Society issues, painkiller solutions, dependence and sustainable agriculture

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Abstract

Mahatma Gandhi listed seven blunders of humanity: Wealth without work, Pleasure without conscience, Commerce without morality, Worship without sacrifice, Politics without principles, Knowledge without character, and Science without humanity.

Here I tackle three major issues, climate change, financial crisis and nation security, to disclose weak points of current remedies, and to propose sustainable solutions. Global warming and the unexpected financial crisis will undoubtedly impact all nations. Treating those two critical issues solely by painkiller solutions will fail because only adverse consequences are healed, not their causes. Therefore all sources of issues must be treated at the same time by enhancing collaboration between politicians and scientists.

Furthermore, the adverse consequences of globalisation of markets for energy, food and other goods have been overlooked, thus deeply weakening the security of society structures in the event of major breakdowns. Therefore dependence among people, organisations and nations must be redesigned and adapted to take into account ecological, social and security impacts. Solving climate, financial and security issues can be done by using tools and principles developed by agronomists because agronomy integrates mechanisms occurring at various space and time levels. Agriculture is also a central driver for solving most society issues because society has been founded by agriculture, and agriculture is the activity that provides food, renewable energies and materials to humans.

I present a to-do list summarising the major practices, principles and benefits of sustainable agriculture based on about 100 recently-published review articles. The practices are agroforestry, allelopathy, aquaculture, beneficial microorganisms and insects, biofertilisation, biofuels, biological control, biological nitrogen fixation, breeding, carbon sequestration, conservation agriculture, crop rotation, cover crops, decision support systems, grass strips, integrated pest management, intercropping, irrigation, mechanical weed control, mulching, no tillage, organic amendments, organic farming, phytoremediation, precision agriculture, seed invigoration, sociology, soil restoration, suicidal germination, terracing, transgenic crops, trap crops, and urban agriculture.

Financial crisis, climate change and the painkiller solution

Society is actually experiencing an unexpected financial crisis that will undoubtedly impact all nations (Beyond growth, 2008). It will affect in particular the poorest countries that are already suffering from hunger and diseases. Governments are attempting to heal this issue by injecting large amounts of money in banking systems and major companies. At the same time, effects of climate change are accelerating and deeply altering ecosystems (IPCC, 2007). Recent alarming reports even warn that it is already too late to stop global warming, though the forecasted value of the warming in degrees C and the date at which it will occur are still debated (Vince, 2009). Given the urgency geoengineering - the notion that to save the planet we must artificially tweak its thermostat by, e.g., firing fine dust into the atmosphere to deflect sun rays - is even gaining cause as a rapid solution to attempt cooling earth (Brahic, 2009). Injecting government cash and geoengineering are both urgency actions that may indeed temporarily heal the financial market and the effects of climate change. Nonetheless, those two strategies suffers from the same drawback. Both are "fireman" or "painkiller" solutions, meaning that only adverse consequences are treated, not the cause of those effects (Lal, 2009a, Lichtfouse, 2009a).

Enhancing politician and scientist collaboration

Treating solely negative effects without treating sources will undoubtedly fail in the long run. Therefore I strongly advice that politicians and other policy-makers treat the source of the adverse effects. This can be done by closer collaboration with scientists. It is indeed unacceptable that almost nothing has been done to counteract global warming before 2007, knowing that the Nobel Prize winner Svante Arrhenius has clearly predicted in 1896 - more than a century ago - that temperature will rise of about +5°C as a result of fossil fuel burning (see Lichtfouse, 2009b and refs. therein). In the next section I discuss dependence, another critical and overlooked factor, and its implication on the security of our society.

Rethinking society dependence

Globalisation of the market for food, fuels and other goods has undoubtedly induced positive effects such as lowering prices and fostering collaborations among citizens and nation. However, it has also induced serious dependence-induced problems such as a sharp increase of maize prices in Mexico following the fast-rising use of maize as biofuels in northern countries. Another striking example is the peak of petroleum prices that has impacted almost all nations. A recent failure of the European electricity grid resulting in thousands of home without current for several days further illustrates the weaknesses of global dependence. We also know that crop control with pesticides is contaminating drinking water, even many years after the ban of those pesticides (Barth et al., 2009). And so on. As a result, though we live at a time of outstanding technology, the excess of dependence created by wild globalisation has strongly weakened our society. In case of major catastrophic events, the society structures were probably more secure 100 years ago because most people were farmers, producing and consuming locally. The fundamental sources of our actual society issues are evidenced in the visionary article by Dr. Rattan Lal, entitled *Tragedy of the global commons: soil, water and air* (Lal, 2009b).

Though this is a very sensitive topic because dependence is the basis of most public and private organisations, the adverse effects of dependence have been largely overlooked because benefits such as growth and profit have predominated until now. Environmental, social and security impacts have indeed not been taken into account. Therefore we should rethink dependence. More specifically, the production of food, fuels and other goods, their transportation and their selling should be redesigned and controlled to lower dependence among people and nations. For instance, producing and consuming food more locally will both reduce dependence and decrease the ecological footprint of long-range transportation. Switching partly to renewable, locally-produced energies will also produce a similar positive effect.

Of course, less dependence does not mean no dependence and no collaboration among people and nations. The degree of dependence should be adapted to the nature of goods or energy, their transportation, their selling, their ecological footprint, and their social impact. Some goods may be distributed globally without weakening nations, others not. Obviously, the southern, poorest nations should be at the same time supplied with food and helped to produce their own food and energy. Scientists and policy-makers should therefore study, assess and enforce the relevant level of goods circulation. Here, the tools developed by agronomists to build sustainable farming systems should be particularly useful because agriculture is the foundation of society (Lal, 2009c, Lichtfouse et al., 2009f). Agronomists are indeed experts at deciphering mechanisms occurring at various scales, from the molecule to the global scale, and from seconds to centuries.

Agronomy should thus be used as a core tool to build a sustainable society. Table 1 gathers the major practices, principles and benefits of sustainable agriculture. It should thus help readers to build rapidly an overall vision of current innovative tools and approaches to save the world.

Table 1. Practices, principles and benefits of sustainable agriculture. Most citations are review articles published in the following books: Sustainable Agriculture (Lichtfouse et al. 2009g); Sustainable Agriculture Reviews, Vol. 1 Organic farming, pest control and remediation of soil pollutants (Lichtfouse, 2009c); Sustainable Agriculture Reviews, Vol. 2 Climate change, intercropping, pest control and beneficial microorganisms (Lichtfouse, 2009d); Sustainable Agriculture Reviews, Vol. 3 Sociology, organic farming, climate change and soil science (Lichtfouse, 2009e, this volume).

PRACTICES	BENEFITS	References
AGROFORESTRY Homestead agroforestry	Carbon sequestration Diversification Disease control Employment Food security Higher biodiversity Higher relative plant density Less soil erosion Mitigate climate change Nutrient recycling Pest control Water quality	Carrubba and Catalano, 2009 Etchevers et al., 2009 Lal, 2009e Malézieux et al., 2009 Miah and Hussein, 2009 Palaniappan et al., 2009 Spiertz, 2009 Zuzao and Pleguezuelo, 2009
ALLELOPATHY Biofumigation Hormones Plant growth regulators and other biochemicals	Adaptation to climate change Decreasing costs Drought tolerance Food security Increase water uptake Less pesticides Weed control	Aroca and Ruiz-Lozano, 2009 Biesaga-Kocielniak and Filek, 2009 Farooq et al., 2009a,b Kalinova J., 2009 Khan et al., 2009b Martínez-Ballesta et al., 2009 Runyon et al., 2009 Wu et al., 2009
AQUACULTURE	Diversification Food security Recycling farm wastes	Palaniappan et al., 2009
BENEFICIAL MICROORGANISMS AND INSECTS	Bioremediation Biosensors Cheaper fertilisation Disease control Drought tolerance Increasing nutrient uptake Increasing plant growth Pest control Phytoremediation Pollinisation	Aroca and Ruiz-Lozano, 2009 Bonilla and Bolaños, 2009 Deguine et al, 2009 Gamalero et al., 2009 Garg and Geetanjali, 2009 Ghorbani et al., 2009a Gregoire et al., 2009 Holb, 2009 Joner and Leyval, 2009 Khan et al., 2009a,b Latour et al., 2009 Saha, 2009 Viebahn et al., 2009 Wrage et al., 2009 Yair et al., 2009
BIOFERTILISATION Biofortification Foliar sprays	Disease resistance Drought resistance Higher micronutrient levels Less malnutrition Improving human health Salt resistance	Bonilla and Bolaños, 2009 Dordas, 2009 Farooq et al., 2009a Ghorbani et al., 2009a Viebahn et al., 2009 Wrage et al., 2009 Zuo and Zhang, 2009
BIOFUELS	Carbon neutral Higher biodiversity Local source of energy Mitigate climate change Renewable fuels	Ceotto, 2009 Lal, 2009d,e Hill, 2009 Miah and Hussein, 2009 Scholz et al., 2009

Table 1 (continued)

PRACTICES	BENEFITS	References
BIOLOGICAL CONTROL (See also beneficial organisms and insects)	Cheap control Disease control Higher biodiversity Less or no pesticide Pest control Wildlife conservation	Askary, 2009 Clergue et al., 2009 Deguine et al, 2009 Ferron and Deguine, 2009 Ghorbani et al., 2009b Holb, 2009 Latour et al., 2009 Viebahn et al., 2009 Yair et al., 2009
BIOLOGICAL NITROGEN FIXATION (See also cover crops)	Alternative fertilisation Food security Increases plant growth Increases soil N Less, no mineral fertilisers Local fertiliser Mitigate climate change Nutrient recycling	Bonilla and Bolaños, 2009 Garg and Geetanjali, 2009 Khan et al., 2009b Knörzer et al., 2009 Rodiño et al., 2009 Spiertz, 2009
BREEDING Recurrent mass selection	Adaptation to climate change Disease resistance Drought resistance Genetic diversity Salinity resistance	Banilas et al., 2009 Carrubba and Catalano, 2009 Hejnak et al., 2009 Marais and Botes, 2009 Martínez-Ballesta et al., 2009
CARBON SEQUESTRATION (See also organic amendments)	Decreases erosion Higher nutrient retention Higher soil biodiversity Higher water retention Mitigate climate change Offset CO_2 emissions Prevent desertification	Anderson, 2009b Erhart and Hartl, 2009 Benbi and Brar, 2009 Bernoux et al, 2009 Etchevers et al., 2009 Füleky and Benedek, 2009 Ghorbani et al., 2009b Lal, 2009c,d,e,f Malézieux et al., 2009 Nguyen, 2009 Pati et al., 2009 Shaxson, 2009 Stagnari et al., 2009
CONSERVATION AGRICULTURE	Air, soil and water protection Biodiversity conservation Decreases erosion Decreases pollution Higher water retention Improves soil structure Mitigates climate change Reduces farm costs Reduces flooding Reduces work time	Palaniappan et al., 2009 Stagnari et al., 2009
CROP ROTATION	Biofertilisation Enhances soil organic matter Increases biodiversity Increases soil N Increases water use efficiency Plant disease control Water conservation Weed control	Anderson, 2009a,b Dordas, 2009 Erhart and Hartl, 2009 Ghorbani et al., 2009a Kalinova J., 2009 Lal, 2009e Spiertz, 2009 Stagnari et al., 2009
COVER CROPS	Improves fertility Improves water availability Nutrient recycling Reduces costs Soil erosion and runoff control Weed control	Kalinova J., 2009 Malézieux et al., 2009 Pati et al., 2009 Runyon et al., 2009 Wu and Sardo, 2009 Stagnari et al., 2009 Zuzao and Pleguezuelo, 2009

Table 1 (continued)

PRACTICES	BENEFITS	References
DECISION SUPPORT SYSTEMS Farming systems Indicators Land husbandry Modelling	Assesses sustainability Designs sustainable practices Integrates various sciences Integrates space and time levels Forecasts farming system evolution Forecasts impacts Optimises ecological benefits Optimises performance	Barth et al., 2009 Bockstaller et al., 2009a,b Clergue et al., 2009 Debaeke et al., 2009 Doré et al., 2009 Duru and Hubert, 2009 Faivre et al., 2009 Handayani and Prawito, 2009 Karami and Keshavarz, 2009 Mir and Qadrri, 2009 Roger-Estrade et al., 2009 Sadok et al, 2009 Shaxson, 2009 Veldkamp et al., 2009 Wu and Sardo, 2009 Zamykal and Everingham, 2009
GRASS STRIPS Buffering strips Filtering strips Artificial wetlands	Degrades pesticides Reduces soil erosion Reduces water pollution	Gregoire et al., 2009 Lacas et al., 2009 Wu and Sardo, 2009
INTEGRATED PEST MANAGEMENT	Decreases pesticide input Decreases pollution Decreases cost	D'Addabbo et al., 2009 Deguine et al, 2009 Ferron and Deguine, 2009 Holb, 2009 Wu and Sardo, 2009
INTERCROPPING	Biofortification Decreases erosion Increases biodiversity Increases yield Increases soil nitrogen Recycles nutrients Pest control Plant disease control	Carrubba and Catalano, 2009 Deguine et al, 2009 Dordas, 2009 Etchevers et al., 2009 Kalinova J., 2009 Knörzer et al., 2009 Malézieux et al., 2009 Palaniappan et al., 2009 Spiertz, 2009 Zuo and Zhang, 2009
IRRIGATION Drip irrigation	Food security Saves water	Hillel, 2008 Lal, 2009e Palaniappan et al., 2009 Wu and Sardo, 2009
MECHANICAL WEED CONTROL Solarisation Flaming Heating	Disease control Food security Increases yield Increases plant growth Improves water availability Increases soil nutrients Less or no herbicides Weed control	Anderson, 2009a Carrubba and Catalano, 2009 Chicouene, 2009 D'Addabbo et al., 2009 Holb, 2009
MULCHING (See also Organic amendments and Carbon sequestration)	Improves soil structure Prevents frost damage Soil water conservation Soil temperature moderation Weed control	D'Addabbo et al., 2009 Kalinova J., 2009 Lal, 2009e,f Wu and Sardo, 2009 Shaxson, 2009

Table 1 (continued)

PRACTICES	BENEFITS	References
NO TILLAGE Reduced tillage Conservation tillage Direct seeding	Disease control Improves soil structure Increases biodiversity Increases carbon sequestration Mitigates climate change Reduces erosion Reduces farm costs Reduces work time Water retention	Anderson, 2009a,b Bernoux et al., 2009 Deguine et al., 2009 Etchevers et al., 2009 Ghorbani et al., 2009a Lal, 2009e,f Pati et al., 2009 Roger-Estrade et al., 2009 Wu and Sardo, 2009 Scholz et al., 2009 Shaxson, 2009 Stagnari et al., 2009
ORGANIC AMENDMENTS Sewage sludge Manure Organic mulch Biochar Biosolid Compost Crop residues Wood, etc. (See also Carbon sequestration)	Buffers soil temperature Cheap fertilisation Carbon sequestration Disease control Decreases erosion Increases microbial activity Increases yield Improves soil structure Mitigates climate change Recycles waste Stores soil nutrients Water retention	Baize, 2009 Bernoux et al., 2009 Dordas, 2009 Etchevers et al., 2009 Erhart and Hartl, 2009 Füleky and Benedek, 2009 Ghorbani et al., 2009a,b Gresta et al., 2009 Holb, 2009 Kalinova J., 2009 Lal, 2009e Palaniappan et al., 2009 Pati et al., 2009 Saha, 2009 Scholz et al., 2009 Shaxson, 2009 Sigua, 2009 Spiertz, 2009 Stagnari et al., 2009
ORGANIC FARMING	Carbon sequestration Decreases erosion Disease control Food security Increases biodiversity Increases fertility Increases soil carbon Increases soil nitrogen Higher soil quality Improves soil structure Mitigates climate change Recycles nutrients Social improvement	Erhart and Hartl, 2009 Füleky and Benedek, 2009 Ghorbani et al., 2009a,b Handayani and Prawito, 2009 Holb, 2009 Kalinova J., 2009 Lamine and Bellon, 2009 Saha, 2009 Wu and Sardo, 2009 Spiertz, 2009 Winter and Davis, 2007
PHYTOREMEDIATION See also Grass strips	Aesthetic improvment Cleans soil, water and air Decreases pollutant bioavailabilty Decreases pollutant toxicity Decreases pollutant concentration Degrades organic pollutants Extracts metals from soils Low-cost remediation Socially-acceptable reclamation	Al-Najar et al., 2005 Babula et al., 2009 Baraud et al., 2005 Harvey et al., 2002 Joner and Leyval, 2009 Khan et al., 2009b Morel et al. 1999 Rodriguez et al., 2005 Scholz et al., 2009 Wahid et al., 2009
PRECISION AGRICULTURE Robotic agriculture	Disease control Manages crop variability Manages crop conditions variability Optimises fertilisation Optimises watering Weed control	Wu and Sardo, 2009 Unibots Zamykal and Everingham, 2009

Table 1 (continued)

PRACTICES	BENEFITS	References
SEED INVIGORATION	Dormancy management Drought resistance Flood resistance Increases yield Low temperature resistance Salt stress resistance	Farooq et al., 2009a,b
SOCIOLOGY Indigenous knowledge	Behaviour, attitude approach Better adoption of practices Eco-protection Ecological modernisation Equity Human dimension, traditions Integrated, holistic approach Integrates economic factors Integrates people culture, religions Resource-conserving practices Tackles sources of issues	Handayani and Prawito, 2009 Karami and Keshavarz, 2009
SOIL RESTORATION	Decreases desertification Decreases poverty and hunger Decreases soil erosion Disease control Food security Increases biodiversity Increases yield Improves water quality Less pollutants	Anderson, 2009b Baize, 2009 Barth et al., 2009 Bernoux et al., 2009 Changwen and Jianmin, 2009 Etchevers et al., 2009 Erhart and Hartl, 2009 Ghorbani et al., 2009a,b Handayani and Prawito, 2009 Knörzer et al., 2009 Lal, 2009a,b,c,d,e,f Pati et al., 2009 Roger-Estrade et al., 2009 Saha, 2009 Sigua, 2009 Shaxson, 2009 Wrage et al., 2009
SUICIDAL GERMINATION	Parasitic plant control	Runyon et al., 2009
TERRACING	Carbon sequestration Increases yield Soil erosion control	Doumbia et al., 2009 Zuzao and Pleguezuelo, 2009
TRANSGENIC CROPS	Biopesticide Drugs, vaccines Easier weed control Higher income Increases yield Insect management Less pesticide treatments Reduced tillage	Bonny, 2009 Deguine et al., 2009 Devos et al., 2009 Graef et al., 2009 Marvier, 2009 Sanchis and Bourguet, 2009 Torres et al., 2009
TRAP CROPS	Pest control	Deguine et al, 2009 Kalinova J., 2009 Runyon et al., 2009 Torres et al., 2009
URBAN AGRICULTURE Local agriculture	Food security Lower prices Less environmental footprint Less transportation Local production and use Mitigates climate change Recycles wastes Provides employment	De Bon et al., 2009 Miah and Hussein, 2009

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