

How Can India Help Prevent Food Price Volatility?

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Abstract This article is about India's role in reducing food price volatility in the world. India has come a long way from a 'ship-to-mouth existence' to a country that is ready to confer legal right to food to its citizens based on its own production. India has 18 per cent of the world's population and therefore food self-sufficiency of India would be a blessing for the struggle against price volatility. By improving productivity, by reducing energy use, by augmenting water resources and by conserving prime farm land, India can produce enough food for an estimated population of 1.5 billion by 2030. Further, by controlling speculative trade in food prices, by maintaining stable domestic prices and by sharing its agricultural and food policy expertise, India can help reduce food price volatility. However, to reduce global price volatility and to remove price distortions in the world market, it is important to resolve the issues of agricultural trade and to adopt a small farmer-friendly global trading system.

1 Historic transition in India's agricultural history

India's population at the time of its independence in 1947 was about 300 million. Yet the country was very short of food then, and memories of the great Bengal famine of 1942–43, which resulted in the death due to starvation of over 2 million children, women and men, were fresh. High priority was hence accorded to agricultural research, education and extension from 1950 onwards, when India started its Five Year Plans for development. Much of the investment in agriculture went to large irrigation projects and to the manufacture of fertiliser and other inputs. A national extension service was organised to help in bridging the gap between available scientific know-how and field level do-how. Agricultural research and education were strengthened through the organisation of a national network of Agricultural Universities based on the Land Grant Universities of the United States.

Thanks to rapid advances in preventive and curative medicine after the Second World War, death rates started falling while birth rates remained more or less constant in most parts of India. Population growth became rapid and, today, India's population exceeds 1.2 billion, or four times the population of 1947. In addition,

there is the need for feed and fodder as well as grazing land for over 1 billion farm animals (cattle, buffalo, sheep, goats and poultry). During the 1950s and 1960s the country depended on concessional food imports, particularly under the PL-480 programme of the USA, to fill the gap between demand and supply. Such imports touched a peak of 10 million tonnes in 1966, leading to India being described as a nation living on a ship-to-mouth basis.

The beginning of the green revolution era in 1968 helped to change this dismal scenario and India soon became self-sufficient in its food requirements at the prevailing level of purchasing power. Economic rather than physical access to food became the primary cause for the persistence of extensive endemic hunger. It is this component of hunger that is being addressed through the National Food Security Bill introduced in the Indian Parliament in December 2011. The current production of foodgrains in India is about 250 million tonnes, with rice and wheat contributing over 70 per cent. The Food Security Bill confers the legal right to highly subsidised rice, wheat or nutri-millet (often referred to as coarse cereals) to about 75 per cent of the rural and 50 per cent of the urban population. The implementation of this right will involve the distribution of over

Table 1 Indian wheat imports/exports and world prices

1	2	3	4
Year	Imports	Exports	Int. price
	000 tonnes	000 tonnes	US\$/ton
2000–01	4.22	813.49	129.65
2001–02	1.35	2649.38	150.83
2002–03	nil	3671.25	149.64
2003–04	0.46	4093.08	161.31
2004–05	nil	2009.35	157.81
2005–06	nil	746.18	199.65
2006–07	6079.56	46.64	263.8
2007–08	1793.21	0.24	344.58
2008–09	0.01	1.12	235.69
2009–10	164.38	0.03	240.81

Source Columns 2 and 3, Gol (n.d.); Column 4, FAO (2011) Global Food Price Monitor.

60 million tonnes of foodgrains at a very low price. When the Act is passed by Parliament and gets implemented probably towards the middle of 2012, India will be operating the largest social protection programme against hunger in the world. *This historic transition from a ship-to-mouth existence to conferring the legal right to food implemented with homegrown food is India's greatest contribution to combating price volatility in the global market.*

Experience in the past has shown that entry into or exit out of the international grain markets by India as an importer and exporter of grain tends to influence the prices: '... observations that international rice prices surged in response to export restrictions by India and Vietnam suggested that trade-related factors could be an important basis for overshooting, especially given the very tangible link between export volumes and export prices' (Headey 2010). It was also obvious that, among other factors such as the level of international food stocks, the demand from importing countries such as India also contributed to the price rise, albeit sometimes with a lag. The data show that international wheat prices jumped when India entered the market as an importer. A food self-sufficient India, which takes care of the needs of about 18 per cent of the human population, is hence a blessing in the struggle against high price volatility.

2 India's multi-pronged strategy to reduce price volatility

In addition to improving domestic food supply, India has launched a multi-faceted programme to insulate the poor against food inflation and unfavourable price fluctuations. Among the steps designed to control food inflation at home, and extreme price volatility abroad, the following are important.

2.1 Improve domestic food supply

A US\$5 billion programme titled *Rashtriya Krishi Vikas Yojana* (National Agricultural Development Programme) has been launched to help bridge the prevailing gap between potential and actual yields in the fields of farmers with smallholdings. That this gap is wide will be evident from the fact that the productivity of foodgrains in China is currently 5,322kg/ha, while it is 1,909kg/ha in India. An important component of food inflation in India is the high cost of vegetables, fruit, milk, egg, poultry products and pulses (grain legumes). Steps have been taken to eliminate the demand–supply gap in relation to all these food items. A National Horticulture Mission has been launched to increase the production of vegetables and fruit to over 300 million tonnes by 2015. Similarly, 60,000 villages are being converted into 'Pulses Villages', to enable farm

families to produce a wide range of pulses, enough to bridge the existing demand–supply gap of 3–4 million tonnes. Already, this programme has helped to raise annual pulses production from 16 to 18 million tonnes. The target for milk production is 200 million tonnes by 2030 as against the existing production of 115 million tonnes (India already leads the world in milk production). *The aim of all these initiatives is to both improve domestic food supply and minimise demand on global markets.*

2.2 Maintain stable domestic prices

Domestic food prices of staple grains have been kept under check by building substantial grain reserves and by operating a vast Public Distribution System which ensures the availability of wheat and rice at low prices to the economically underprivileged sections of the population.

3 National Food Security Bill 2011

The stated goal of the National Food Security Bill 2011 is ‘To provide for food and nutritional security in human life cycle approach, by ensuring access to adequate quantity of quality food at affordable prices for people to live a life with dignity’.

Moving from food to nutrition security involves concurrent attention to a balanced diet with reference to the required macronutrients and micronutrients, clean drinking water, environmental hygiene, sanitation and primary health care. The M.S. Swaminathan Research Foundation is training a cadre of community hunger fighters to help promote delivery of food and non-food components of food security as one package. The ‘deliver as one’ approach of the food and non-food entitlements is to be followed for food security (Swaminathan 2012).

Since this Bill confers legal rights, it is important that the availability of the needed foodgrains is assured either wholly from home production or from supplementary support through imports. In India, nearly two-thirds of the rural population depend on crops and animal husbandry, fisheries and forestry and agro-processing for their livelihood. Experience has shown that procurement at remunerative price (that brings profits to the producers) is the best stimulant for production. Therefore imports should be regarded as a last resort. Steps have to be taken to insulate agricultural production from the

vagaries of the monsoon through carefully designed drought, flood and good weather codes (Swaminathan 1973). The aim of these codes is to maximise the agricultural benefits of a good monsoon and to minimise the adverse impact of unfavourable weather.

Some of the major causes of food price fluctuations and unprecedented hikes are:

- increases in petroleum products and other input costs;
- unfavourable weather conditions due to climate change;
- diversion of prime farmland for biofuels, and real estate;
- widening demand–supply gap due to higher consumption of animal products;
- speculative trade (futures market).

The following are some of the steps taken to check their adverse impact.

Increase in input costs

Input costs have increased in agriculture the world over, especially due to the price hikes in fertiliser and energy costs for machinery and equipment, including irrigation equipment. Labour costs have also increased in the developing countries. Scarcity of oil and natural gas has affected agriculture as well. Estimates show that each calorie produced by the agro-food system in the USA uses seven calories of energy in terms of fertiliser and fuel from fossil sources for production, transportation and transformation (Heinberg 2009). The British food systems are equally energy-inefficient, where fertiliser energy alone constitutes 50 per cent of the total energy used in wheat bread production (Woods *et al.* 2010). Estimates of the energy footprint of agriculture show that energy has been increasing disproportionately in agriculture over time, bringing about decreasing returns per unit of energy use, fertiliser accounting for over 70 per cent of the total energy used in crop production (Khan and Hanjra 2009). The world fertiliser consumption as well as fertiliser prices have been steadily increasing, leading to higher input costs in crop production. In India, steps have been taken to improve fertiliser use efficiency by replacing product-based subsidy with nutrient-based subsidy, in order to promote balanced nutrition based on Soil Health Passbooks (GoI 2007).¹

Table 2 Rate of growth of consumption in the world (%)

Period	1989–90	1990–99	2000–09
Food item			
Cereals	1.8	1.0	1.8
Vegetable oils	4.9	4.5	5.2
Oilseed meals	3.6	4.2	3.8

Source: USDA (see www.ers.usda.gov/Publications/OCE111/OCE111c.pdf – accessed 29 May 2012).

Unfavourable weather conditions and climate change

Climate change increases the frequency of droughts and floods as well as winter temperatures. Different farming areas get affected in different ways (Mall *et al.* 2006). Warmer temperatures may bring better growing conditions for countries such as Canada and Russia, while increasing aridity is expected to bring down yields in sub-Saharan Africa and South Asia. The drop in yield is caused by a reduction in crop duration. Vector-borne diseases may become more severe and irrigation water resources may be adversely affected. India has therefore launched a programme titled ‘WAR for Water’ (Winning, Augmentation and Renovation).

Diversion of prime farmland for biofuels and real estate

Estimates show that in recent years about 50–80 million hectares of land in middle- and low-income countries has been bought or leased by international investors (HLPE 2011). The governments of the developing world are offering large tracts of lands as large as 4,000–5,000ha free or at nominal prices to international investors, to attract foreign capital. Often the investors get long-term tax breaks, and clauses that protect them from host country legislation and so on. These lands are normally earmarked either for infrastructure development for urbanisation or for biofuel production (HLPE 2011).

Aerial surveys and satellite imagery often give erroneous information about the barren lands and wasteland available for cultivation. Such assessments have led to conversion of huge tracts of productive agricultural land to biofuels in several countries. Poor countries of Africa, Latin America and Asia gave away huge amounts of land to foreign investors, especially from the USA and Europe, for biofuel production. Further, foodgrain crops such as sugar cane, maize and vegetable oils are used for ethanol production.

This process is backed by massive public funding to the tune of US\$8 billion. As a result, prime agricultural land is being diverted from food to fuel consumption, raising the prices of both food and fuel (HLPE 2011). India has a very cautious approach in this area and government policy is to keep prime farmland for farming.

Demand–supply gap

International stocks of foodgrains have been considerably depleted in recent years. Low stocks coupled with high demand increases prices in the international markets. Speculation worsens the price situation. The relationship between stock levels and price volatility is well established. Without a certain minimum level of world foodgrain stocks, it is difficult to restore the buyer’s confidence in continued availability. Demand for food is expected to increase by 70 per cent in 2050, due to population increases, rising incomes and urbanisation. Demand for meat and dairy produce is driving increasing use of land to grow feed. Around one third of arable land is used to provide animal feed (Woods *et al.* 2010) (Table 2).

On the supply side, the structural overproduction due to extensive use of cheap natural resources (e.g. oil, water, biodiversity, phosphate, land) backed by farm subsidies seems to have ended. It appears that the period of historically unprecedented growth in agricultural production is behind us. New demands for biomass are emerging for food, fuel, transport, firewood, timber, housing and so on. Long-term neglect of investment in natural restoration and agricultural research is also partly responsible for the situation of supply not catching up with demand (HLPE 2011).

Speculative trade (futures market)

A paper by the International Food Policy Research Institute (IFPRI) attempted to explain that

speculation could be the main cause of price volatility. Using time series data at monthly frequencies on corn, wheat, rice and soybeans, the empirical analysis mainly provided evidence that financial activity in international futures markets and proxies for speculation may have influenced the price rise more than the other factors. In the case of wheat prices, the study found that the supply of wheat and the growth rate of worldwide real money supply had a positive effect on wheat prices, supporting the idea that world aggregate demand pressures might have played a role in the acceleration of wheat price rises. The speculation proxies, based on the futures trading data, however, provided stronger significant association with wheat prices. The conclusions explain the increase in international prices. All other factors are found insignificant (Cooke and Robles 2009; Tyner *et al.* 2010; Headey 2010). India has suspended the operation of futures trading for important food crops like wheat and rice, red gram (*tur*), black gram (*urad*), sugar and so on in the periods of shortage.²

4 India's contribution to global food security

India has a vast research infrastructure as well as considerable experience in handling weather extremes such as drought and floods. Therefore, the Indian experience and expertise may be valuable in assisting countries in sub-Saharan Africa to become food self-sufficient.

Recently, it has been demonstrated that India could influence world foodgrain prices through exports as well. As per the 'Bloomberg News' report, rice prices slumped by 15 per cent in February 2012 from a three-year high in November 2011, soon after India, the second biggest grower of rice, lifted a three-year ban on exports of non-basmati grain. India's exports could boost supplies of the staple for half the world. Global food prices fell by 10 per cent from a record high in February 2011, according to the United Nations.³ When India imposed a ban on export three years ago, stocks were reduced, leading to an increase in the price of rice. The aim for India is to facilitate steady exports of certain quantities of foodgrain, especially to African countries. India can substantially reduce price volatility by not importing grain (or staggering the imports) and keeping the export commitments steady. A panic reaction or 'bans' increase price volatility. Failure of the commercial actors to respect contractual obligations leads to uncertainty and speculation

Table 3 Foodgrain exports

Year	Quantity ('000s tonnes)	% of total production
2001–02	5,156.55	2.42
2002–03	8,979.51	5.14
2003–04	8,223.49	3.86
2004–05	8,185.39	4.13
2005–06	5,820.59	2.79
2006–07	5,767.56	2.65

Source Gol (n.d.).

and increases price volatility. Hence, it is important for India to allay the fears of the international markets that the Indian government may ban exports if production falls. Flexibility to raise tariffs according to predefined conditions for vital crops is a better practice, when there is a need to protect domestic markets from imports. If the tariff bands are known in advance, there will be an informed reaction and stability. Such measures are important to protect the small farm producers and domestic consumers. Avoiding action that would lead to global price volatility also leads to better stabilisation of domestic prices in India. Export of rice and nutri-millet (sorghum, pearl millet, finger millet (*ragi*) and minor millets) by India contribute to global food security and price stability by making additional quantities of grains available to the food-deficit countries. It also helps the farmers of semi-arid areas to realise better prices as these crops require less water.

The foodgrain exports were highest in 2003 at 8.9 million tonnes. Normally they are in the range of about 5–6 million tonnes. At present, exports at the peak of 2003 constitute less than 4 per cent of the demonstrated peak production potential of 247 million tonnes. By maintaining the level of export of cereals at 2–3 per cent of production, India can effectively stabilise international prices. By keeping the commitment levels unchanged, price stability would be achieved.

5 Bridging the yield gap

At present in many parts of the country, there is a big gap between actual and potential yields. Closing part of it by enhancing yields would boost the country's production substantially. Fortunately for India there has been a sustained

Table 4 Annual compound rates growth of area production and yield

S. No	Crop	1980–90			1990–2000			2000–10		
		Area	Prod.	Yield	Area	Prod.	Yield	Area	Prod.	Yield
1	Rice	0.41	3.62	3.19	0.68	2.02	1.34	-0.10	1.51	1.61
2	Wheat	0.46	3.57	3.10	1.72	3.57	1.83	1.28	2.16	0.87
3	Jowar	-0.99	0.28	1.29	-3.53	-3.07	0.48	-3.27	-0.54	2.82
4	Bajra	-1.05	0.03	1.09	-1.46	0.95	2.44	-0.26	2.40	2.66
5	Maize	-0.20	1.89	2.09	0.94	3.28	2.32	2.81	5.65	2.77
6	Ragi	-1.23	-0.10	1.14	-2.85	-0.80	2.10	-2.87	-1.00	1.93
7	Small millets	-4.32	-3.23	1.14	-5.40	-5.88	-0.51	-6.16	-3.49	2.82
8	Barley	-6.03	-3.48	2.72	-2.62	-0.64	2.03	-0.79	0.67	1.46
9	Coarse cereals	-1.34	0.40	1.62	-2.12	-0.02	1.82	-0.75	2.80	4.24
10	Total cereals	-0.26	3.03	2.90	0.04	-0.02	1.59	0.09	2.01	3.19
11	Total pulses	-0.09	1.52	1.61	-0.60	0.59	0.93	1.62	3.35	1.90
Total foodgrains		-0.23	2.85	2.74	-0.07	2.02	1.52	0.37	2.12	2.89

Source Gol (n.d.).

positive production growth and yield growth. India harvested a record 241 million tonnes of foodgrains in 2010–11. Foodgrain production is expected to touch 250 million tonnes in the current agricultural year (*The Hindu* 2012). Yield growth for foodgrains as a whole has been positive in the last decade. Nutri-cereals and pulses also had positive production growth. However, the shift of land to maize is mostly meant for cattle and poultry feed. The production pattern indicates the increasing shift of consumption towards vegetables, fruit and animal products. Furthermore, average annual compound rate of growth of population has fallen in India. It is 1.64 per cent in the past decade and the average annual compound rate of growth of foodgrain production stood at 2.12 per cent over the same period. Thus India has become self-sufficient in foodgrains, reducing the pressure on world stocks of foodgrain (Table 4).

6 India and world trade

The Doha Round of negotiations have not yet yielded positive results, since developing countries including India would like to ensure that global trade is not only free but fair. Industrialised countries are finding it difficult to reduce subsidies to their farmers. Much of the support is shown under green box provisions. In the World Trade

Organization (WTO) terminology, subsidies in general are identified by 'boxes' which are given colours such as green, blue and amber. Article 6.1 of the Agreement on Agriculture states that Annex 2 or green box subsidies can be provided without limits. This is the only category of support under the Agreement where no limits are set on the support. There will thus be no level playing field in the area of agricultural trade, unless industrialised countries agree to reduce subsidies.

Small farmers and family farms are central to maintaining the sustainability of agriculture and stability of production in the developing countries (Rosset 1999). Today, global free trade threatens their very existence. Prices of non-traded food items also get indirectly affected. Overall, trade-distorting domestic support provided to farmers in the developed nations range between 30 and 80 per cent of the production value.⁴ The subsidies make imported food items cheaper in the international markets. The small farmers of developing nations who are facing the rising costs of inputs will go out of business if free trade is allowed without appropriate safeguards.

The WTO has an important role to play in this context. It is increasingly recognised that protecting the livelihoods of developing countries

and reducing poverty and hunger are global concerns of both the developed and developing world. They need to be urgently addressed by the WTO. The Doha Round in 2001 raised hopes for resolving trade issues in agriculture.

Unfortunately, the issues remain unresolved. Since then, developing countries have unilaterally phased out quotas, lowered tariffs and even allowed free trade on some items. On the other hand, agricultural subsidies (for food and fuel crops) in the developed world have not only remained high, but have been further raised as in the case of the US Farm Bill of 2007 and the Food, Conservation and Energy Act of 2008 and biofuel subsidies in the European Union.

The three important issues remaining to be resolved are market access, domestic support and export subsidies. The most important issue of 'special safeguard mechanisms' for small farmers in developing countries to put them in a 'safe' box has to be resolved soon. For over a decade, since the Doha Round in 2001, subsequent ministerial meetings in Cancun in 2003, Hong Kong and Paris in 2005, Geneva in 2004 and 2006, Potsdam in 2007, Geneva in 2008, and smaller ministerial meetings in London in 2009 and India in 2010, including the informal ministerial meetings at Davos in 2011 and 2012, have not made much progress. The challenge in the farm sector is the promotion of a livelihood-

and food security-enhancing system of trade. Such a small farmer-friendly global trading system will contribute significantly to maintaining price stability.

7 Conclusion

India can make significant contributions to maintaining price stability in the international food market by maintaining both food self-sufficiency and internal price stability. In addition, the Indian experience in agricultural technology will be relevant to food-importing countries in sub-Saharan Africa. Also, because India maintains substantial food reserves it may be possible to make strategic interventions to halt rising prices by releasing some of its stocks to meet the needs of countries in a state of food crisis. Thus, a well-planned home food security strategy coupled with an international price stabilisation strategy will be two of the major contributions India can make to prevent food price volatility. There is, however, one danger in this scenario – the adverse impact of climate change. India will have to promote climate-resilient and conservation agriculture, so that it enters an era of evergreen revolution, designed to increase productivity in perpetuity without associated ecological harm. (Swaminathan 2010). Finally, we should remember that the future will belong to nations with grains and not guns.

Notes

- 1 Areas of focus under the National Agricultural Development Programme or *Rashtriya Krishi Vikas Yojana* (RKVY), include activities to enhance soil health. Soil health cards that contain the results of soil testing on farmers' fields are issued to the farmers. See <http://agricoop.nic.in/Rkvy/Rkvyfinal-1.pdf> (accessed 11 April 2012).
- 2 Economic survey 2008–09, 2009–10, chapters on agriculture, website of Forward Markets Commission (www.fmc.gov.in). Since 2007,

- India suspended future trading on eight commodities. The suspension was removed on many commodities in 2009 and 2010. On 28 February 2007 futures trading was suspended on paddy. Also see www.fmc.gov.in/htmldocs/Commodities/Commodities%20Suspended.htm (accessed 11 April 2012).
- 3 See www.bloomberg.com/news/2012-02-21/record-rice-harvests-seen-boosting-stockpiles (accessed 11 April 2012).
 - 4 WTO 'Highlights of the December 2008 draft' (CRS Report 2010).

References

- Congressional Research Service Report (CRS Report) (2010) *Comparing US and EU Program Support for Farm Commodities and Conservation*, R40539, 26 January, www.crs.gov
- Cooke, B. and Robles, M. (2009) *Recent Food Prices Movements: A Time Series Analysis*, IFPRI Discussion Paper 00942, Washington DC: International Food Policy Research Institute, www.ifpri.org/sites/default/files/publications/ifpridp00942.pdf (accessed 11 April 2012)
- FAO (Food and Agricultural Organization) (2011) *Food Outlook: Global Market Analysis – Wheat Prices*, www.fao.org/economic/est/prices (accessed 2 May 2012)
- GoI (Government of India) (2007) *Guidelines for National Agricultural Development Programme (RKVY)*, New Delhi: Department of Agriculture and Cooperation
- GoI (Government of India), Ministry of Agriculture, Department of Agriculture and Cooperation (n.d.) *Statistics at a Glance*, tables on imports and exports of agricultural commodities, http://agricoop.nic.in/Agristatistics.htm (accessed 2 May 2012)
- Headey, Derek D. (2010) *Rethinking the Global Food Crisis – The Role of Trade Shocks*, IFPRI Discussion Paper 00958, Washington DC: International Food Policy Research Institute, www.ifpri.org/sites/default/files/publications/ifpridp00958.pdf (accessed 11 April 2012)
- Heinberg, Richard (2009) *Power Down; Options for a Post Carbon World*, Gabriola Island BC, Canada: New Society Publishers
- The Hindu* (2012) 'Prime Minister of India made a Statement in a Workshop on "Policy Initiatives for Promoting Partnership between Stakeholders in Agriculture with Particular Reference to Rainfed and Dryland Farming" at Rashtrapati Bhavan, New Delhi', 15 February
- HLPE (2011) *Land Tenure and International Investments in Agriculture*, report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security (Chairman, M.S. Swaminathan), Rome
- Khan, S. and Hanjra, M.A. (2009) 'Footprints of Water and Energy Inputs in Food Production – Global Perspectives', *Food Policy* 34.2: 130–40
- Mall, R.K.; Singh, R.; Gupta, A.; Srinivasan, G. and Rathore, L.S. (2006) 'Impact of Climate Change on Indian Agriculture: A Review', *Climate Change* 78: 445–78
- Rosset, P.M. (1999) 'The Multiple Functions and Benefits of Small Farm Agriculture, in the Context of Global Trade Negotiations', *Food First Policy Brief* 4, World Food Programme
- Swaminathan, M.S. (2012) 'Tenth Convocation Address', National Dairy Research Institute, Karnal, India
- Swaminathan, M.S. (2010) *From Green to Evergreen Revolution*, New Delhi: Academic Foundation
- Swaminathan, M.S. (1973) *Our Agricultural Future*, Sardar Patel Lectures, New Delhi: All India Radio
- Tyner, Wallace E.; Taheripour, Farzad; Zhuang, Qianlai; Birur, Dileep and Baldos, Uris (2010) *Land Use Changes and Consequent CO₂ Emissions due to US Corn Ethanol Production: A Comprehensive Analysis – Final Report*, West Lafayette IN: Department of Agricultural Economics, Purdue University
- Woods, J.; Williams, A.; Hughes, J.K.; Black, M. and Murphy, R. (2010) 'Energy and the Food System', *Philosophical Transactions of Royal Society B* 365.1554: 2991–3006