rising; one very famous example is India, where reforms promoted in the 80's have pushed the spread of intensive agriculture practices.

Not only the number of people is changing, but its redistribution between rural and urban areas is shifting, too, mostly in favour of the second alternative. Urbanization has a double meaning: on one hand, it is the increasing share of urban dwellers; on the other hand it implies the expansion of urban land uses[2]. Urbanization is highly associated to globalization in several ways. Defining globalization and providing incontrovertible evidence is very hard: not only potential gains and losses are debated among experts, but its very existence is denied by many eminent scholars, and the discussion is still ongoing. In this work, we assume that, though counter-globalization trends do exist, there are some very strong globalizing forces at work. Among all definitions of globalization, a useful one is provided by FAO[3]: "*reduction in barriers to the cross-border movements of goods, services and capital; an increased flow of commodities, technology, information, financial capital, modes of distribution and marketing; and, to a certain extent, migration of people and labour*". This reduction in barriers and increasing transport and communication grids has allowed many cities to grow economically and demographically. Considering food demand and the supply system, international trade allows for a higher availability and diversity of food, but it has also brought to a convergence of practices in food production, distribution, and consumption that is damaging the environment. In particular, Godfray *et al.* (2010)[4] state that, since economic development is causing higher purchasing power in many countries and higher food consumption, we will have to satisfy an increasing demand for animal products and processed food from a larger population, while ensuring environmental sustainability. As a matter of facts, not only the quantity of food demanded is soaring, but the kind of food consumed worldwide is undergoing a shift towards those products typical of the North-American diet.

Such dynamics are deeply connected to environmental depletion phenomena. According to the fifth edition of UNEP Global Environmental Outlook[5] climate change, loss of biodi-

[1] Barilla Center for Food and Nutrition (2012), "*Eating planet – Nutrirsi oggi: una sfida per l'uomo e per il pianeta*", Milano: Edizioni Ambiente.

[2] Satterthwaite D., McGranahan G., and Tacoli C. (2010), "Urbanization and its implication for food and farming", *Phil. Trans. R. Soc. B* vol. 365 no. 1554, pp. 2809-2820.

[3] Kennedy G., Nantel G., and Shetty P.(2004), "Globalization of food systems in developing countries: a synthesis of country case studies", in FAO Paper no 83, "*Globalization of food systems in developing countries: impact on food security and nutrition*", Rome 2004, pp 1-26.

[4] Godfray H.C.J. et al.(2010), "*Food Security: the Challenge of Feeding 9 Billion People*", in Science, vol. 327 no. 5967, pp. 812-818.

[5] UNEP (2012), "GEO 5 – Global Environmental Outlook", internet : http://www.unep.org/geo/ (consulted on June 25th, 2013).

versity, and pollution seem to be the most delicate challenges, since little or no progress has been achieved. Climate change is a natural phenomenon, but the majority of the academic community believes that this process is speeding up because of human activities-related atmospheric pollution; however, some scientists assert that rising temperatures are not caused by human activities, and, thus, are not a dangerous sign of the Earth's depletion. In this work, we will take as a valid hypothesis the one upheld by the majority of scientists, i.e. that climate change is being amplified by atmospheric pollution due to human greenhouse gas emissions; UNEP maintains this hypothesis, too. GEO 5 report states that greenhouse gas emissions and concentrations keep rising, so that temperatures seem to be increasing both globally and regionally, and there are no positive signs of regression of such tendency. Climate change has an influence on extreme climatological disasters, which are increasing in number and intensity: in particular, floods have more than doubled between the 1980s and the 2000s. Biodiversity loss is a most critical issue, since many species, habitats, and ecosystems are lost or at risk, mainly due to climate change and overexploitation of resources. Pollution of air, soil, and water is a serious challenge as well, and land overuse results in major desertification and productivity decrease in drylands.

The aim of this paper is to explain the correlation between the nutrition transition towards the North American dietary style and environmental depletion phenomena, which have become a noticeable source of concern today. In particular, it analyzes how and why this transition is happening, and what impacts such changes have on the environment. Although the nutrition transition and environmental damages caused by intensive agriculture have been deeply studied in previous years, a very few papers deal with both dynamics at the same time, emphasizing their link. However, there is a rising need to explore the two topics together: energy-dense foods, typical of the North-American diet, are produced through industrial agriculture processes that cause a remarkable stress on the environment. The nutrition transition is occurring now in developing countries, where population is growing, at a faster pace than before. As a consequence, the demand for high-energy dense foods is soaring, so that the environmental depletion caused by conventional agriculture is a major challenge to food security. First, we will present the existing evidence of the nutrition transition and its main causes. Then, we will explain how industrial agriculture is damaging the environment. Last, we conclude by evaluating the role of the nutrition transition.

2. The nutrition transition: evidence

There is some evidence that the world dietary habits have been changing in an unprecedented way in the last decades, and that this shift is happening at a faster pace today. Drewnowski and Popkin (1997)[6] have conducted a deep research on the world dietary trends, stressing that official data show an ongoing nutrition transition affected by incomes, urbanization, and globalization, and that the way this transition is occurring has changed over time. Popkin (2004)[7] maintains that the nutrition transition includes three main elements: change in dietary habits, change in body composition, and reduced physical activity. For the purpose of the present work, the first issue only is analyzed in depth. Overall, in the second half of the XX century

[6] Drewnowski A. and Popkin B. M. (1997), "The Nutrition Transition: New Trends in the Global Diet", *Nutrition Reviews* vol 55 no. 2, pp. 31-43.

[7] Popkin B. M. (2004), "The Nutrition Transition: an Overview of the World Patterns of Change", *Nutrition Reviews* vol. 62 no 7, pp. S140-S143.

there has been an increase in energy-dense food, in particular edible oils, fats, and sweeteners[8], which has been identified as a westernization of local diets, i.e. a shift from traditional food towards typical North-American eating habits. Even though each country and each region is experiencing a different path, reported data[9] show that between 1970 and 1995-1997 the world calories intake from meat and vegetable oils has increased by 33% and 46% respectively, while energy intake from starch roots and pulses has decreased by 30%; although cereals still make up the largest share of the world's diet, the energy intake from fat and sugar is increasing at the expenses of complex carbohydrates.

Recent data (see figures 7 and 8 below)[10] show that the global variation of food intake in the last 30 years appears to be very different in each continent, yet there is a general trend of steady consumption of cereals, starchy roots, pulses, sugar and sweeteners; vegetables, fruits, edible oils, meat and dairy consumption tends to increase almost everywhere, while animal fats intake is quite steady, except from Asia. Unsurprisingly, the most "westernizing" area in terms of food intake is Asia, where a general rise of income (particularly in China and the "Asian Tigers") has led to an overall increased consumption, especially of foods typical of the North-American diet. In Africa the nutrition transition is slower, but still there are clear signs of an increase in demand for vegetable oils, meat, eggs, and milk (dairy consumption has not risen very much over time, but absolute quantity is rather high, compared to vegetables and fruits). Developed areas (Europe, Oceania, and the Americas) show less relevant variation, with Oceania displaying a counter-trend behavior about pulses, eggs, dairy, and meat; this is because consumption in the developed world is already high in absolute terms, as fig. 8 illustrates. One remark has to be done on "the Americas" grouping: North America (where the western diet comes from) and South America used to have very different dietary habits, so North-South aggregate data may not be extremely significant. We can hypothesize that developing South American states consumption tendency might be more similar to that of the Asian states: absolute quantity lower than average, but high percentage change. On the contrary, North American trends might be more similar to that of the other developing areas: high absolute quantities and low, if not negative, percentage changes.

[8] *Ibidem.*

[9] Drewnowski A (2000), "Nutrition Transition and Global Dietary Trends", Nutrition vol. 16 no 7/8, pp. 31-43.

[10] In FAO database food types are grouped as follows: cereals include wheat, maize, barley, rice, oats, millet, sorghum rye, other cereals; starchy roots include cassava, potatoes, sweet potatoes, yams, other roots; pulses include beans, peas, and other pulses; vegetables include tomatoes, onions, and other vegetables; fruits include oranges, mandarins, citrus, bananas, apples, pineapples, plantains, grapefruit, dates, grapes, and other fruits; sugar and sweeteners includes sugar, honey, and others; vegetable oils includes oil from soybean, groundnut, sunflower seed, rape and mustard, cottonseed, palm kernel, palm, sesame seed, coconut, olive, rice bran, maize germs, oil crops and others; meat includes bovine, mutton & goat, pig, poultry, others; animal fats includes butter and ghee, cream, raw fat, fish body and liver oil.

Fig. 1 Percentage change of regional consumption per food type (Kg/Yr per capita), over the period 1980-2009, (FAO data re-elaboration, 2012)

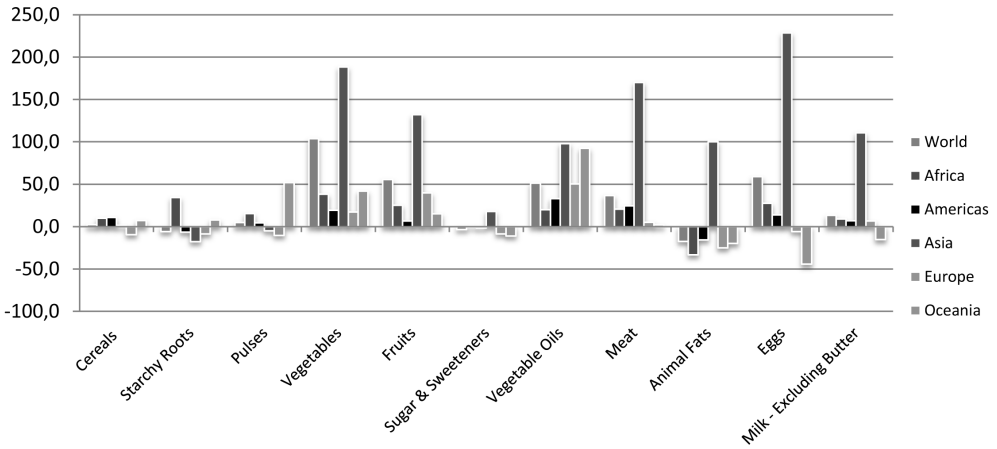
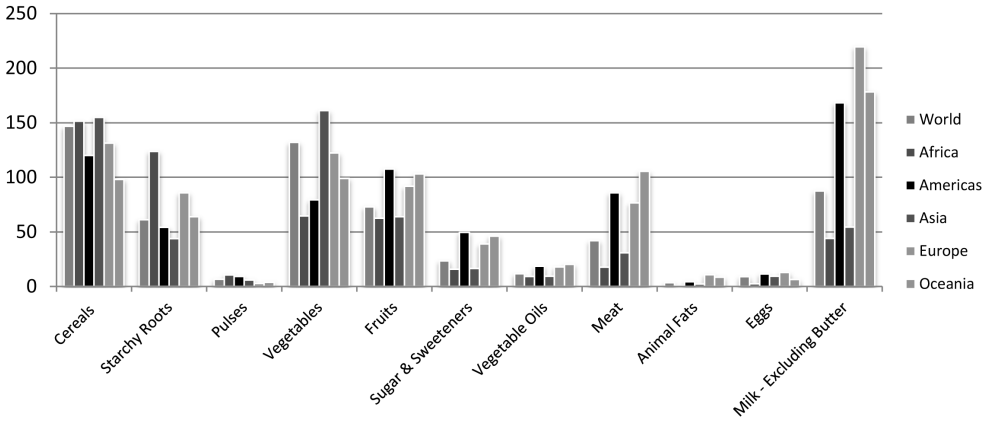


Fig. 2 Absolute regional consumption per food type in 2009, expressed in Kg/Yr per capita (Source: FAOSTAT, 2012)



FAO (2004)[11] provides for a cross-country study, showing that dietary patterns are going through two main processes: convergence and adaptation. Changes in food prices and individual incomes seem to be driving food demand towards the same choices in all regions (polished grains, animal products, vegetable oils), while changes in lifestyle seem to be leading towards similar adaptation phenomena (higher consumption of packaged and processed food) in different countries. This is also due to a certain idea of "being modern"; evidence from South Africa demonstrates that fried food is considered a sign of modern living, while boiled food is regarded as outdated.

Beyond data on food demand in terms of kilos per year, which give us a first indication of how consumption has changed, another important information to take into account is the relative weight of each food type in terms of calories per day. Figs. 9 and 10 below report data on Kcal/Day per capita of different food types. The percentage change of consumption shows

[11] Kennedy G., Nantel G., and Shetty P.(2004), *see reference list.*

tendencies extremely similar to fig. 8 above; considering such trends and looking at fig. 10, the conversion process observed by FAO[12] finds some confirmation in 2009 data: the divergences in regional percentage changes lead to similar consumption habits in absolute terms. For instance, the consumption of fruits and vegetables in Asia and Africa has remarkably increased, but only to reach the average consumption patterns; the same, the intake of calories deriving from meat, animal fats, eggs and milk in Asia has risen exceptionally, so that the absolute calories amount is growing similar to that of developed regions.

Fig. 3 percentage change of regional consumption per food type (KCal/Day per capita), over the period 1989-2009 (FAO data re-elaboration, 2012)

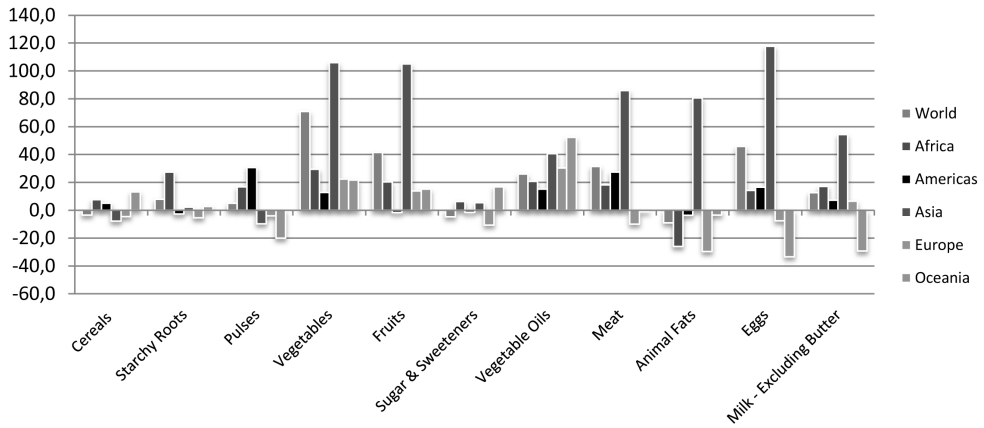
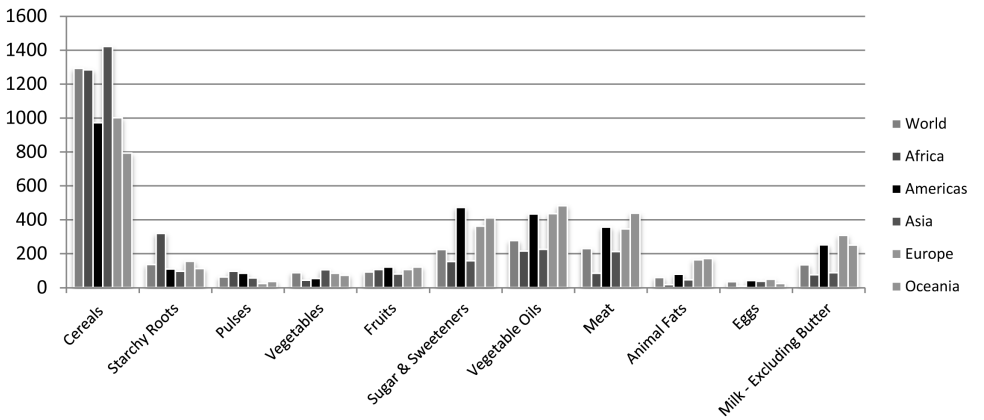


Fig. 4 Absolute regional consumption per food type in 2009, expressed in KCal/Day per capita (Source: FAOSTAT, 2012)



[12] *Ibidem.*

This dietary transition, along with population growth, has led to an increasing demand for fish, meat and animal products, causing what has been defined as the "livestock revolution"[13]. Developed countries will, in absolute terms, keep a high consumption of animal fats and proteins, while developing countries account for 85% of global rising demand in cereals and meat. According to Steinfeld and Gerber (2010)[14], while the green revolution was a planned policy, the livestock revolution is occurring without political planning, as a direct consequence of a remarkable increase of the demand for animal source foods, which is expected to increase by 68% (meat) and 57% (milk). Demand for meat implies a greater demand for cereals to feed livestock and a higher environmental impact of dietary habits, as it will be demonstrated in the next part. Yet, though total world calories intake are on the rise in the developing world, food insecurity and under-nutrition will persist. This livestock revolution, like the green revolution, is primarily involving developing countries, where the increase in the share of production and consumption is more significant, causing heavier stress on resources and a need for rapid technological change[15]. There is a need for policy regulation of the livestock industry, since it may bring opportunities, as well as dangers: in low-income countries, meat is an important source of nutrients to fight against under-nutrition, but in wealthier countries it brings health problems, and, moreover, without proper techniques livestock management causes environmental depletion.

3. Main causes of the westernization of diets

Drewnowski and Popkin (1997) have tried to investigate possible genetic and inner causes of fat- and sugar-rich food preferences observed all around the world. According to their findings, although human beings have directed their choices towards high-energy food to survive during the evolution process, there seems to be a regulatory mechanism for sugars, but not for fats. Sugar is highly desired by children, and less by adults; the same, proteins demand may be tied, to a certain extent, to internal mechanisms. On the contrary, the perception of fat in foods is often misguided and its consumption appears to be determined by economic factors, plus a general desire for a more diverse diet. Thus, socio-economic factors like urbanization, incomes and economic growth, prices dynamics, and globalization are regarded as the leading cause for the nutrition transition.

According to Drewnowski (2000), the nutrition transition is highly influenced by income levels and GNP, so that two steps can be identified: at an early stage of the transition there is an increase in oil and vegetable fats consumption, while in the second phase dietary habits move towards a higher intake of animal products and western processed foods. Developing countries may be an example of the first stage, while wealthier nations (like Japan) have already reached the second step. Between the '50s and the '70s, economic growth in Japan has been followed by an increase in fats intake: the traditional diet based on rice, fish, and soybeans has been enriched with meat (poultry, in particular), milk, and dairy products. Drewnowski and Popkin (1997) report that from 1946 to 1987, Japanese people have experienced a three-fold increase in fat intake (from 9% to 25% of daily energy), while cereals have been reduced from

[13] Pinstrup-Andersen P., Pandya-Lorch R., and Rosegrant M. W. (1999), "World Food Prospects: Critical Issues for the EarlyTwenty-First Century", *IFPRI Food Policy Report October*, Washington D.C.: International Food Policy Research Institute.

[14] Steinfeld H., Gerber P. (2010), " Livestock production and the global environment: Consume less or produce better?", PNAS vol. 107 no. 43, October 26, 2010, pp. 18237-18238.

[15] *Ibidem.*

66% to 39% of daily energy. Developed countries have already undergone this transition. The research mentioned above has found out that today GNP-nutrition shift ratio is less strong than in the past. The analysis of 1962 data has outlined a remarkable connection between incomes and animal fats, while a less marked behavior has been observed with animal proteins and sweeteners; vegetable fat consumption was pretty constant and independent of GNP levels. The same study, conducted on 1990 data, has detected an increase of animal fat consumption in poor countries, and a reduction in rich countries, while results for animal proteins and sweeteners did not change substantially; consumption in vegetable fat remained independent of income levels, but significantly higher. The conclusion drawn from this study is that the nutrition transition is happening today at much lower incomes than before. This means that dietary shift are much faster than in the past, with the result that in many developing countries chronic under-nutrition and rising over-nutrition are found together, causing a double burden for the State to deal with. The same hypothesis is maintained by Abrahams *et al.* (2011)[16] in a study on 40 Sub-Saharan countries: even though most of the countries analyzed appear to be in the early stages of the transition, the recession of famine and the concurrent increased access to low-cost western food (due to globalization and urbanization dynamics) are deeply affecting dietary habits and spending-up the transition in low- and middle-income countries.

China and India are an example of nutrition transition due to advanced living standards and improved economic performances, although income inequality is still high. A rapid increase in GDP per capita has led to a shift towards western lifestyle; in particular, all income groups have moved away from a cereal-based diet, seen as poverty status[17], to higher energy-dense diets. Reported data[18] show that, approximately from the mid-'70s to the mid '90s, Chinese people have sharply increased animal products consumption (almost eight-fold), and vegetable and fruit consumption, while in India global demand for dairy and edible oils has grown fast. A similar pattern has been followed by South America: all Latin American countries show an increase in animal protein and fat, sugar and processed food intake, occurred between 1970 and 1997; at the same time, despite being the principal source of energy, cereals' consumption has decreased. Yet, each of them is in a different step of the nutrition transition and wealthier countries (like Chile) or rapidly developing ones (Brazil) seem to be in a much advanced phase[19].

The main reason why dietary shifts are occurring at lower income levels than in the past, along with rising income, is a general reduction in "western" foods' prices, due to industrialization of agriculture and livestock. Price is very important in food selection and it can be affected by economic means, but it is difficult to find a balance between reducing calories intake of wealthier people without harming food insecure households[20]. Egypt, for instance, is undergoing an early phase of the nutrition transition[21], with growing consumption of polished grains (wheat and rice), animal products, fats, and vegetable oils. The shift from a kind of bread mainly made of corn flour to a wheat flour dependency is due to State subsidies, accord-

[16] Abrahams Z. *et al*. (2011), "Diet and mortality rates in Sub-Saharan Africa: stages in the nutrition transition" *BMC Public Health* 2011 11:801.

[17] Popkin B. M. (2001), "Nutrition transition: The changing global nutrition challenge", *Asia Pacific Journal of Clinical Nutrition*, vol 10 (suppl.), pp. S13-S18.

[18] Popkin B. M. *et al*. (2001), "Trends in Diet, Nutritional Status, and Diet-related Non‑communicable Diseases in China and India: The Economic Costs of the Nutrition Transition", *Nutrition reviews* vol. 59 no. 12, pp. 379-390.

[19] Bermudez O. I. and Tucker K. L. (2003), "Trends in dietary patterns of Latin America populations", *Cad. Saude Publica*, vol 19 (sup. 1), pp. S87-S99.

[20] Popkin B. M. (2001), see above.

[21] Galal O. M. (2002), "The nutrition transition in Egypt: obesity, undernutrition, and the food consumption context", *Public Health Nutrition* vol. 5 no 1A, pp. 141-148.

ing to Galal (2002), which made wheat bread and flour less expensive, thus more preferable by consumers.

Satterthwaite, McGranahan, and Tacoli (2010) have remarked that urbanization, beyond economic growth, has a deep impact on food production and consumption, mainly for three reasons: first, cities' physical expansion causes losses of local agricultural lands, forcing people to rely on large international chains; second, urbanization in less developed countries is not always associated to income growth, so that there are large masses of urban poors suffering from food insecurity; last, increased consumption of meat. A FAO cross-country study[22] has shown, as well, that urban dwellers tend to consume more edible oils, animal products, sweeteners, and, to a minor extent, fruits and vegetables. Satterthwaite, McGranahan, and Tacoli (2010) believe that this last feature of urbanization is mainly due to higher incomes, not to urbanization itself. However, there is some evidence contrasting with this statement. According to Ghassemi, Harrison, and Mohammad (2002)[23], Iran is experiencing a rapid dietary shift, in a context of a quick demographic transition (due to fertility rate control policy), urbanization, and social development, but the absence of a steady economic growth. Data provided in the mentioned research show that, since 1985, urban population in Iran tends to move towards an inexpensive energy-dense diet, rich in bread, sugar, fats and oils, while animal proteins, fruit and vegetable consumption has decreased. Iran is a clear example of a fast transition, happening at low income levels and affecting urban poors above all, causing a double burden of undernutrition and overnutrition. Furthermore, a study conducted on China[24] shows that, keeping a steady level of socio-demographic variables, income, and food prices, there is a "urban effect" on dietary habits, causing a shift towards western diets: higher consumption of superior grains, fats, animal products, sweeteners, and processed food. This "urban effect", according to Popkin (2001), marks a significant difference between urban and rural dietary habits in low-income countries; on the contrary, in wealthier countries there seems to be a market penetration in rural areas, due to transportation and national distribution infrastructures, causing a convergence of rural habits towards urban dietary styles.

Another issue affecting dietary habits, usually deriving from economic growth and urbanization, is globalization and spreading mass media. This is a common feature of developing economies: for instance, in China, during the '70s, there was no television, no transportation, and (almost) no food trade; today, almost 90% of households own a television, transportation has developed, and industrial techniques are applied to the food chain, too[25]. Evaluating globalization's real impact on food choices is a hard task, because it is always mixed up with other dimensions affecting lifestyle changes. As mentioned above, the nutrition transition implies a dietary convergence towards the North-American diet. This shift cannot be always connected to globalization dynamics: taking again China as an example, the dietary transition started when domestic production of vegetable oil increased, while changes in lifestyle pushed people to consume more food away from home and to increase the use of sweeteners; a higher demand for animal products and fats caused more import, but foreign food or habits started to play a role in the country only later, when the transition had already begun[26].

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[22] Kennedy G., Nantel G., and Shetty P. (2004), see reference list.

[23] Ghassemi H., Harrison G., and Mohammad K. (2002), "An accelerated nutrition transition in Iran", *Public Health Nutrition* vol. 5 no 1A, pp. 149-155

[24] Popkin B. M. (1999), "Urbanization, lifestyle changes, and the nutrition transition", *World Development* vol. 27 no 11, pp. 1905-1916.

[25] Popkin B. M. (2001), see reference list.

[26] Drewnowski A. and Popkin B. M. (1997), see reference list.

On the contrary, in some cases globalization seems to have a good part in the transition: one is South Korea. This country underwent a process of modernization much earlier, compared to other Asian countries (except for Japan); according to Kim *et al.* (2000)[27], food shortages in South Korea have led to higher importation of wheat from the US in the '70s, originating a process that has led to a higher demand of foreign products and, as a consequence, the spread of fast food restaurants, food processing technologies, importation of meat. In the last thirty years, South Korean people have reduced consumption of plants in favor of animal products, anticipating the rest of the region; one remarkable feature of this country is that, contrary to most of the other ones, the dietary transition has not caused a marked rise in fat intake. One explanation[28] is that many socio-cultural movements to protect and retain the traditional diet have developed and spread through mass media, exploiting other features of globalization (for instance, by creating a chain of traditional Korean fast-food restaurants). Globalization of food culture is also affecting Indigenous Peoples' communities with a long history of traditions separated from those of the countries they live in. A study on forty-four large cultural areas from the Canadian-Arctic[29] shows that there has been a sharp reduction in the consumption of traditional food, and higher demand for fats, sugars, and proteins, especially among the youngsters and in more urban or connected areas.

4. Expansion and intensification of agriculture

To assess the environmental impact of food production, interconnected dynamics must be taken into account. The growing demand for agricultural products is due to increasing world population, the need to ensure food security, and rising consumption of animal products, so that the need for feed-grains cultivation has risen, too. Thus, to face the demand both for human needs and animal livestock, farming had to find a way to achieve higher yields.

In a detailed study on food production, the Barilla Center for Food and Nutrition (BCFN)[30] has provided data on carbon footprint, water footprint, and ecological footprint[31] of most food types. The Life-Cycle Assessment (LCA) analysis takes into account farm production, processing, packaging, transport, and cooking. Even though we focus on the production stage only, a synthesis of wider data provided by the BCFN (see Table 1 below) gives a clear idea of the importance of changing diets in terms of resources consumption. The general outcome of the research is that more energy-dense foods require production methods having a deeper impact on the environment.

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[27] Kim S. *et al.* (2000), "The Nutrition Transition in South Korea", *American Journal of Clinical Nutrition* vol. 71, pp. 44-53.

[28] Kuhnlein H. V. *et al.* (2004), see above

[29] Kuhnlein H. V. *et al.* (2004), "Arctic Indigenous Peoples experience the nutrition transition with changing dietary patterns and obesity", *The Journal of Nutrition* vol. 134 no 6, pp. 1447-1453.

[30] Barilla Center for Food and Nutrition (2011), "*Doppia piramide: alimentazione sana per le persone, sostenibile per il pianeta*", Parma: BCFN.

[31] The Carbon footprint measures carbon dioxide emissions and all other greenhouse gases emission, converted in carbon dioxide emissions through proper coefficients, established by IPCC. The Water footprint indicates the amount of freshwater needed for a certain production, including rainwater absorbed by plants (green water), surface water and groundwater used (blue water), polluted water (grey water). The Ecological footprint determines the amount of land needed to provide for all services necessary to production, divided in: energy land, cropland, forest land, built-up land, fishing ground; this indicator is largely artificial (for instance, energy land is calculated as the amount of land needed to absorb carbon dioxide emissions), and does not include degraded land, but it is recognized by the academic community as a valid instrument, even though some methodological improvements are desirable.

Table 1 Carbon footprint, water footprint, and ecological footprint of selected foods including production, processing, packaging, and transport (Source: BCFN, 2011)

Type of food (data per kilo)	Carbon footprint (CO2 equivalent)	Water footprint (litres of water)	Ecological footprint (m2 total)
Agricultural food			
Fruit	70	600	3
Greenhouse vegetables	4000	106	9
Seasonal vegetables	302	106	4
Pulses	1130	1800	16
Foods resulting from agricultural products processing			
Pasta	1564	1390	12
Rice	2750	3400	9
Bread	983	1300	6,7
Sugar	470	1500	4
Oil	3897	4900	14,6
Animal products (livestock)			
Red meat	30400	15500	106
White meat (pig)	4359	4800	36
White meat (avians)	3830	3900	33
Butter	8800	5000	75
Cheese	8784	5000	75
Milk	1000	3300	15
Eggs	5233	3300	14

The improvement of yields occurred in the last decades has been reached through the physical expansion of agricultural land and, above all, through intensification of production. In other words, new consumption patterns have led farming enterprises to embrace intensive monocrop production systems to enhance yields remarkably. The main features of the so-called conventional (industrial) farming are: mechanization, greater use of fossil fuels, chemical fertilizers and pesticides, intensive monocrop cultivations. According to Foley *et al.* (2005)[32], nowadays almost 40% of the total land surface is employed in croplands and pastures (not to mention livestock), becoming one of the largest terrestrial biomes on earth; this figure is consistent with official FAOSTAT data[33], reporting that 38,47% of total land area is classified as agricultural land. The way farming has evolved towards intensive croplands is causing a deep alteration on surrounding ecosystems.

The widespread shift to intensive agriculture and livestock results, above all, in climate-changing gas emissions, loss of biodiversity, and land degradation. Sonesson, Davis and Ziegler (2010)[34] outline that, while post-farm activities are quite similar among food groups, implying

[32] Foley, J.A. *et al.*(2005), "Global Consequences of Land Use", *Science* vol. 309, no. 570, July 2005, pp. 570-574
[33] FAOSTAT database (2012), internet: http://faostat3.fao.org (consulted on August, 14th, 2013)
[34] Sonesson U., Davis J., and Ziegler F. (2010), "Food Production and Emissions of Greenhouse Gases", *SIK-Report no. 802,* Göteborg: SIK – The Swedish Institute for Food and Biotechnology, ISBN 978-91-7290-291-6

similar impacts on the atmosphere, in-farm activities differ substantially among food groups in terms of emissions. However, a common trait highlighted is that carbon dioxide emissions are relatively lower, compared to other biogenic greenhouse gas emissions: methane, nitrous oxide and dioxide. The research mentioned above offers a wide explanation of where does greenhouse gases emissions come from in each sector. Climate-changing gas emissions in agriculture are mostly due to the use of chemical fertilizers and pesticides; nitrogen, in particular, interacts with other particles present in soil and water, causing direct and indirect emissions of nitrous dioxide. Besides, agricultural operations requiring fossil fuels energy, as well as transportation of inputs necessary to production, result in carbon dioxide emissions. According to Smith *et al.* (1997)[35], there is a linear relationship between nitrogen fertilizers' quantity and nitrous oxide and dioxide emissions, even though other variables may affect the final result, such as fertilizers' timing, crop residues, water management, nitrification inhibitors, etc. Animal products' environmental impact depends on the kind of animal livestock. Sonesson, Davis and Ziegler report that red meat and dairy from beef cause a high level of methane emissions, due to enteric fermentation of ruminants; such emissions may be higher in nitrous dioxide if the cattle is fed with grains and soy, instead of non-edible grass. White meat from poultry has relatively less importance in direct climate-changing gas emissions, but poultry livestock needs a high amount of fossil-fuel energy; the same, white meat from pork causes less methane production than beef, but pigs need to be fed in grains, causing a rise in nitrous dioxide emissions. If we take into account all elements previously presented, as well as emissions due to deforestation and land-use change, it is clear how much intensive agriculture and livestock can affect local and global climate.

Another feature of the dramatic increase in food production is the preference for the so-called High Yielding Varieties (HYV), meaning those breeds that perform better in intensive farms. Today, although there are more or less 50.000 edible plants, rice, maize, and wheat provide for 60% of the global energy intake[36]. Thus, contrary to traditional farming, intensive agriculture relies on a few crops cultivated in wide areas, affecting all three types of biodiversity: genetic, specific, and ecosystemic. Furthermore, intensive agriculture has a double set of impacts on biodiversity: at the single field level, it modifies natural vegetation and soil biota, while at the landscape level the large size and homogeneity of cultivations affects the whole ecosystems, both directly and indirectly. Table 2 below lists the main benefits of biodiversity; increasing simplification of biological resources causes a progressive loss of natural services which are essential to agriculture itself.

Table 2 Benefits of biodiversity (Source: Interagency report to the Mexican G20 presidency, 2012; author's elaboration)

Provisioning	Regulating	Supporting	Cultural
Food and nutrients	Pest regulation	Soil formation	Sacred groves as food and water sources
Fuel	Erosion control	Soil protection	Agricultural lifestyle varieties
Animal feed	Climate regulation	Nutrient cycling	Genetic material reservoirs
Medicines	Natural hazard regulation (droughts, floods and fire)	Water cycling	Pollinator sanctuaries
Fibres and cloth	Pollination		
Materials for industry			
Genetic material for improved varieties and yields			
Pest resistance			

[35] Smith K. A. *et al.* (1997), "Emissions of N20 and NO associated with nitrogen fertilization in intensive agriculture, and the potential for mitigation", *Soil Use and Management*, vol. 13 Issue supplement s4, pp. 296-304.
[36] OECD (2012), *Sustainable agriculture productivity growth and bridging the gap for small-family farms*, Interagency report to the Mexican G20 presidency, 12 June 2012, internet: www.oecd.org (consulted on July 15th, 2013).

Altieri (1999)[37] highlights that biodiversity has many economic advantages for farmers and consumers, namely dietary diversity, income diversification, efficient use of labor and resources, resistance to crop diseases, and efficient exploitation of different soil types; as a consequence, biological simplification hinders natural services, causing environmental damages and higher economic costs due to the growing need for external inputs. Negative impacts of agriculture intensification on biodiversity are due, first of all, to the expansion of cultivated areas; this is causing, especially in developing countries, the loss of many habitats and ecosystems. Beyond expanding areas, intensification of production systems is the main cause for biological simplification. According to Thrupp (2000)[38], agrobiodiversity, including not only biodiversity itself but also the skills of farmers to exploit and preserve it, is mostly concentrated in Africa, Asia, and South America, where there is a tradition of cultivation of landraces, i.e. local breeds. Yet, the introduction of many HYV has endangered biodiversity in developing countries: the research mentioned above reports that in the Philippines more than 300 traditional rice varieties have been displaced, while in Senegal a highly nutritive local cereal (fonio) is threatened by the introduction of western-imported HYV monocrop cultivations. Thrupp and Altieri outline that monocrop cultivations are highly vulnerable to pests and diseases, so that farmers resort to chemical pesticides. Besides, a reduction in soil organisms and nutrients leads to the increasing use of chemical fertilizers, with subsequent release of higher quantities of climate changing gas. As previously outlined, one characteristic of intensive agriculture is the use of great quantities of chemical pesticides (there are more or less 1600 pesticides available nowadays), which, although should be projected to attack targeted organisms only, have a disruptive effect on biodiversity: bird wildlife and pollinator insects are the most affected species by poisonous effects of chemical pesticides[39]. The intensification of production systems and subsequent loss of biodiversity is attributable to livestock activities, too. Baumung and Hoffmann (2010)[40] state that the increasing demand for animal products, due to dietary shifts, is leading to widespread settlement of (intensive) livestock, even in developing countries where, traditionally, animals were not kept for food. Widening livestock areas cause the loss of ecosystems due to land-use change, and spreading intensive methods cause environmental depletion. Most often, the adoption of intensive livestock systems couples with the increasing use of cross-breeding and non-local breeds, largely coming from developed countries, at the expenses of local resources (Campbell, Noonan-Mooney, and Mulongoy (2010)[41]). Baumung and Hoffmann outline that animal genetic resources loss is happening both at a specific and sub-specific level; for instance, only four out of forty domesticated avian and mammalian species are raised worldwide. Within-breed diversity plays a key role in animal genetic conservation and, like crops, decreasing biological diversity makes livestock more sensitive to diseases.

The third issue mentioned above, soil depletion, is mainly caused by the massive employ-

[37] Altieri M. A. (1999), "The ecological role of biodiversity in agroecosystems", *Agriculture, ecosystems, and Environment* vol. 74 (1999), pp. 19-31.

[38] Thrupp, L. A. (2000), "Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture", *International Affairs* vol. 76 no.2, pp. 265-281.

[39] Angelo M. J. (2009), "Corn, carbon and conservation: rethinking U.S. agricultural policy in a changing global environment" ExpressO Available at: http://works.bepress.com.

[40] Baumung R. and Hoffmann I. (2010) "Animal genetic diversity and sustainable diets" in Burlingame B. and Dernini S. (ed.) *Sustainable diet and biodiversity*, FAO – Food and Agriculture Organization, pp. 82-93.

[41] Campbell K., Noonan-Mooney K., Mulongoy K. J. (2010), "Biodiversity, nutrition, and human wellbeing in the context of the Convention on Biological Diversity" in Burlingame B. and Dernini S. (ed.) *Sustainable diet and biodiversity*, FAO – Food and Agriculture Organization, pp. 36-43.

ment of chemical fertilizers and pesticides. According to Tilman *et al.* (2002)[42], these practices damage heavily the environment, as only a part of chemicals is taken up by crops, while the rest is released in the ecosystem; besides, growing resistance to pesticides generates extra need for external inputs, causing further disruption of the environment, and so on. Evidence shows that the result of this vicious cycle is a growing expenditure of farmers to buy more fertilizers, while the progressive reduction in chemicals efficiency generates decreasing yields' growth anyways. In a study on developing countries, Scherr and Yadav (1996)[43] state that this process is highly risky, since not all land degradation phenomena are reversible, at least not in the short-medium run. Without appropriate policies, land degradation due to overexploitation will result in a serious threat to yields and food security, especially in regions with higher population density and growing demand for food. One example of disruptive land degradation effect has occurred in the Indian state of Haryana, according to the research delivered by Singh (2000)[44]. Haryana has undergone a first process of cropland expansion, prior to the '60s, then an intensification of practices through the introduction of HYV (rice and wheat, replacing pulses, bajra, sorghum), chemicals, and irrigation facilities. Yields improved so much that Haryana, together with Punjab, provided for 20% of national grain production. Growing population and pressures on land has led to soil degradation and extreme climatic events, as floods and droughts, becoming more evident and worrying since the '80s. Phenomena of environmental depletion described above are a serious risk for food security. The conventional model of food production has not developed in a way suitable to climate change adaptation and is vulnerable to extreme climatic events, especially in developing countries. Biodiversity loss and environmental depletion expose farming to diseases and external shocks, due to a lower threshold of resilience compared to that guaranteed by a healthy ecosystem. This means that the more intensive methods will be protracted, the more the environment will be endangered, and productivity may start to decline over time.

5. Concluding remarks

Developing countries are undergoing the same nutrition transition that developed countries have experienced decades ago. There is a widespread shift in dietary habits from traditional diets towards the so called western diet, rich in red meat, animal products, edible oils, fats, and, polished grains. Even though each country and each region is experiencing a different path, between 1970 and 1995-1997 the world calories intake from meat and vegetable oils has increased by 33% and 46% respectively, while energy intake from starch roots and pulses has decreased by 30%; although cereals still make up the largest share of the world's diet, the energy intake from fat and sugar is increasing everywhere, especially in Asia. The nutrition transition is caused by a multitude of interconnected dynamics. Economic growth and rising income levels in developing countries make energy-dense products far more accessible than before, while urbanization causes a "urban effect" on dietary habits, resulting in a shift of urban dwellers' dietary habits towards the North-American diet. Moreover, globalization and

[42] Tilman D. *et al.* (2002), "Agricultural sustainability and intensive production practices", *Nature* vol. 418, 8 August 2002, pp. 671-677.
[43] Scherr S. J. and Yadav S. (1996), "Land Degradation in the Developing World: Inplications for Food, Agriculture, and the Environment to 2020", *Food, Agriculture, and the Environment Discussion Paper 14*, May 1996, Washington D.C.: International Food Policy Research Institute.
[44] Singh R. B. (2000), "Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India", *Agriculture, Ecosystem, and Environment*, vol. 82 (2002), pp. 97-103.

the spread of mass media seem to affect the perception of food tradition, favoring the nutrition transition, even though evidence on the role of globalization is still controversial.

Thus, the nutrition transition entails an increasing production of energy-dense foods (meat, animal products, fats, edible oils). Cross country studies demonstrate that such change is happening at lower income levels than before, because the industrialization of agriculture and livestock has caused a general reduction in western food prices. As a consequence, the transition is happening today at a much faster pace than a few decades ago, so that in the short run there will be a further, significant increase in the demand for energy-dense foods. However, in conventional industrial agriculture processes, energy-dense foods require production methods having a deep impact on the environment.

Due to population growth and, consequently, soaring demand for nutritious food, conventional agriculture methods have been adopted in developing countries during the green revolution. The improvement of yields occurred in the last decades has been reached through the physical expansion of agricultural land and, above all, through intensification of production. The main features of the so-called conventional farming are: mechanization, greater use of fossil fuels, chemical fertilizers and pesticides, intensive monocrop cultivations. Although, in the short run, the industrialization of agriculture and livestock provided for higher production, in the long run damages to the environment are a serious issue. Beef livestock, as well as the use of agrochemicals result in a large share of climate-changing gas emissions; the introduction of HYV and monocropping practices threaten biodiversity; soils are depleted due to the massive employment of chemical fertilizers. Given that the high demand for foodstuff produced by industrial farming is expected to rise sharply, and that such methods are causing greenhouse gas emissions, loss of biodiversity, and soil degradation, there is a growing concern for the environment and for food security. Such considerations have raised interest in sustainable farming practices, based on traditional knowledge and new technology in a locally-specific approach, environmentally and socio-economically sustainable, representing a possible response to the increase in food demand.

References

Abrahams Z et al (2011) Diet and mortality rates in Sub-Saharan Africa: stages in the nutrition transition BMC Public Health 2011 11:801

Altieri MA (1999) The ecological role of biodiversity in agroecosystems, Agriculture, ecosystems, and Environment vol. 74 (1999): 19-31

Angelo MJ (2009) Corn, carbon and conservation: rethinking U.S. agricultural policy in a changing global environment ExpressO Available at: http://works.bepress.com

Barilla Center for Food and Nutrition (2011) Doppia piramide: alimentazione sana per le persone, sostenibile per il pianeta, Parma: BCFN

Baumung R, Hoffmann I (2010) Animal genetic diversity and sustainable diets in Burlingame B, Dernini S. (ed.) Sustainable diet and biodiversity, FAO – Food and Agriculture Organization: 82-93

Bermudez OI, Tucker KL (2003) Trends in dietary patterns of Latin America populations, Cad. Saude Publica, vol 19 (sup. 1): S87-S99

Boehlje M, Doering O (2000) Farm Policy in an Industrialized Agriculture, Journal of Agribusiness, vol. 18 no. 1, March 2000: 53-60

Campbell K, Noonan-Mooney K, Mulongoy K. J. (2010) Biodiversity, nutrition, and human wellbeing in the context of the Convention on Biological Diversity in Burlingame B, Dernini S. (ed.) Sustainable diet and biodiversity, FAO – Food and Agriculture Organization: 36-43

Drewnowski A, Popkin BM (1997) The Nutrition Transition: New Trends in the Global Diet, Nutrition Reviews vol 55 no. 2: 31-43

Drewnowski A (2000) Nutrition Transition and Global Dietary Trends, Nutrition vol. 16 no 7/8: 31-43

Foley JA et al.(2005) Global Consequences of Land Use, Science vol. 309, no. 570, July 2005: 570-574
Galal OM (2002) The nutrition transition in Egypt: obesity, undernutrition, and the food consumption context, Public Health Nutrition vol. 5 no 1A: 141-148
Ghassemi H, Harrison G, Mohammad K (2002) An accelerated nutrition transition in Iran, Public Health Nutrition vol. 5 no 1A: 149-155
Godfray HCJ et al (2010) Food Security: the Challenge of Feeding 9 Billion People, in Science, vol. 327 no. 5967: 812-818
Kennedy G, Nantel G, Shetty P (2004) Globalization of food systems in developing countries: a synthesis of country case studies, in FAO Paper no 83, Globalization of food systems in developing countries: impact on food security and nutrition, Rome 2004, pp 1-26
Kim S et al (2000) The Nutrition Transition in South Korea, American Journal of Clinical Nutrition vol. 71: 44-53
Kuhnlein HV et al. (2004) Arctic Indigenous Peoples experience the nutrition transition with changing dietary patterns and obesity, The Journal of Nutrition vol. 134 no 6: 1447-1453
Pinstrup-Andersen P, Pandya-Lorch R, Rosegrant MW (1999) World Food Prospects: Critical Issues for the EarlyTwenty-First Century, IFPRI Food Policy Report October, Washington D.C.: International Food Policy Research Institute
Popkin BM (2004) The Nutrition Transition: an Overview of the World Patterns of Change, Nutrition Reviews vol. 62 no 7: S140-S143
Popkin BM (2001) Nutrition transition: The changing global nutrition challenge, Asia Pacific Journal of Clinical Nutrition, vol 10 (suppl.): S13-S18
Popkin BM et al (2001) Trends in Diet, Nutritional Status, and Diet-related Non-communicable Diseases in China and India: The Economic Costs of the Nutrition Transition, Nutrition reviews vol. 59 no. 12: 379-390
Popkin BM (1999) Urbanization, lifestyle changes, and the nutrition transition, World Development vol. 27 no 11: 1905-1916
Pretty J (2007) Agricultural sustainability: concepts, principles and evidence, Philosophical Transactions of the Royal Society B, vol. 363 (2008) pp. 447-465
Satterthwaite D, McGranahan G, Tacoli C (2010) Urbanization and its implication for food and farming, Phil. Trans. R. Soc. B vol. 365 no. 1554: 2809-2820
Scherr SJ, Yadav S (1996) Land Degradation in the Developing World: Inplications for Food, Agriculture, and the Environment to 2020, Food, Agriculture, and the Environment Discussion Paper 14, May 1996, Washington D.C.: International Food Policy Research Institute
Singh RB (2000) Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India, Agriculture, Ecosystem, and Environment, vol. 82 (2002) pp. 97-103
Smith KA et al (1997) Emissions of N20 and NO associated with nitrogen fertilization in intensive agriculture, and the potential for mitigation, Soil Use and Management, vol. 13 Issue supplement s4: 296-304
Sonesson U, Davis J, Ziegler F (2010) Food Production and Emissions of Greenhouse Gases, SIK-Report no. 802, Göteborg: SIK – The Swedish Institute for Food and Biotechnology, ISBN 978-91-7290-291-6
Steinfeld H, Gerber P (2010) Livestock production and the global environment: Consume less or produce better?, PNAS vol. 107 no. 43, October 26, 2010: 18237-18238
Thrupp LA (2000) Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture, International Affairs vol. 76 no.2: 265-281
Tilman D et al (2002) Agricultural sustainability and intensive production practices, Nature vol. 418, 8 August 2002: 671-677
Websites
FAOSTAT database (2012) internet: http://faostat3.fao.org (consulted on August, 14th, 2013)
OECD (2012) Sustainable agriculture productivity growth and bridging the gap for small-family farms, Interagency report to the Mexican G20 presidency, 12 June 2012, internet: www.oecd.org (accessed on July 15th, 2013)