World agricultural policies for climate adaptation and energy conservation

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Abstract

Even if the primary and secondary agricultural sectors share 3 and 6% of world energy resources, associated management policies create secondary effects on world resources which have a much greater impact. Agriculture uses 60 and 37% of the world water and land resources, while generating 12% of greenhouse gases. Its low profitability explains: the rural migration towards urban areas increasing service issues and risks of climatic disasters; 25% food production wastage leading away from climate change adaptation. This paper proposes a solution favoring higher rural populations, and improved world food security and resource sustainability.
Keywords: resource, management, agriculture, energy, water, soil

Résumé

Si les secteurs agro-alimentaires primaire et secondaire n'utilisent que 3 et 6% des ressources énergétique mondiales, leurs politiques de gestion créent des répercussions beaucoup plus larges. L'agriculture utilise 60 et 37% des ressources mondiales en eau et sol, et génère 12% des gaz à effet de serre. Ses faibles profits expliquent : la migration rurale vers les milieux urbains augmentant un manque de services et des risques de désastres climatiques. Le présent article propose une solution améliorant les profits agricoles, diminuant les présentes pressions urbaines, et améliorant la sécurité alimentaire mondiale et la pérennité des ressources.
Mots clés : ressources, gestion, agriculture, énergie, eau, sol

1. Introduction

In the early 1970's, world starvation was predicted for the beginning of the 21st century [1]. In 2013, some 40 years later, with a world population increasing by almost 2 fold from 3.7 to 7.0 billion, agriculture is feeding the world better than ever yet with the same resources as in 1970. Agriculture is doing such a good job feeding the world that it is taken for granted by the population of North America and Europe. Nevertheless, agriculture has a wide spread impact on world resources, governed by world agricultural governance and policies. This impact is particularly important in terms of energy resources and climate change. Furthermore, to continue feeding the world population at its present growth rate, more sustainable agricultural resource management systems must be introduced. Such will be the topic of the present paper.

2. The world agricultural situation and climate change/energy consumption

Despite the fact that it continues to feed the world, agriculture is facing some major issues, which must be resolved to protect soil, water and air resources. Climate change has been strongly associated with energy usage while climate adaptation requires the more efficient use of resources. The primary agricultural sector was responsible for 3.0% of the world energy resource usage in 2004 (Table 1). This percentage varied from 1.1% for the USA, to 2.2-2.4% for Canada and Europe and over 3.0% for some of the countries under development. In Canada, the secondary agricultural sector uses about twice as much energy at a share of about 6%. The uncertainty in this number stems from the estimation of agriculture's share of freight transport which is not reported separately [2] (Tables 2).

If the direct energy share of the primary and secondary agricultural sectors is slightly less than 10%, both sectors have a far greater indirect impact on world climate change and resource usage, including energy. This is explained by the following facts.

2.1 Agriculture and world resource usage

Agriculture uses a major portion of world resources, and accordingly, any policy impacting agriculture, also impacts these resources. Agriculture occupies 37% of the globe's land surface or 4.9 billion ha out of a world land base of 13.4 billion ha [5]. Within this 4.9 billion ha used by agriculture, 1.54 billion ha are cropped and 3.35 ha are under natural pasture or meadow. In 1995, agriculture had a 65% share of the world fresh water withdrawals, compared to 9% for domestic and 20% for industrial purposes [6]. The remaining 6% was lost through reservoir evaporation. Interestingly enough, agriculture consumed 70% of the water it withdrew, as compared to 14 and 10% for domestic and industrial usages. Finally, in terms of atmospheric gas emissions, agriculture is responsible for 10-12% of greenhouse gas (CH_4 and N_2O) and 70% of ammonia emissions [7].

Although the caretaker for an important portion of world resources, farm operators have been challenged in terms of managing such resources because of world policies leading towards a constant drop of price at the farm, relative to inflation.

2.2 The impact of agriculture's low profitability

The price of agricultural produce at the farm has not increased since the early 1970's [1], while that of supplies, equipment and structures has climbed with inflation. The only exception is the price of cereals over the past few years because of their use as biofuel and wide spread unfavourable climatic conditions especially in North America. This price increase resulted as much from speculations as from actual production deficits. Over the past 40 years, inflation has dropped the price paid for produce at the farm by a factor of 10. Despite agricultural practices which have consistently adapted to become more efficient, the profitability of the agricultural sector has dropped leading to poor economic performance as compared to most other sectors. The results are serious issues of sustainability for world resource because: from the transformer's point of view, the produce is rather inexpensive and can be wasted at relatively little loss, and; from the producer' point of view, the low price at the farm does not provide the necessary capacity to face environmental issues.

Accordingly, a lack of evolution of produce prices at the farm is leading to accelerated climate changes through energy, resource and produce wastage, and poor climate change adaptation from the improper management of resources and population distribution. The following sections expand on these points.

Table 1. Energy share of the primary agricultural sectors [2, 3, 4]

Country/Continent	Energy share (%)	Energy usage (10^{12} J)
Canada	2.4%	8.2
USA	1.1%	98
Europe	2.2%	71.5
World	3.0%	

Table 2. Energy share of the primary and secondary sector in Canada [2]

Sector	Energy share (%)	Agricultural share (% total energy)	
		Primary	Secondary
Transportation			
- passenger	16.0%		
- freight	11.0%		3%
Buildings			
- residential	13.6%		
- commercial	17.0%		2%
Industrial	42.4%	2.4%	1%
Total	100.0%	2.4%	6%

2.2.1 Urban population migration for higher climatic risks and resource requirement

The first major impact resulting from this relatively poor economic growth for agriculture is the migration of populations towards urban centres (Figure 1) [8]. No matter the continent, urban population (UP) in 2005 was highly correlated to Gross Domestic Product (GDP). People leave rural regions because of their poor economic conditions, and move to urban centres hoping for a better job within a more prosperous economic sector.

In North America and most regions of Europe, the rural population has dropped to about 2% with 98% of the total population living in urban centres. The same trend is expected for Asia, especially with the economic growth of India and China, where a 50 to 70% rural population can also drop to less than 10%.

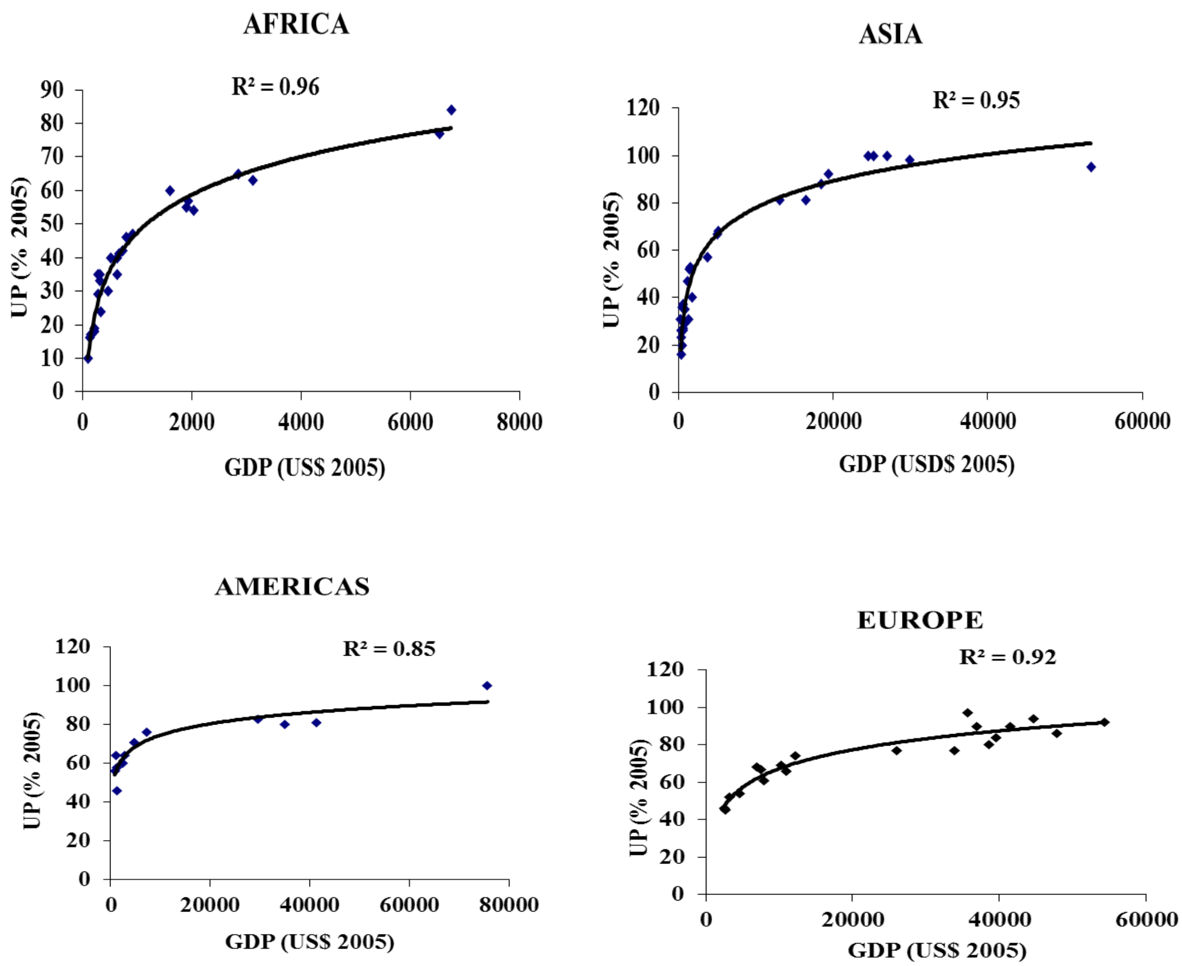

Figure 1. Percentage urban population (UP) as a function of Gross Domestic Product (GDP) for Africa, Asia, the Americas and Europe for 2005 [9].

The presently observed exponential growth of cities in Asia for example, is a challenge for local authorities unable to keep up with the installation of infra-structures, such as transportation, energy, drinking water, and garbage and wastewater services.

In terms of climate adaptation, mega cities result in a greater exposure of a larger population to disastrous climatic events. With respect to drainage, mega cities are more at risk of flooding and water damage because of paved surfaces preventing rainfall infiltration and generating more runoff. This issue is heightened in view that climate change causes more intense rainfall events. Furthermore, city expansions often rely on existing sewer systems which become insufficient as a result of climate change and increased drainage requirements [8].

Mega cities around the world are known to create strong localized atmospheric convective forces generating even more extreme climatic events [15]. Although cities are heat islands at 1 to 2 °C above surrounding regions, it's the tall buildings which generate storms by increasing wind drag and upward velocity. Accordingly, enlarging the canopies of a city may have little is any impact on attenuating convective climatic effects. As a result, cities are exposed to 30% more rainfall causing flash flooding and amplifying the climate change issue.

Many mega cities are located in coastal areas, augmenting population exposed to tsunamis and flooding as a result of higher sea levels and the increased occurrence of hurricanes.

Finally and in terms of resource utilization, cities have long been known to facilitate the provision of services, by concentrating users for example for power distribution and garbage pickup. But, mega cities also result in the world population becoming even more dependent on energy resources, because for example: all produce, equipment and wastes have to be transported over greater distances; people travel further to get to work creating traffic jams wasting energy and generating atmospheric pollutants including greenhouse gases, and; infra-structures are more costly because of the large capacity required.

2.2.2 Food wastage leading to resource sustainability and environmental issues

The second major impact resulting from this relatively poor economic growth for agriculture is the wastage of agricultural products, leading to: greenhouse gas emissions from the disposed produce; wastage of production fertilizer and energies; unnecessary soil erosion from the production surfaces, and; unsustainable resource management practices, when for example, phosphorous and fossil fuel reserves are being depleted.

According to FAO, 25% of the world food production is loss because: in developing countries, of a lack of storage, processing and transportation facilities, and; in developed countries, of food wastage after processing. Besides such factors, food wastage results from production levels exceeding markets often as a result of market price fluctuations producing incentives for overproduction, and produce quality not meeting aesthetics specifications [1].

Farms are often observed to grow produce in large quantities because of the high price of the produce during the previous growing season. This flux in production level often lowers the commodity price, leading to wastage because of a lack of market beyond transformation capabilities. In 2004, an over production of tomatoes was observed in Central Eastern India, as a result of high prices during the previous season. While tomatoes produced from irrigation were being left in the fields, the urban population relied on the Indian government to transport drinking water and refill the empty water storage tanks [1].

Tunisia offers a good example of food losses as a result of aesthetic reasons, where some 45 000 tonnes of dates are let unharvested, on an annual production of 113 000 tonnes (25 % wastage), because of a poor colour and appearance [11].

The loss of 25% of the world food production is demonstrated by a compilation of statistics presented in Table 3. An average reported food intake of the world population of 2710 kCal, compared to a food production after harvest of 3320 kCal, amounts to a 22% food lost worldwide. This loss excludes all production left in the fields, and Table 3 is a compilation of only the major food produce.

The 25% wastage of food production brings about the unnecessary use of resources and the production of atmospheric and water pollution. In turn, cities have to spend more in infra-structure and energy to provide drinking water to their population. If the loss of food production could drop to an acceptable level of 5 to 10% worldwide, some 15 to 20 million tons of nitrogen and 6 to 8 million tons of phosphorous fertilizers could be saved and waterways would be saved from some 55 to 75 thousand tons of herbicides, 25 to 35 thousand tons of insecticides and 1.1 to 1.5 billion tons of eroded soil at a low level of 5 tons/ha. These numbers are crude estimates because they are based on the total world fertilizer and pesticide usage. In terms of the phosphorous load only, water treatment processes could be reduced by $100 million annually [16]. In terms of preventing such contaminant load, the value of safer water for drinking and recreational purposes is estimated at $2 000 billion annually for 66 % of the world population depending on rivers and lakes for their supply. In industrialized countries another $2 500 billion could be recovered in terms of increased property value [17].

Interestingly enough, meat (excluding milk and eggs) is the produce which suffers the least wastage, likely because it is considered a luxury item in most countries. Among all meat productions, cattle play a major role in sustaining world food supply by using the natural meadows and pasture land of the world, accounting for 66% of the land cropped by agriculture. These meadows and natural pastures would otherwise not be used because of their stoniness or low rainfall. In countries such as Ethiopia, cattle play a major role in feeding the population. Cereal crops harvested every 6 months can only be preserved for 3 months, considering the climatic conditions and lack of proper storage facilities. On the other hand, cattle are fed from the straw and stalks left behind after harvesting cereals and from road side growth. Furthermore, live cattle does not need any storage facility until slaughtered. Being mono-gastric, poultry and pork productions consume only cereals, which otherwise could be used to feed the world population.

2.2.3 Food produce travel on the average 2 000 km

The third issue resulting from the low price of produce at the farm is the distance it travels in the order of 2 000km. For example, in 2008, oranges, bananas and apples consumed in grocery stores of the USA had travelled on the average 11 450, 3 200 and 10 400 km, respectively [12]. For the city of Edmonton Canada, organic produce sold in super markets had travelled 4 200 km compared to 1 500 for conventional produce [12].

Enjoying food produce out of season is a practice enjoyed by many countries, but importing produce to compete with those locally produced is a costly resource practice. Often this results from produce paid at the farm at a much lower price than that produced in the receiving (likely developed) country where labour cost especially are much higher.

2.2.4 Lack of change in farm enterprise ownership

The final major impact resulting from agriculture's relatively poor economic growth is the 'in-breeding' of its population. In developed countries, most farm enterprise are handed down at a lost cost from father to son, because of the high debt load and a revenue which cannot justify the value of the property. The high debt load resulted from: a constantly increasing demand and price for land as farms expand to maintain its revenue despite the greater margin between produce and supply prices, and; farm owners compensating for their lack of revenue by borrowing against the increasing value of their property [1]. For example, in the Montreal region of Canada, land is worth 25 000$/ha, representing annual interest payments at 6% of $1500/ha, as compared to a general net revenue expected from a cereal, corn or soybean crop ranging from $250 to $500, before interest and depreciation.

As a result, outsiders to the farming community cannot afford to purchase a farm because of a lack of net revenue, unless interested in investing funds for the future. Rather, farms are being handed down from father to son, or smaller operations are bought out by larger farms. The result is a farming community with no new entrepreneurship being introduced, thus impacting the innovative and managerial capability of the rural population. Nevertheless, the farming community exploiting its own land has a stronger culture of preserving one's heritage through whatever sustainable methods are feasible, as compared to investors expecting their farm employees to regularly generate profits [1].

In developing countries, the situation is worse with farm enterprises not being able to borrow against the value of their property. Even worst, farm operator do not even have the financial means of purchasing the proper supplies to crop their land, resulting in soil erosion and degradation and nutrient depletion in exchange for limited food production. The irony for developing countries, is that those producing food for the country are those most likely to starve.

With an agricultural population lacking 'new blood', the introduction of new practices is slowed down, including those related to climate change adaptation and sustainable resource management.

3. Greater climate change adaptation capacity by improving agriculture's profitability

The allocation of production quotas for some of the most perishable agricultural produce, such as milk, eggs and poultry, is a Canadian system which has worked extremely well in controlling commodity supply versus consumption, and in stabilizing prices while advantaging the producers, the manufacturers and the consumers. Furthermore, this system has ensured a relatively low level of wastage at all levels, thus encouraging sustainable practices and preserving resource for future generations. Nevertheless, the system is not without challenges.

The Canadian milk quota system is perhaps the most obvious example of success. It will be used to demonstrate how such a system can improve climate change adaptation, better protect world soil, water and air resources, and provide a better status of living for 50% of the world population, thus reducing world hunger.

3.1 Production management based on consumption

In Canada, the milk quota system was instituted in the early 1960's and although still a matter of debate, producers, transformers and consumers have consistently benefited from it. The quota system was first allocated based on the proportion of production of each party. Each year, this production right is adjusted based on consumption and reserves. The price given to the producers is based on a cost of production formula which includes measures based on production efficiency, environmental practices, soil and water conservation, product quality improvement and food safety assurance. Transformation quotas and price increases are also imposed onto the transformers, to complete the loop.

Table 3. World food production versus consumption [9]

	Continent							
	NA	CA	SA	Europe	Africa	Asia	Oceania	World
Population millions	344	156	393	738	4164	1022	36	6853
Food intake (kCal)	3500	2850	3000	3500	2600	2200	2800	2712
Food production (kCal)								
Cereals	6180	537	322	1395	1529	1033	857	1579
Fruits and vegetables	182	304	318	214	233	161	318	224
Meat	1443	533	945	1062	349	180	2195	504
Oils	834	157	1726	499	310	67	298	386
Sugar	231	370	1180	279	130	97	1314	218
Roots and tubers	100	30	179	211	110	332	167	156
Pulses	160	90	78	58	52	103	167	156
Nuts	149	34	41	16	104	164	24	100
Total	9279	2055	4789	3734	2817	2137	5340	3323

Note: cereals exclude that used to feed livestock; meat include milk and eggs; only major oils are considered, such as soybean, olive and palm; nuts include tree nuts and peanuts; the values in this table were computed from statistics available from FAO [9].

: NA- North America, CA- Central America; SA- South America.

Within the quota system, producers are paid a fair price for their product but expected to produce high quality milk. Limited government support is required to manage the program and the consumer pays for the full but fair price of the produce. In Canada, the price paid at the store for dairy products is generally share equality between the farm producer and the transformer. Yet, the price of milk in Canadian grocery stores is the same as that found in grocery stores of the USA, for exemple, implying that profits are better shared. This can be contrasted with: wheat, where its value in a loaf of bread is only 5%, and; meat where the farm value ranges from 10 to 15%.

Compared to their USA neighbours, Canadian dairy farms enjoy better infra-structures especially in terms of dairy barns, with more insulation for a more efficient milk production requiring less feed. Money saved in the cost of barns is generally spent during its life time in higher feed cost because of greater exposure to adverse climatic conditions. Barn insulation requires less resources and is therefore a ‘greener’ practice. Greater revenue security allows Canadian dairy farmers to obtain long term financing for better infra-structures. Canadian dairy transformers are also better able to plan their financial year and manage their cost, thus enabling them to have a high equity. For this reason, two important Canadian transformers have used their strong financial status to purchase plants in the USA and take advantage of a larger market.

Milk wastage is reduced by the Canadian dairy system, both at the farm and at the plant. At the farm, production is matched with consumption. At the plant, a litre lost is a litre less in sales. Canadian transformers operating plants in the USA observe raw milk wastage as a common occurrence also creating wastewater treatment issues [1].

Nevertheless, the size of Canadian dairy farms has been limited by the fact that producers needed to purchase quota. Although, this is true, it should also be considered that if all farm produce were under quota, less competition would exist between agricultural sectors and quota prices would likely be lower. There would also be less pressure for farms to expand to stay profitable, resulting in more affordable land prices.

3.2 Applying production management practices worldwide

When properly managed, production quota systems match consumption thus: preventing the fluctuation of market prices; diminishing speculation to advantage both the producer and consumer; reducing wastage to a strict minimum for more sustainable resource management including energy, and; building calculated reserves to improve food security. Furthermore, farm producers are guaranteed a specific level of profitability, determined by a pricing formula based on the price of supplies, equipment, and property value, and on accepted sustainable and environmental practices. The living standard of the rural population can therefore be improved, allowing them to acquire better food storage facilities, thus reducing risks of starvation in many regions of the world.

Implementing production systems based on consumption worldwide would bring about many advantages in terms of climate change adaptation. First of all, about 50% of the population in Africa, Asia and South America would benefit from a revenue allowing them to use sustainable resource practices. The rural population wold also benefit from an improved standard of living, thus reducing the level of poverty in rural areas.

Because farms would be better able to hire labourers besides the family members, the migration of population towards cities would slow down and be perhaps reversed. This would provide for a more uniform population distribution around the world and less risk of damage during adverse climatic events created by mega cities [8].

Farm operators would have better means of improving their production efficiency, quality and storage without government subsidies, leading towards better world food security. For example, one of the reason for low yields in Africa, is the lack of financial means to purchase mineral fertilizers. Through better means, crop yield could be improved and even less land would be required to feed the same population. It has also been demonstrated that better fertilized crops make better use of irrigation water [14] and can be more resistant to diseases and insects.

In developed countries exporting agricultural produce, a lower production would be compensated by a higher price, thus providing the same revenue. For the consumer, the farm share of the grocery store shelf price is so low, that even doubling the farm revenue would increase the shelf price by only 10 to 15%. In developing countries, a higher price for food produce would be compensated by a lower class population, mostly made up of the rural community, which could better afford its purchase.

Implementing production management systems worldwide for all food produce could prove to be a challenge. First of all, the transition requires adaptation and training of the farm producers to be able to wisely manage new revenues. Secondly, higher farm revenues must be accompanied by improve environmental and sustainable practices, when most farm operators of the world have very little education.

4. Conclusion

This paper demonstrated that agriculture is a principal resource user around the globe. Past agricultural policies and management practices have reduce the profitability of farm enterprises leading to: large population migration towards urban sectors increasing risks associated with climate change, especially in Asian countries; important amounts of food produce wastage at all levels of the production chain leading to poorer drinking water quality for 66% of the world population; unsustainable world resource utilization; accelerated climate change effects; higher risk of food safety and more marked starvation worldwide especially for the rural communities, and; a lack of capacity for climate change adaptation.

This paper demonstrated that an interesting solution is the matching of production with consumption. Better revenues at the farm, would improve the living standard of about 50% of the world population (especially the rural population); decrease if not reverse the migration of populations towards urban centres while decreasing the stress for such cities to provide services, and; reduce risks of climate disasters. Although production management systems could provide some means to reaching this goal, its implementation would be challenging and would require some transition time for the training of the rural communities.

5. References

[1] Barrington S. Forty years of Canadian and International experience in the agro-food industry. Consumaj Inc., St Hyacinthe, Qc.

[2] Natural Resource Canada, Energy use handbook 1999 to 2009. Ottawa, Canada, 2012.

[3] Schenkel Y., Energy as a driver for European agriculture, forest, bioenergy and bio products. Agricultural Research Station, Wallonia, 2010.

[4] Schnepf R., Energy use in agriculture background and issues. CRS report for US Congress, Order Code RL 32677, Washington, DC, USA, 2004.

[5] FAO. Crop production and natural resource use. In: World agriculture: Towards 2015/2030. An FAO perspective. www.fao.org/docrep/005/y4252e/y4252e06.htm. Consulted on February 15th, 2013.

[6] World water Council. Chapter two: the use of water today. www.worldwatercouncil/org. Consulted February 15th, 2013.

[7] Working group for the 4th assessment report of the Intergovernmental panel on Climate change. Chapter 8, Agriculture. In: Climate change 2007: Mitigation. 2007, Cambridge University Press, Cambridge, UK.

[8] United Nation, Climate change an urbanization. Expert group on population distribution, urbanization, internal migration and development, report UN/POP/EGM-URB/2008/16, 2008, Department of Economics and Social Affairs, New York, USA.

[9] Adhikari B., Barrington S., Martinez J., Predicted growth of food waste production from urban areas around the world. *Journal of International Waste Management*, 24, 2006, pp. 421-433

[10] FAO. Statistics on world agriculture: www.fao.org/corp/statistics/en/, Consulted on February 8th, 2013.

[11] Trigui M., Gabsi, K., El Amri, I, Barrington S.,Modular feed forward networks for predicting sugar diffusivity from date pulp Part I. Model validation. *International Journal of Food Properties*, Vol. 14, 2010, pp. 356-370

[12] Bernatz, G., Apples, bananas and oranges: using GPS to determine distance travelled, energy use and emissions from imported fruits. St Mary's University, Winoma, MN, USA

[13] Burt, V., Buy local: organic food miles offset benefits, Department of Anthropology, University of Alberta, Edmonton, Canada, article published in Science Daily, June 7th, 2010.

[14] Tani, F., Barrington, S. Zinc and copper uptake by plants under two transpiration rates. Part I. Wheat (*Triticum æstivum L.*). *Journal of Environmental Pollution*, Vol. 138, 2005, pp. 549-548

[15] Ntelekos, A.A., Smith, J.A., Krajewski, W.F., Climatological analysis of thunderstorms and flash floods in the Baltimore metropolitan region, *Journal of Hydrometeorology*, Vol. 8 (1), 2007, pp88-101

[16] Jiang, F., Beck, M.B., Cummings, R.G., Rowles, K., Russell, D., Estimation of cost of phosphorous removal in wastewater treatment facilities: adaptation of existing facilities. Water Policy Working Paper 2005-011, Georgia Soil and Water Conservation Commission, US EPA and USDA, 2005, pp 45

[17] Sawyer, D., Chung, L., Renzetti, S., Cost benefit of cleaner source water. Marbek resource consultants Ltd. and Brock University. Canadian Council of Environmental Ministers, Project 38-2007, 2007, pp 58

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7. Biography

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