FERTILISER, FUEL AND FOOD: WIN-WIN OPTIONS FOR BIHAR

A report by Greenpeace

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Image: A farmer in Khagaria, working in his wheat field
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Image on the cover: A progressive farmer standing among her crops in Khagaria district. She has adopted certain ecological fertilisation practices and is reaping the benefits
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EXECUTIVE SUMMARY

Twenty years after supposedly prioritising the global fight to eliminate hunger and poverty, the world has failed to achieve food security. Yet at the same time there is now more evidence than ever on available and affordable solutions to realise this goal.

Hunger and poverty are mostly rural phenomena. The biggest group of the hungry and the poor in the world are farmers, mostly small-scale farmers in developing countries. Still, agriculture is the biggest business in the world. About 2.6 billion people, 40% of the world's population, are small-scale farmers. Strikingly, considered globally, they produce most of the food we consume.

This report looks at the problems that farmers face in one of the poorest regions in India, Bihar, focusing particularly on the economic and environmental burden arising from the current dependency on chemical fertilisers. The double aim of this report is to understand the impacts on farmers of the current dependency on chemical fertilisers, and identify potential solutions based on an ecological farming system that works towards healthy food and healthy farming for today and tomorrow.

Bihar: economically poor while rich in natural resources and potential for development

Among the different Indian states, Bihar ranks as the second most impoverished. About 56% of Bihar's rural population lives below the poverty line, compared to 37% for the all-India average. Despite cultivation of food crops as the main economic activity in the state, food insecurity is widespread, particularly in rural areas of Bihar. However, according to the Government of Bihar (2012), agriculture *"is sure to play the most important role for the development of the state."* Bihar has abundant fertile soils and freshwater sources, although natural resources had not been managed towards sustainable social development.

The data presented in this report are derived from detailed interviews with farmers and field-data collection in 5 districts of the state of Bihar: Khagaria, Madhepura, Muzaffarpur, Nalanda and Patna.

Underlying low agricultural incomes are the large and increasing costs of cultivation coupled with falling returns from farming

Costs of cultivating crops include costs of labour, of seeds and of irrigation, and, for the great majority of farmers in Bihar, also the costs of a large amount of chemical inputs. Chemical fertilisers are generally one of the highest proportional costs of cultivation, with 20-25% of the total costs being spent by Bihar farmers on buying these inputs.

Chemical fertilisers are generally an expensive input with prices very vulnerable to fluctuations in oil and energy prices. From 2010/11 to 2011/12, the price that Bihar farmers had to pay for chemical fertilisers increased by between 20% and 45%.

As India is dependent on imports for a significant proportion of chemical fertilisers, volatility of supply and of cost makes India and its farmers more financially vulnerable and insecure.

Chemical fertilisers are a costly input, inefficiently used. Around 70% of the nitrogen chemical fertiliser applied to Bihar farms can be lost, with both monetary and environmental impacts

Surveyed farmers in Bihar were found to apply a considerable amount of chemical fertilisers to their crops, often resulting in excessive amounts of plant nutrients in the soil. For example for nitrogen, average application rates reported by farmers were some 35% over the recommended rate. For the combination of nitrogen (N), phosphorus (P) and potash (K) fertilisers, the NPK application rate averaged across surveyed farms was about 30% over the recommended rates in terms of nutrients for good yields.

Globally, it has been estimated that about 41% of the N applied to croplands is not recovered in the harvested crops. It is lost to the soil or, in larger quantities, to aquatic systems and to the atmosphere. We have approximately estimated the recovery efficiency for N applied to farm soils in Bihar based on a simplified model and available parameters/data, acknowledging a number of *caveats*.

Farmer Shivnandan Prasad and villagers in Dawoodpur village, Ben block, Nalanda district with water source used for irrigation and for household needs, including drinking.
© Swapan Nayak / Greenpeace

Our tentative estimates show considerable losses of 67% of the total applied N chemical fertilisers. Specifically, about 71% and 64% of the N applied to rice and wheat, respectively, is not recovered in the harvested crop, and is thus lost to water or to atmosphere, with only a small proportion remaining in the soil.

Considered in financial terms, the above inefficiencies represent an effective financial loss of between 841and 1462 Rs/ha. This can be viewed as an annual investment in the farming operation that shows no return. This, in turn, is roughly 10% of the average *per capita* income in the state.

The cost in terms of public money spent on N fertiliser subsidies that is not recovered in food grain, and thus lost, would amount to 1530 crore Rs of total subsidy money lost in Bihar. This represents a crucial opportunity cost of not investing this money in more effective policies (like policies that benefit rural livelihoods and sustainable economic growth).

In all, these losses of chemical fertilisers represent a significant loss for farmers who pay for this expensive input, for Government (and public money) used in subsidies, and for people and for the wider environment affected by the resulting pollution of water resources and/or potential climate change impacts.

Excess chemical fertiliser can pollute water sources, including drinking water

Overuse of nitrogen fertilisers can also degrade the drinking water resources available to farmers and farm labourers on their farms. The most significant potential health risks associated with drinking water contaminated with nitrate is blue-baby syndrome (methemoglobinemia) and cancer, particularly cancer of the colon.

In this current survey, nitrate concentrations were measured in wells supplying drinking water on 65 farms located in 5 districts in Bihar – Khagaria, Madhepura, Nalanda, Muzzaffarpur and Patna – covering 33 villages and 17 blocks.

Drinking water in farm wells was largely found to be safe for drinking in the majority of the locations relative to the safety levels established by the World Health Organisation. However, in two districts, Nalanda and Patna, nitrate levels in the groundwater wells on farms clearly showed pollution from nitrogen fertilisers. In Nalanda, 65% of wells (18 out of 28) had nitrate levels above 10 mg/l nitrate (as NO_3), thus showing some degree of pollution although not above levels currently considered unsafe for human consumption. Also in Patna, where nitrogen chemical fertiliser consumption is one of the highest, some wells were found with degraded water quality due to high nitrate concentrations.

Pollution with chemical fertilisers represents a call for action to the Bihar Government to work towards protecting drinking water and human health. Cutting down on excess chemical fertiliser use will have many benefits: in addition to economic benefits for farmers, it will protect water resources and protect the health of farmers, farm labourers and their families.

Ecological farming can bring more food and higher incomes, better energy sources and cleaner water for all the people of Bihar

Bihar still has the opportunity of choosing a different path to that taken by the 'Green Revolution' states in India, where degradation of soil and water through intensive agriculture have "now exemplified the post-Green Revolution stagnation and challenges" (Erenstein and Thorpe, 2011).

In addition to relatively low crop productivity, in rural Bihar there is also limited access to energy, to clean water and to sanitation facilities. Solving the huge joint challenges embedded in each of these areas of food, energy and water is unlikely to come from adopting the path of the 'Green Revolution' as followed by states like Punjab and Haryana. These states focused mostly on external inputs for increasing staple yields. Science and the current reality of farmers' lives show the results of this intensive approach is not one to follow.

A new model of agriculture centred on people, not on chemicals or on other expensive inputs, can increase food production where it is most needed, and at the same time help in rural development. Greenpeace takes the view that these people-centred approaches should be based on ecological farming principles that aim towards increasing food security for today and tomorrow while working with nature, not against it.

Working with a vision of ecological farming coupled with renewable energy principles, Bihar farms could increase agriculture productivity, increase energy availability and access, and secure future clean water systems. In this report we explore potential solutions under three major axes:

1. High yields without chemicals: ecological farming optimises livestock and ecological fertilisation practices that are locally available, knowledge intensive and financially secure. Ecological fertilisation practices can increase food production without costly chemical inputs and the pollution they bring. Ecological farming practices can also optimise livestock production and uses of land, by looking at closing nutrient cycles and building resilient and healthy soils.

2. Clean water, improved public health and cheap local fertilisers: Eco-sanitation. Low public coverage with sanitation systems offers an opportunity to reinvent sewage treatment and sanitation paradigms. Sanitation systems can be designed based on new ways of dealing with excreta *and* working in synergy with the needs of agriculture and renewable energy requirements.

3. Energy access, food production and rural livelihoods: Potential for holistic win-win-win solutions. Non-availability of reliable power supplies is a key constraint on economic development in rural India, as in other developing countries. Energy needs in the rural communities of Bihar could be met using a decentralised system based on locally-available renewable sources of energy (solar, wind, rice husk biomass, etc.). The livestock manure currently used as cow dung cakes for cooking could be fully utilised as fertiliser and soil conditioner, and hence potentially contribute to increasing crop productivity. This would reduce farmers' expenses in purchasing chemical fertilisers. In addition, a decentralised renewable energy system could also provide a more efficient and reliable energy source for irrigation, hence likely improving agricultural productivity.

The way forward: more research and funding on ecological agriculture

The Agriculture Road map for the next 10 years (2012-2022) announced by the Government of Bihar is a step in the right direction. The Government's stated intentions to promote organic farming and eco-fertilisation are to be broadly welcomed. However, the reality on the ground will likely prove challenging to the effective implementation of these policies. In order to bring about a real effective shift towards sustainable ecological agriculture in Bihar, there is a need for convergence and integration of initiatives designed to address issues in agriculture, livelihood, energy and sanitation.

In particular, more funding for research in agroecological systems and holistic solutions is needed. During the last 4 years, only 6 out of the total 241 projects implemented under the Central Government flagship programme for agriculture development, Rashtriya Krishi Vikas Yojana (RKVY), supported ecological farming or fertilisation and only 7.7% of the total amount spent under RKVY was utilised for the promotion of organic farming. It is also revealing that the total amount spent on promotion of ecological or organic farming over 4 years (141 Rs. crore) is less than 10% of the subsidy amount for urea N fertiliser that is lost in non-recovered N in Bihar (1,529 Rs. crore).

Greenpeace India recommendations:

1) Launch a State Ecological Farming and Fertilisation Mission, converging relevant Central and State Government policy instruments, and by enabling a dedicated institutional mechanism with grassroots presence. The Mission should find synergy with livelihoods, bio-energy, regeneration of common pool resources and eco-sanitation initiatives in the state.

2) Create School of Agro-ecological Systems Analysis in the two Agricultural Universities in the State with regional, block level holistic research and extension programmes.

3) Enable effective district level planning to ensure that 25% of RKVY funds are earmarked to promote ecological farming and fertilisation to start with and with an objective to progressively raise the amount to 50% of the funds by the end of the five year plan period.

4) Set targets for systematically replacing chemical fertilisers with ecological fertilisation during the five year plan period.

INTRODUCTION

Twenty years after supposedly prioritising the global fight to eliminate hunger and poverty, the world has failed to achieve food security. Yet at the same time there is now more evidence than ever on available and affordable solutions to realise this goal (Schutter, 2010, IAASTD, 2009).

Agriculture is the biggest business in the world. About 2.6 billion people, 40% of the world's population, are small-scale farmers. These farmers produce most of the food we consume. Strikingly, considered globally, they also comprise the biggest group of the hungry and the poor.

"Business as usual is not an option for agriculture" was one of the headlines which emerged from the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). The IAASTD is a comprehensive first global assessment of the role that agricultural knowledge, science and technology could play, both in fighting poverty and hunger and in promoting sustainable development. More than 400 lead authors from across the world worked together for several years to produce this global assessment in 2009, which was subsequently endorsed by 58 national governments. A central message of the IAASTD report is that hunger is primarily a rural problem, which, in the long term, can only be overcome locally. In much of the world, addressing hunger and poverty means facing up to the problems that small farmers and their families face in their daily life as working farmers.

It is true that humanity has nearly tripled global agricultural output over the past 50 years, but this has come at considerable cost to the environment, to public health and to social welfare. Industrial farming, with its dependency on fossil fuels, toxic inputs (e.g. pesticides and chemical fertilisers), and neglect of social assets, has proven to be a dead-end road. Indeed, as concluded by the IAASTD, continuing with business as usual threatens to undermine the basis of our food supply and the intricate web of life upon which we all depend (Greenpeace International, 2009).

Accordingly, this report looks at the problems that farmers face in one of the poorest regions in India, focusing particularly on the economic and environmental burden arising from the current dependency on chemical fertilisers.

A farmer in Khagaria crosses the river by boat, carrying a bundle of fodder
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SECTION 1

FARMING LIVELIHOODS IN BIHAR AND THE INFLUENCE OF CHEMICAL FERTILISERS

1.1. Socio-economic situation of the Bihar rural population

Poverty and hunger continue to be widespread in India in spite of rapid national economic growth. The country accounts for nearly 50% of the world's hungry (UN WFP, 2010). Around 35% of India's population, some 380 million in number, are considered food-insecure (UNWFP, 2010). The majority of these hungry and poor people live in rural areas and produce crops for a livelihood. Although some progress in alleviating poverty has been made, the World Bank, nonetheless, considers that the rate of poverty reduction in India has slowed during the last 15 years.

Among the different Indian states, Bihar ranks as the second highest in terms of poverty. According to Government estimates, about 56% of Bihar's rural population lives below the poverty line[1], compared to 37% for the all-India average (Government of Bihar, 2012). This poverty is also reflected in the annual *per capita* income. In Bihar this is less than one third of the average for India as a whole (Table 1).

Bihar state lies in the eastern part of the Indo-Gangetic plain. It occupies the fertile alluvial land stretching from the foothills of the Himalayas in the north to a few miles south of the river Ganges which crosses the state from west to east. The Indo-Gangetic plain is one of the world's major food-grain producing regions. About 90% of the Bihar population lives in rural villages, and about 75% of Bihar's economically active population is employed directly in agriculture, forestry or fishing and according to the Government of Bihar (2012),

Village women carrying fodder (picked weeds) back home through the wheat fields in Barchhibigha village, Nalanda district
© Swapan Nayak / Greenpeace

Children playing in the fields at sunset in Barchhibigha village, Giriak Block, Nalanda District. Many farmers cannot afford to send their children to school, because of their low income and the high cost of cultivation. They spend most of their money on inputs for cultivation, hoping that it will result in better yields and, therefore, better incomes

agriculture *"is sure to play the most important role for the development of the state."*

Agricultural land accounts for around 60% of the geographical area of Bihar state with rich fertile soils and abundant water sources. Farmers produce large amounts of cereals (rice in the *kharif* season – monsoon – and wheat and maize in the *rabi* season – winter), vegetables, pulses, oilseeds and fruits (mango, banana, litchi). Bihar is at the top of vegetable production in the country (Government of Bihar, 2012). The benefits of generally good water resources, however, are offset to some extent by lack of irrigation facilities, which means that agricultural productivity fluctuates with annual variation in monsoon rainfall.

Despite cultivation of food crops as the main economic activity in the state, food insecurity is widespread, particularly in rural areas of Bihar. Compared nationally, people living in these areas have the lowest monthly disposable income. Of the average income of Rs 780, about 65% is used to buy food (compared to 53% in urban areas) (Government of India, 2012). Moreover, indicators of food insecurity, like child and infant mortality, are significantly elevated in Bihar, at about 10 points higher than the average for India as a whole (Table 1). As of 2011, Bihar was home to 104 million people: it is the third most populous state in India with the highest population density in the country, at 1102 persons per km^2.

Other economic indicators attest to the impoverished status of the area. For example, Bihar has the lowest annual *per capita* consumption of electricity in the country but even so, frequently suffers acute shortage of power.

Table 1. Socio-economic indicators in India, Bihar and some districts in Bihar. Bihar holds the lowest *per capita* income in India and it is one of the most food insecure states in the country.

	Per Capita Income (Rs.)*	Child under 5 mortality rate (per 1000)#	Infant mortality rate (per 1000)$	% Employed in agriculture, forestry and fishing~	Human Development Index^
India	30,354	74.3	57	58.5	0.467
Bihar	9,617	84.8	62	73.4	0.367 (21/23 rank)
Districts:					
Khagaria	9,307	101.7			
Muzaffarpur	7,776	122.5			
Madhepura	6,949	98.2			
Nalanda	8,503	108.3			

*2007-08 at 2004-05 prices (Rs.) [last available complete data] (Economic Survey of India 2011-12 & Government of NCT Delhi Estimates of State Domestic Product 2010-11)
#(2005-06) (UN World Food Programme Food Security Atlas of Rural Bihar, 2009)
$(2010) (Economic Survey of India 2011-12)
~(2004-05) (UN World Food Programme Food Security Atlas of Rural Bihar, 2009)
^2007-08 (Summary of India's Human Development Report 2011 by Institute of Applied Manpower Research and Planning Commission)

1.2. Economics of farming: Cost of cultivation

Around 60% of geographical area in Bihar is agricultural land

A number of factors appear to be contributing to poverty and low *per capita* income among Indian farmers and these include increasing costs of cultivation coupled with falling returns from farming. Income from farms in Bihar seems to be very variable, although accurate data are not always available. For example, estimates of net income from paddy cultivation range from about 8,600 to 10,000 Rs/ha, and for wheat from about 6,600 to 13,000 Rs/ha (Singh et al., 2011, Directorate of Economics and Statistics, 2012). Taking into account that these are net incomes per hectare and that, usually, farms in Bihar are small and shared among various family members, the *per capita* income resulting from farming is likely, indeed, to be very low.

Underlying low agricultural incomes are the large and increasing costs of cultivation. These include costs of labour, of seeds and of irrigation. For the great majority of farmers, the costs of a large amount of chemical inputs also need to be factored in. Chemical inputs, mostly in the form of chemical fertilisers, are generally one of the highest proportional costs of cultivation. For example, official data from Bihar estimate the share of chemical fertilisers to be between 10 and 14% of the total cost of rice and wheat farming, respectively. This estimate assumes a relatively low fertiliser application rate (Directorate of Economics and Statistics, 2012). However, other estimates, based on direct data recorded from farmers in Bihar, give a higher value – about 20% of total costs of cultivation of rice or wheat are spent on chemical fertilisers (Singh et al., 2011).

Based on data from the Jeevika survey reported in this document (see box 1), in the 2011/2012 growing season farmers in the districts of Khagaria and Muzaffarpur spent 25% and 20%, respectively, of their total cultivation budget for *rabi* season on chemical fertilisers (Table 2).

A farmer in Khagaria district during the survey interview
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Box 1

Jeevika survey, 2012

Jeevika, the Bihar Rural Livelihoods Project, conducted a farmer survey for Greenpeace India in early 2012. The Bihar Rural Livelihood Promotion Scheme, a society registered with the Government of Bihar, aims to improve rural livelihood options and works towards social and economic empowerment of the rural poor and of women, through the Bihar Rural Livelihoods Project (BRLP). The BRLP works with the community on four theme areas: institution and capacity building, social development, microfinance and livelihood.

The survey covered two blocks (district units) each in the two districts of Muzaffarpur and Khagaria. Fifty farmers from each of the two districts were interviewed in detail by members of Jeevika's field teams. These farmers were interviewed about the crops cultivated, yields, fertiliser consumption and overall costs of cultivation, including specific details about costs of fertilisers.

Table 2. Cost of cultivation and cost of chemical fertilisers in *rabi* season 2011/12 in the districts of Khagaria and Muzaffarpur in Bihar, as recorded in the Jeevika survey (2012) from interviews with 50 farmers in each district. Cost of chemical fertilisers given here includes only the three most used fertilisers by quantity: urea, phosphate (as DAP) and potash (as MOP). Other minor chemical fertilisers and additives are not included, and thus their cost will add to the total costs and the percentages estimated here.

	Khagaria	Muzaffarpur
Cost of cultivation (Rs/ha)*	21,258	27,312
Cost of chemical fertilisers (Rs/ha)	5,291	5,548
% Spent on chemical fertilisers	25%	20%

*The total costs of cultivation estimated by the Jeevika survey data for *rabi* season 2011/12 give a higher cost than other published estimates. This may be due to actual increasing costs in recent years or to methodological/data discrepancies. For the year 2008/09, costs were estimated for *rabi* wheat at 13,780 Rs/ha, and for year 2006/07 at 14,230 Rs/ha. Values from Directorate of Economics and Statistics (2012), and Singh et al. (2011) respectively.

1.3. Chemical fertilisers price trends

As a globally traded commodity whose prices are dependent on fossil fuel and associated costs, chemical fertilisers are generally an expensive input with prices very vulnerable to fluctuations in oil and energy prices. Data from the Jeevika survey shows how in one cropping year, from 2010/11 to 2011/12, the price that farmers had to pay for chemical fertilisers increased by between 20% and 45% (Table 3). Urea and potash (MOP) prices increased by about 20-29% and 33-38% in Khagaria and Muzaffarpur respectively. The greatest increase was for diammonium phosphate (DAP), which almost doubled in price in that period in both districts.

The price rise recorded for phosphatic and potassic chemical fertilisers in the last two years can be mostly attributed to the new Nutrient Based Subsidy (NBS) policy introduced in 2010. This new system of fixed subsidies for specific chemical fertilisers also allowed suppliers to decide the retail prices of these fertilisers at the farm gate level. Urea was kept out of the NBS policy, and the Government continued to fix its retail price (PIB, 2010). As a result, for fertilisers other than urea the farm gate prices fluctuated with international market prices. This resulted in the markedly increased costs of these chemical fertilisers. When farmers started replacing costlier fertilisers with cheaper urea, soil health was critically impacted as a result (Modi, 2012). Increased demand for urea may have led, in part, to an increase in its price at the farm gate level as well.

Table 3. Price that farmers paid for chemical fertilisers urea, diammonium phosphate (DAP) and muriate of potash (MOP) in the Bihar districts of Khagaria and Muzaffarpur in 2010/11 and 2011/12. Data source is the Jeevika survey (see box 1), values are averages of 50 interviewed farmers in each district.

	Price paid in 2010/11 (Rs/100 kg)	Price paid in 2011/12 (Rs/100 kg)	% Increase from 2010/11 to 2011/12
In Khagaria:			
Urea	531	744	29%
DAP	1,261	1,889	33%
MOP	598	1,083	45%
In Muzaffarpur:			
Urea	666	835	20%
DAP	1,165	1,865	38%
MOP	606	1,096	45%

A resident of Khagaria town rides past sacks of chemical fertilisers piled up along the railway platform. Train loads of urea and other chemical fertilisers arrive regularly at the station for distribution – Khagaria district has the highest kg/ha fertiliser consumption in Bihar (Fertiliser Statistics 2009-10) © Karan Vaid / Greenpeace

Official fertiliser prices from 2000 to 2012 in India

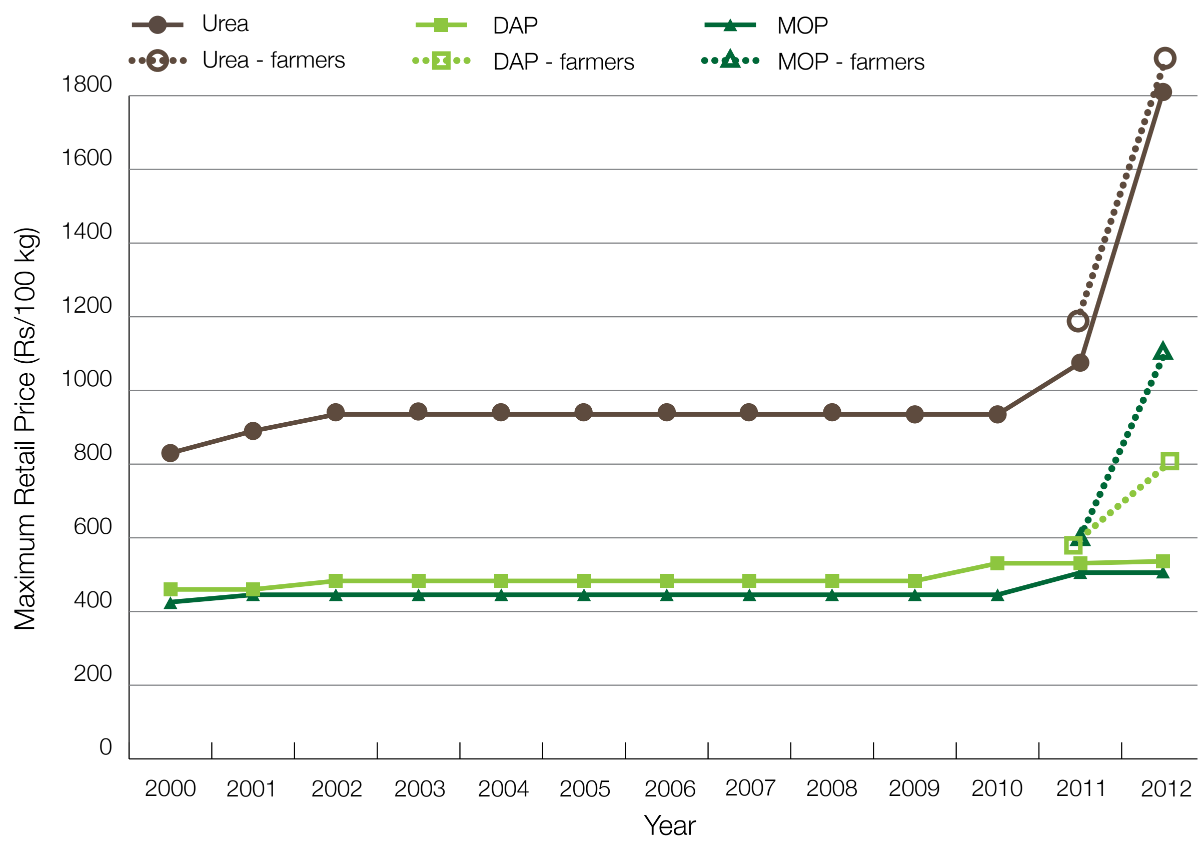

Figure 1. Official maximum retail prices for the three most common fertilisers (urea, DAP (Diammonium Phosphate), and MOP (Muriate of Potash)) from 2000 to 2012 in India. Official price of DAP almost doubled from 2011 to 2012. Official data source: Fertilizer Statistics yearbook (2000 to 2011) and IFFCO (2012). For comparison, in dashed lines we also show the price paid by farmers according to the Jeevika survey (Table 3).

Other market forces are also in play. For example, the price that farmers pay for chemical fertilisers in their village is often higher than the Maximum Retail Price (MRP) set officially, as dealers usually apply some additional costs. Figure 1 shows the trajectory of official chemical fertiliser prices from 2000 to 2012: price paid by farmers and official price are similar for DAP 2010-2012 (approx. 1,800 Rs/100 kg DAP), however for urea and potash, farmers had to bear a price increase that is not reflected in the officially set prices (i.e. in 2011 farmers paid between 744 and 835 Rs/100 kg urea, while official MRP was 536 Rs/100 kg urea) (Fig. 1 and Table 3).

International market prices for chemical fertiliser fluctuate widely, as they depend to some extent on the prices of fossil fuels used in their manufacture as well as other volatile market forces. India currently imports more than 20% of the nitrogen consumed nationally in synthetic fertilisers, mostly as urea and other finished products. Phosphorus and potash fertilisers are manufactured from mined chemicals. In the case of phosphorus, mines are exclusively located in a handful of countries that control production, and hence the international supply and price of this commodity (Elser and Bennett, 2011). For example, in 2008, international phosphate rock prices increased by 800%. While prices went down quite quickly, they did not fall to the pre-peak values. Prices now stand at about 4 times higher than they were before prices started to escalate around 2006. Ultimately, such volatility of supply and of cost makes phosphate import-dependent countries, like India and its farmers, more financially vulnerable and insecure. A similar situation of vulnerability and international dependence exists for urea and other nitrogen fertilisers (which are also dependent on direct imports and/or fossil fuel imports), and for potash, 100% of which India imports.[2]

Farmer Binay Yadav of Bigha village, Nalanda district, during his interview

SECTION 2

CHEMICAL FERTILISERS RISK ECONOMIC AND ENVIRONMENTAL LOSSES

Dependence on costly inputs, like chemical fertilisers, that are prone to supply/price fluctuations and rely on non-renewable resources for their manufacture, translates to a financial risk for farmers, especially for smallholders in low-income regions.

In addition, chemical fertilisers tend to cause damage to the resource base needed for sustainable food production: they pollute water and can harm soil fertility. This has proven to be the case in the “Green Revolution” regions located in nearby states such as Punjab and Haryana. A long-term dependence on chemical fertilisers is already contaminating water and damaging soils (see further discussion below).

Bihar’s current trajectory of chemical fertiliser usage suggests that the state could repeat the mistakes of excessive and inefficient use of chemical fertilisers. Accordingly it could fall victim to the economic and environmental problems associated with such excessive and inefficient use. Below, current trends in chemical fertiliser usage are discussed in relation to five districts within the state, and a preliminary estimate of possible economic and environmental losses arising from chemical fertiliser usage at currently recorded levels is presented.

A farmer in Khagaria applying fertiliser to his crop – he uses only chemical fertilisers for all his crops
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Box 2

Data Collection

The data presented in sections 2 and 3 were recorded during a fieldtrip in February and March 2012 by the authors of this report. Working with local organisations, agricultural regions in 5 districts were visited: Khagaria, Madhepura, Muzaffarpur, Nalanda and Patna. We randomly selected farmers in villages within these districts and interviewed them in detail about crop patterns and production, agricultural practice, and usage of chemical inputs. We recorded information from a total of 65 farmers, distributed in 33 villages and 17 blocks across the 5 districts. For each farm, we recorded data through a lengthy interview with the farmer. We collected specific data for each crop grown in the farm during the 2011/12 growing season, including the different types and amounts of chemical fertiliser applied to each crop.

In addition, water samples from irrigation groundwater wells within each surveyed farm were taken in order to test nitrate concentration in the water. We sampled groundwater wells located within farms and surrounded by chemically fertilised crops (mostly rice and wheat rotations). Sampled farm wells were located away from other potential sources of nitrate contamination (concentration of animals, human sewage), in order to try and isolate and focus on the impact of synthetic fertiliser application. All the water tested was used for drinking by farmers and families and farm workers.

When sampling groundwater, the water outlet (usually driven by a diesel-operated pump) was allowed to run for approximately three minutes before collecting a duplicate sample in sterile bottles. Measurements of pH and electric conductivity (EC) were taken on site at the time of sampling using a pH/conductivity/TDS tester HI 98130 (Hanna Instruments, UK).

Nitrate concentration (mg/l NO_3) in water samples was tested colorimetrically with the chromotropic acid method (Method 10020, Test 'N Tube™ Vials, Hach Lange, UK), using a portable DR 2400 spectrophotometer (Hach Lange, UK). The value given for each sample is the average of testing two or three sub-samples for improved accuracy. Samples were kept in a cool box after collection and were tested within a maximum of ten hours after collection.

1. Collection of water samples from a wheat field by Dr. Reyes Tirado (Senior Scientist at Greenpeace Research Laboratories, based in the University of Exeter) in Bichchacol village, Nalanda district

2. Dr. Reyes Tirado collecting water samples from a farm in Bigha village, Nalanda district

3. Collection of water samples by Dr. Reyes Tirado, from a farm in Bigha village, Nalanda district

4. Dr. Reyes Tirado collecting water samples from an electric water-pump in Barchhibigha village, Nalanda district

5. Dr. Reyes Tirado testing water samples for Nitrate contamination

6. Tested samples showing varying levels of Nitrate contamination – the stronger the yellow colour, the higher the contamination

2.1. Chemical fertiliser usage in Bihar, 2012

From the results it was found that the surveyed farmers in Bihar applied a considerable amount of chemical fertilisers to their crops often at levels higher than those recommended.

In Table 4, the recorded data for application rates of nitrogen (N), phosphorus (P) and potash (K) are shown for the main crops. The main chemical fertilisers used were urea, DAP (Diammonium Phosphate) and MOP (Muriate of Potash). The amount of N, P and K applied was calculated from the combination of different chemical fertiliser types reported as used by each farmer, and this generated an averaged NPK rate for each district surveyed. Almost all farms grew at least two crops per year, so rates per *gross*[3] cropped area reflect this double cropping pattern (Table 4).

Recommended nitrogen application rate for production of rice-wheat/maize in rotation is 230 kg N/ha whereas the average reported by farmers was 311 kg N/ha [annual rate in *net* cropped area]. This represents an overuse of some 35% over the optimal application rate for nitrogen. This does not include other inputs of nitrogen in addition to those from chemical fertilisers (green manure, animal livestock manure, etc., that are also commonly applied to soils in the region).
For the combination of nitrogen (N), phosphorus (P) and potash (K) fertilisers, the NPK application rate averaged across the 65 surveyed farms is 263 kg NPK per hectare of *gross* cropped area. This surveyed rate is somewhat higher than the official estimate for Bihar of 174 kg NPK per hectare of *gross* cropped area, and also higher than the recommended dose for rice/wheat in rotation of 200/220 kg NPK per hectare of *gross* cropped area.

Official estimates suggest that only 38% of the farms produce two crops per year, giving a cropping intensity of 1.38. The current survey suggests that in fact 90% of farms produced two or more crops per year giving a much higher cropping intensity of 1.90. Accordingly, the lower NPK application rates from official estimates may relate simply to the use of a lower cropping intensity figure in calculations. It may also be that in less productive areas (those which are flood prone, etc.) cropping intensity is lowered. In the areas covered in this survey, however, cropping intensity and chemical fertiliser application rates are both very high. The survey data considered in this study can be taken moreover, as reflecting the current situation for the majority of farmers in Bihar. The data, supplied by the farmers themselves reflect prevalent agricultural practices in the region. However, in regions where conditions less favourable to agriculture prevail, lower fertiliser application rates may be the norm.

Table 4. Fertiliser application rates in the five Bihar districts sampled in March 2012. The main chemical fertilisers used were urea, DAP (Diammonium phosphate) and MOP (Muriate of Potash). We calculated the amount of N, P and K from the combination of different chemical fertiliser types used by each farmer, and averaged NPK rates for each district. Almost all farms had at least two crops per year, so rates per *gross* cropped area reflect this double cropping pattern. The recommended fertiliser application rates for Bihar [*net* cropped area based on a rice-wheat rotation system] are N: 230 kg/ha, P: 120 kg/ha, K: 70 kg/ha (Source: Mr. Ashok Prasad, DDA (HQ), Department of Agriculture Bihar, May 2012).

	Sampled farms	Main crops in *Kharif* - *Rabi*	Fertiliser rate (kg of nutrient/ha per year [*net* cropped area])				Total fertiliser rate NPK (kg /ha per crop [*gross* cropped area])
			N	P	K	NPK	NPK
Bihar	65	rice – wheat/maize	311	151	63	525	263
Khagaria	14	rice - wheat/maize	276	127	84	487	243
Madhepura	8	rice - wheat	260	148	102	510	255
Muzaffarpur	8	rice - wheat	328	178	98	604	302
Nalanda	30	rice - wheat/maize	312	133	33	478	239
Patna	7	rice - onion	416	253	67	736	368
Official estimate for Bihar*							174
Official estimate for India*							144
*Fertiliser Statistics year book, 2011							

The documented NPK application rates in the current survey are comparable with the high rates recorded in the official data for previous years for Indian states such as Andhra Pradesh, Punjab or Haryana (see Figure 2). As with other data, official estimates seem, however, to be much lower than other farm-level surveys (Singh et al., 2007). The field data suggest that farmers in Bihar have already adopted, or will soon adopt, the unsustainable path of Green Revolution states like Punjab or Haryana, where high agrochemical use is already compromising future soil fertility and water quality (Erenstein and Thorpe, 2011, Bhattacharyya et al., 2007, Roy et al., 2009, Sarkar, 2012).

As noted above, the NPK application rates presented here are those from chemical fertilisers only. Other inputs of NPK that occur by application of farmyard manure, or by growing green manures are excluded. A large percentage of the farmers interviewed have adopted these beneficial practices, although applications are not quantitatively high in comparative terms. Organic fertilisation practices not only add nutrients but also enhance soil fertility by building up organic matter, by promoting soil biodiversity and also protecting it against erosion. They are, therefore, preferable to the use of chemical fertilisers. If the inputs of NPK from these organic fertiliser usages are included in the estimated fertilisation rates, the overuse (as related to recommended application rates) of chemical fertilisers effectively becomes even greater than is initially evident from the data.

Progress towards truly sustainable agriculture in Bihar could be made if the Government of Bihar could step up its positive work in promoting organic farming. As part of this promotion they could do much more to encourage minimising chemical fertiliser dependency and overuse, with a view to an eventual phase out in the future. Sections 4 & 5 of this report describe the Greenpeace vision for an ecological farming system without the use of chemical fertilisers that maximises food security, underpins secure farming economics and improves environmental health.

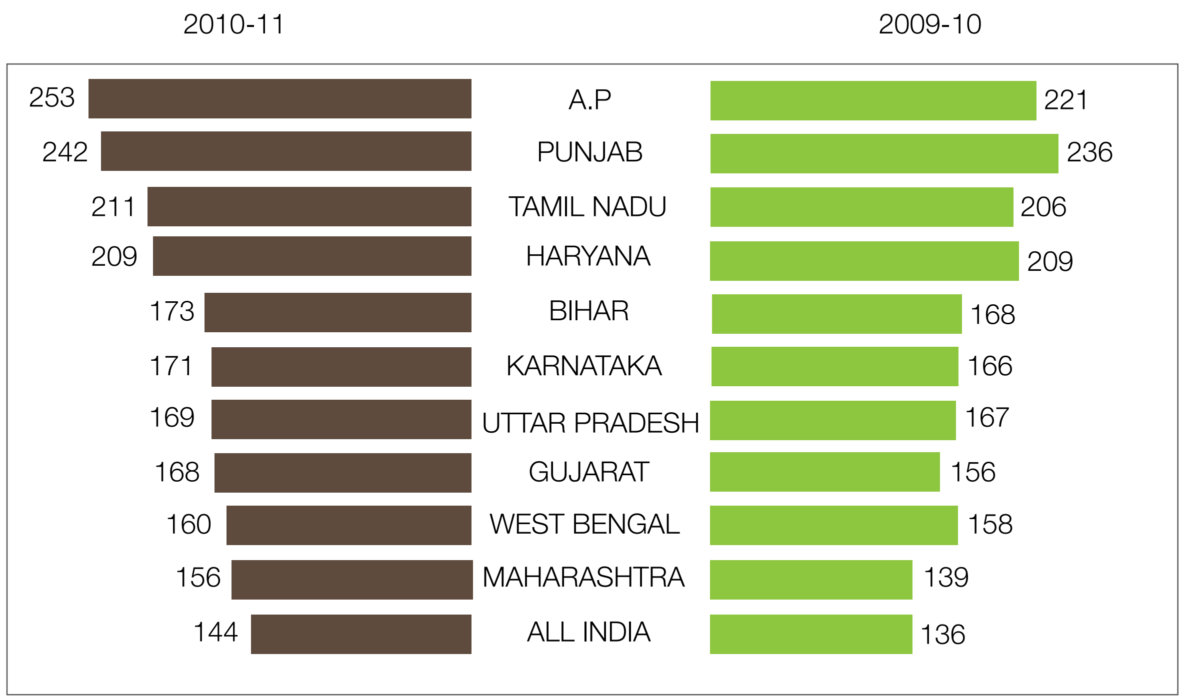

Figure 3. Fertiliser application rates in major Indian states, according to the latest official data from the Fertiliser Statistics year book (2011). The estimate in Table 1 reflects an apparent trend for increasing consumption of chemical nutrients. Bihar, with 263 kg NPK/ha (*gross* cropped area), is closely following the course of nearby states which already have a high overuse of chemicals and associated environmental damage (i.e. Punjab or Haryana). [Figure taken from Fertiliser Statistics year book (2011).]

A progressive farmer in Khagaria district, poses in front of her wheat field with a freshly plucked cauliflower. She has benefited from ecological fertilisation over the last couple of years
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2.2. Inefficiencies in the recovery of Nitrogen applied to crops and its estimated economic cost

Globally, it is estimated that about 41% of the N applied to croplands is not recovered in the harvested crops, and it is lost to the soil or, in larger quantities, lost to water systems and to the atmosphere (Liu et al., 2010).

Many studies have tried to estimate efficiency of N use applied to Indian agricultural soils. Most of these studies have taken place on experimental research farms, rather than in real-life field situations. Nonetheless, estimates of N losses from Indian croplands range from 20 to 90% of the N applied, with a common average of about 50% N applied not being recovered in crops (Bouwman et al., 2005, Chhabra et al., 2010, Ladha et al., 2005). Low efficiencies of N use in croplands represent a major source of potential damage to the environment as well as a major economic loss for farmers. The costs extend to the general public when prices are subsidised directly or indirectly by Governments or their agencies.

Rough estimates can be made of the recovery efficiency of N applied to farm soils in Bihar based on official statistics and also based on data documented in the survey in March 2012, reported in Table 5. Precise estimates of losses of N would require detailed modelling and data on N inputs (from chemical fertilisers and other sources), N outputs (in N contents in harvested crops and erosion) and detailed information about N cycling and behaviour in the farm soils specific to the area (Ladha et al. 2005). However, a tentative estimation of N losses based on a simplified model and available parameters/data is attempted here with the above *caveats* in mind.

The estimate assumes an average double cropping system with rice-wheat rotations (the case in the large majority of farms in Bihar). Average contents of N in harvested rice and in wheat are derived from previously published values (Bouwman et al. 2005).

N inputs are assumed to come exclusively from chemical N fertilisers. In doing so, N losses estimated are on the conservative side, since this probably assumes lower than actual N inputs due to other sources as noted earlier.

The estimate looks at broad values of how much N is not recovered in the harvested crop. This would ultimately be mostly lost to agricultural systems by leaching to the ground and surface water systems as nitrate, to the atmosphere as the potent greenhouse gas nitrous oxide and in the form of ammonia. Although some of the applied N would remain in soils to be used, potentially, by subsequent crops, it has been estimated by other studies that this would comprise less than 5% of the non-recovered N. The rest, therefore, is effectively lost to the agricultural system (Ladha et al. 2005).

The N unrecovered in harvested crops (kg N/ha) was calculated in the current estimate as the difference between the N input from applied chemical fertilisers (kg N/ha) and the output in harvested crops (kg N/ha). The calculation was based on yields and known N content in rice, wheat, or maize harvested parts (Table 5). N removal is calculated considering only N in the harvested part (grain). It is assumed that N in other vegetative parts will not be removed from the system but that crop residues will be retained on the farm together with manure from animals feeding on these residues. Thus, the estimation of losses is actually conservative, since it is assumed that all N losses in crop residues and animal manure are minimised.

The cost of this lost N (not-recovered) was calculated based on the official price of N (Rs/kg N) and on the price paid by farmers (Table 3). Broadly speaking, this unrecovered N represents an effective financial loss to farmers per hectare of farmland in the form of monetary investment in N fertiliser that is not recovered in the harvest, or retained within the system.

The tentative estimates based on official data from the Bihar Government show considerable losses (67%) of the total applied as N chemical fertilisers. About 71% and 64% of the N applied to rice and wheat respectively is not recovered in the harvested crop, and is thus lost to water or to atmosphere (Table 5) with only a small proportion remaining in the soil. These values are at the higher end of the range of values estimated in other published studies. However, they are close to the average given in the literature for farming areas in developing countries (Bouwman et al., 2005, Chhabra et al., 2010, Ladha et al., 2005). In all, they represent a significant loss for farmers who pay for this expensive input, for Government (and public money) used in subsidies, and for people and for the wider environment affected by the resulting pollution of water resources and/or potential climate change impacts.

The estimate based on the survey data from 5 districts in Bihar gives a similar picture: about 62% of N is not recovered in the crops (Table 5). This value is slightly lower than the one based on official estimates. Farmers reported very high yields for both rice and wheat, thus giving proportionally higher recovery of applied N in harvested grains. The apparent high productivity could be due either to an overestimation by reporting farmers or to the data reflecting a sample of only the more productive farms in the region.
As compared to Bouwman et al. (2005), the rates of N losses estimated in this study are among the highest of the averages given as predictions for various world

Table 5. Analysis of the efficiency of the application of N fertiliser in rice, wheat and maize crops in Bihar. A. is based on data from official statistics (Fertiliser Year Book, 2011 and Government of Bihar) and B. is based on data recorded during our field survey in February and March 2012 in 5 districts in the state and detailed interviews with 65 farmers. N removal in the harvested crop is calculated by multiplying yields by N content in harvested crop.

NITROGEN BALANCES: INPUTS AND OUTPUTS	*Kharif*	*Rabi*		*Kharif+Rabi*
	Rice	Wheat	Maize	Total per year (rice - wheat)
A. Estimate based on official statistics				
N input in chemical fertiliser 2010/11((kg N/ha)*	116	116	116	233
Yield (official data 20011/12) (kg/ha)†	2,625	2,206	2,646	
*N content in harvested crop (kg N/kg)^*	*0.013*	*0.019*	*0.014*	
N removal in harvested crop (kg N/ha)□	*34.1*	*41.9*	*37.0*	*76*
N not recovered in the crop (kg N/ha)$ [N input – harvests removal]	82.3	74.5	79.4	157
N recovered in crop (%)	29	36	32	33%
N not recovered (%)	**71**	**64**	**68**	**67%**
<u>Estimated cost of non-recovered N:</u>				
Price of N (official MRP 2011) Rs/kg N in urea (536 Rs/100 kg)	5.4			
Cost of non-recovered N (Rs/ha) [N amount not recovered x price]	**441**	**399**	**426**	**841**
B. Estimate based on recorded data from farmers in 5 districts, Feb-March 2012				
N input in chemical fertilisers 2011/12 (kg N/ha)	131	189		320
Yield of harvested crop 2011/12 (kg/ha)‡	*4,467*	*3,388*		
N removal in harvested crop (kg N/ha)□	58.1	64.4		122
N not recovered in the crop (kg N/ha)$ [N input – harvests removal]	72.9	124.6		198
N recovered in crop (%)	44	34		38%
N not recovered (%)	**56**	**66**		**62%**
<u>Estimated cost of non-recovered N:</u>				
Price of N (average paid by farmers) Rs/kg N in urea (744 Rs/100 kg)~	7.4			
Cost of non-recovered N (Rs/ha) [N amount not recovered x price]	**540**	**922**		**1,462**

*Fertiliser Year Book 2011, page I-111
†Government of Bihar Statistics: Third advance estimate 2011/12: http://krishi.bih.nic.in/Third%20Adv.%20Estm.%20(2011-12).pdf
^Bouwman et al. (2005).
□N removal is calculated considering only N in the harvested part (grain); we assume N in other vegetative parts will not be removed from the land (crop residues will remained in the farm and manure from animals eating these residues will also be brought back to the farm).
$N lost or remaining in the soil (only 3-5% of N remaining in soil could be recovered by following year crop according to Ladha et al. 2005).
‡Average yields as reported by farmers in our surveyed districts. It might well be that farmers are overestimating their yields, when compared to official estimates above, or that we in inadvertently selected very productive farms.
~Average price for farmers in Khagaria (less expensive than in Muzzafarpur).

regions in 2030. Accordingly, there is an opportunity, through emplacing appropriate policies, to increase fertiliser use efficiency and nutrient recovery. Significant and large downstream beneficial effects could be achieved.

Considered in financial terms, the above inefficiencies represent an effective financial loss of between 841 and 1,462 Rs/ha. This can be viewed as an annual investment in the farming operation that shows no return. This, in turn, is roughly 10% of the average *per capita* income in the state (Table 1). Reducing use of chemical fertilisers, while maintaining good soil fertility and health by building up organic matter, or improving irrigation facilities, represent substantial opportunities to reduce waste and increase efficiency in farming businesses. Improving farm management without increasing expenditure on chemical fertiliser will increase nitrogen use efficiency and improve economic returns for farmers.

It is hoped that the preliminary assessment reported here will encourage a more complete and accurate analysis of fertiliser use efficiency in the state. The results presented here are believed to be conservative estimates, so that actual values may well be higher both in terms of percentage amounts of N being lost and in terms of monetary inefficiencies.

In conclusion, the cost in terms of public money spent on fertiliser subsidies can be calculated by extrapolation (Table 6). Bihar state consumed 0.91 Mt of N in the 2010-2011 growing season, close to a million tonnes of N per year (Fertiliser Statistics, 2011). Assuming 62% of this amount was lost, *i.e.* not recovered in food grain or other crops, this amounted to a total loss of 0.56 Mt of N. Given that the central subsidy for N is set at 27.15 Rs/kg of N, the total public subsidy money lost in Bihar amounted to 1530 crore Rs. This is a very significant loss by any standards, and this is particularly the case in a state needing substantial investment in sustainable development. It represents a crucial opportunity cost of not investing this money in more effective policies (like policies that benefit rural livelihoods and sustainable economic growth, as outlined in section 4 and 5 below).

Table 6. Estimated cost of low nitrogen use efficiency in terms of subsidy money that is not recovered in crops and thus financially lost.

Total Nitrogen consumed in Bihar	0.91 million tonnes
Estimated Nitrogen not recovered in Bihar crops (62% loss)	0.56 million tonnes
Public money subsidy per kg of Nitrogen	27.15 Rs/kg of N
Total subsidy money lost in Bihar as Nitrogen not recovered in crops	1 529 crore Rs.

Farmer Pramod Singh uses only chemical fertilisers in his crops of wheat and maize. A significant amount of the nutrients applied are not recovered in the harvested crop but lost to the soil, water and atmosphere

SECTION 3

WATER POLLUTED WITH NITRATES AND HEALTH RISKS ASSOCIATED WITH SYNTHETIC NITROGEN FERTILISER USE

Excessive chemical fertiliser application not only damages farmers' finances, but also results in losses of nutrients into the wider environment, degrading both air and water quality. Excess nitrogen can enter the atmosphere as nitrogen oxides. These can help cause the development of photochemical smog which is harmful to health. Rising global concentrations of the powerful greenhouse gas nitrous oxide are also mostly attributable to synthetic nitrogen fertiliser use.

Excess nitrogen can also be damaging to aquatic systems. Excess nitrogen is linked to degradation of streams, rivers and lakes and the eutrophication of coastal marine ecosystems. Overuse of nitrogen fertilisers can also degrade the drinking water resources available to farmers and farm labourers on their farms. Excessive nitrogen entering soil can be changed to highly soluble nitrate and move through the soil layer ultimately reaching groundwater. Groundwater near farms that apply nitrogen as chemical fertilisers or as livestock manure is often found to be contaminated with high levels of nitrates (NO_3^-). Nitrate is now considered to be one of the most common chemical contaminants found in the world's groundwater. Some nitrate occurs naturally at very low concentrations, but higher nitrate levels in groundwater are generally related to human activities. Inorganic

Children bathing and playing in the water from a diesel-run water-pump beside a maize field in Khagaria. Drinking this water may expose them to potential health risks in case of nitrate contamination in the water
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fertiliser and animal waste are the dominant sources of nitrate in groundwater around agricultural areas (Galloway et al., 2003, Galloway et al., 2008, Moore and Matalon, 2011).

Nitrate pollution of drinking water resources can have serious health impact on humans, particularly in babies and young children but also in adults. The most significant potential health risks associated with drinking water contaminated with nitrate is blue-baby syndrome (methemoglobinemia) and cancer, particularly cancer of the colon (Ward, 2005, van Grinsven et al., 2010).

In this current survey, nitrate concentrations were measured in wells supplying drinking water on 65 farms located in 5 districts in Bihar, Khagaria, Madhepura, Nalanda, Muzzaffarpur and Patna, covering 33 villages and 17 blocks (see methodology in Box 2).

Drinking water in farm wells was largely found to be safe for drinking in the majority of the locations relative to the safety levels established by the World Health Organisation (Figure 4). However, in two districts, Nalanda and Patna, nitrate levels in the groundwater wells on farms clearly showed pollution from nitrogen fertilisers. In Nalanda, 65% of wells (18 out of 28) had nitrate levels above 10 mg/l nitrate (as NO_3^-), thus showing some degree of pollution although not above levels considered unsafe for human consumption (Figure 4). Also in Patna, where nitrogen chemical fertiliser consumption is one of the highest, some wells were found with degraded water due to high nitrogen concentrations.

Although the levels found were still within limits considered safe for human health, they should nonetheless represent a call for action to the Bihar Government to work towards protecting drinking water and human health. Cutting down on excess chemical fertiliser use will have many benefits: in addition to economic benefits for farmers, they will protect clean water and protect the health of farmers, farm labourers and their families. Moving to cut chemical fertiliser use will also further protect the quality of streams, of the river Ganga itself and of the coastal communities living downstream. Some evidence exists that that chemical fertilisers are already causing significant nitrogen and phosphorus loading in the Ganga, contributing to its overall degradation in quality (Jain, 2002).

In addition, it must be taken into account that the WHO standards may not be fully protective of human health even if they are met. A recent assessment in the EU estimated that a 3% increase in the incidence of colon cancer could result from nitrate in drinking water exceeding 25 mg/L. This level is only half of the WHO safety limit of 50 mg/L. Quite apart from the costs of this in human terms, the authors concluded that "this health impact corresponds to an economic loss of 2.9 euro/capita/yr and of 0.7 euro per kg of NO_3^--N leaching" (van Grinsven et al., 2010). With the *caveat* that health costs and treatments in India might be different to those in Europe, it can be calculated that in Indian Rupees, the health impact will be about 50 Rs per kg of NO_3^--N leaching. This cost will add to the already high financial burden for farmers and Governments from the dependency on chemical nitrogen fertilisers. As shown in previous sections, the commercial price of a kilo of N in urea ranges between 5.4 and 7.4 Rs, and this is about ten times less than the estimated cost of its potential health effects in causing colon cancer when it leaches to the groundwater (based on a tentative estimation for the EU 11, and assuming Indian health cost would be similar (van Grinsven et al., 2010)

Groundwater depletion and high nitrate levels in drinking water are now common in other states of the Indo-Gangetic Plain, such as Punjab and Haryana. This is the result of years of intense agrochemical use and lack of adequate protection of the natural resource base (Tirado, 2009, Rodell et al., 2009, Kundu and Mandal, 2009, Singh et al., 2007).

One of the major problems that humans will face in the future is the availability of clean and safe drinking water. The problem of nitrate pollution is appearing in many different regions of the world, and is one which is often associated with industrial agricultural areas. These include industrial livestock production. For example, recent analysis carried out in the Californian San Joaquin Valley, which accounts for over half of Californian agricultural production, indicated that the number of wells polluted with nitrate will double by 2020. The prevalence of nitrate pollution in the region's drinking water is already increasing the cost of living for rural communities by having to procure safe drinking water, but most usually affects families in the lower-income brackets who can least afford it (Moore and Matalon, 2011).

Significantly, however, Bihar still has the opportunity of choosing a different path to that taken by the 'Green Revolution' states in India, where degradation of soil and water through intensive agriculture have "now exemplified the post-Green Revolution stagnation and challenges" (Erenstein and Thorpe, 2011). There is a need for a "paradigm shift" in agricultural development towards approaches that "link people, innovations and policy" (Erenstein and Thorpe, 2011). Greenpeace takes the view that these people-centred approaches should be based on ecological farming principles that aim towards increasing food security for today and tomorrow while working with nature, not against it. In the following section some options for an ecological farming system centred on improving the livelihood of people in Bihar are explored in more detail.

Nitrate levels in groundwater wells in Bihar farms

Districts Patna and Nalanda are first and third highest in chemical N fertiliser application rates

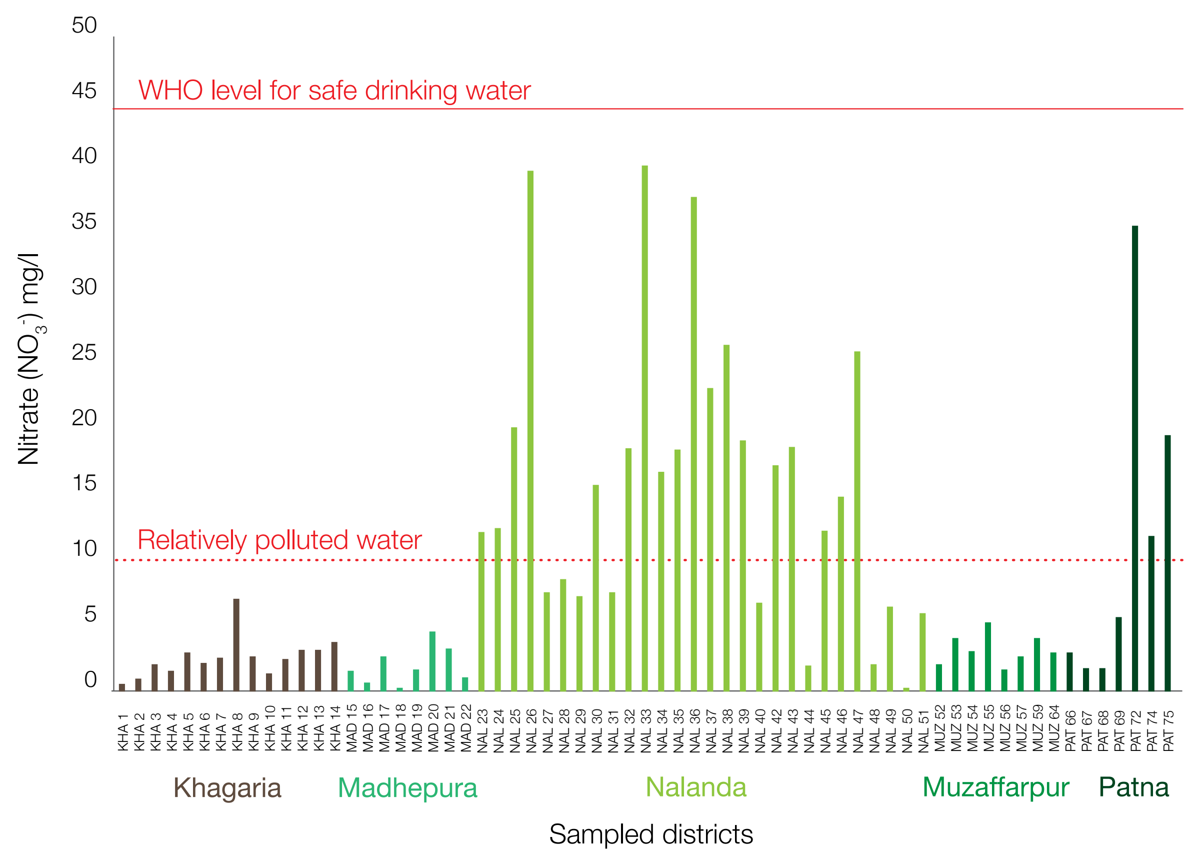

Figure 4. Nitrate concentration in 65 groundwater wells located in farms in 5 districts of Bihar.

SECTION 4

OPTIONS FOR ECOLOGICAL FARMING SOLUTIONS

Livelihoods in rural communities across the developing world centre mostly on the nexus between food, energy and water. Most rural people in India, and indeed, in other developing economies worldwide:

- grow crops for food and livestock in order to make a living,
- rely on various forms of biomass as their main source of energy and fuel, and
- depend on clean and reliable water resources for crops, for farm animals and for their drinking.

As described above, rural people in Bihar are faced with widespread relatively low agricultural productivity and low associated incomes. In addition they are subject to the financial burden associated with dependence on costly agrochemical inputs and the concomitant potential health and environmental effects. Agriculture experts agree that high production costs and high risks are among the general constraints underlying stagnant crop productivity in Bihar (Thorpe et al., 2007).

Climate change is likely to make these problems worse. For example, hotter temperatures seem already to be causing wheat yields to decline in some areas of the Indo-Gangetic Plain (Lobell et al., 2012, Lobell et al., 2011).

In addition to relatively low crop productivity, in rural Bihar there is also limited access to energy, to clean water and to sanitation facilities. Solving the huge joint challenges embedded in each of these areas of food, energy and water is unlikely to come from adopting the path of the 'Green Revolution' as followed by states like Punjab and Haryana. These states focused mostly on external inputs for increasing staple yields. Science and the current reality of farmers' lives show the results of this intensive approach. Green Revolution states are now facing problems which are acting on the resource base that sustains crop production: water and soil are fast degrading, while yield levels are static. A new approach is needed, an approach that works by

Ecological fertilisation would help boost the fertility of this soil
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focusing on people's livelihoods and which works with nature, not against it.

Evidence from across the world shows that the application of a different model is entirely feasible and can be very successful (e.g. Farming Matters, 2012). A new model of agriculture centred on people, not on chemicals or on other expensive inputs, can increase food production where it is most needed, and at the same time help in rural development (IAASTD, 2009, Schutter, 2010, Scialabba, 2007). Further, working with biodiversity can help provide a natural insurance against the uncertainties and vagaries of projected climate change.

Working with a vision of ecological farming coupled with renewable energy principles, Bihar farms could increase agriculture productivity, increase energy availability and access, and secure future clean water systems. Some options for working towards that triple goal: more food and higher incomes, more sustainable energy and cleaner water for all the people of Bihar are explored below.

4.1. High yields without chemicals: ecological farming optimises livestock and ecological fertilisation practices that are locally available, knowledge intensive and financially secure.

Ecological farming practices aim at replacing external inputs with natural processes and locally available technologies, in order to empower farmers and create financial security. Such practices take different technological forms depending on the biophysical and socioeconomic circumstances considered at the regional, or even individual farm level.

To ensure economically optimal yields, farmers need fertile soils and ways of significantly diminishing the risk of nutrient losses. To help achieve this, research and development on ecological fertilisation practices needs to be carried out. This is needed, together with supportive policies and capacity building, to

Earth worms enhance and maintain soil fertility
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Mix cropping of pulses and mustard crop
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provide farmers with the means to decide on the best soil nutrition management methods for their specific circumstances. Supporting farmers in efforts to increase soil fertility and yields on their farms is a first necessary step, best achieved through participatory interventions that take into account local conditions and community needs.

Practices like growing green manures such as legumes (or in paddy fields other N-fixing organisms like *Azolla*), vermi-composting, and adding livestock manure to fields represent just some of ways in which to increase organic matter and fertility of the soil. Natural nutrient cycling and nitrogen fixation can potentially provide fertility without the use of synthetic fertilisers and develop a healthier soil rich in organic matter, better able to hold water and less prone to erosion. At the same time, farmers' expenses on artificial inputs are reduced.

Shifting from dependency on chemical fertilisers to reliance on organic fertilisers (in various forms adapted to local conditions) would make farmers on small holdings more secure and less vulnerable to accessibility of external inputs and price fluctuation. Accordingly, research and development in finding the best ways to shift towards organic and away from synthetic fertilisers is needed in Bihar. The potential for success in improving yields and livelihoods could be very high.

Some examples from elsewhere as well from India of this high potential for increasing yields with ecological fertilisation practices include:

- A meta-analysis of data from 77 published studies which suggests that nitrogen-fixing legumes used as green manures can provide enough biologically fixed nitrogen to replace the entire amount of synthetic nitrogen fertiliser currently in use, without losses in food production (Badgley et al., 2007).
- A 21-year-long study on European farms, in which soils that were fertilised organically showed better soil stability, enhanced soil fertility and higher biodiversity, including activity of microbes and earthworms, than soils fertilised synthetically (Mäder et al., 2002).
- In apple orchards in the US, fertilisation with manure (compared to fertilisation with chemical fertilisers) increased the amount of carbon stored in the soil, increased the diversity and activity of soil microbes, and decreased the losses of nitrates to water bodies while keeping nitrous oxide losses to atmosphere at similar levels (Kramer et al., 2006).
- Ecological farming practices can help reverse the trend of declining soil fertility that many farmers in developing countries are facing. Problems like soil erosion, acidification and organic matter depletion can be solved through ecological farming practices that nurture soil fertility and biodiversity (Eyhorn, 2007).
- The UN Special Representative for the Right to Food, Olivier de Schutter has compiled evidence demonstrating that ecological farming approaches could potentially provide enough food for all. For example, programmes in Malawi aimed at better access to organic fertilisers, improving soil fertility and moving towards fertilising with N-fixing trees (in addition to better access to fertilisers) have increased maize yields from 1 t/ha to 2–3 t/ha, even when farmers cannot afford commercial nitrogen fertilisers (Schutter, 2010).
- In India, a field experiment with rice-wheat cropping in western Uttar Pradesh in the Indo-Gangetic Plain demonstrated how growing cowpea legumes after the wheat harvest and before rice transplanting improved soil condition, reduced losses of nitrates in the soil and improved nutrient use efficiency (Dwivedi et al., 2003). Importantly, cowpea can provide green forage for animals in the forage-scarce summer season and increase the overall productivity of the farm. Some of the farmers we interviewed already practice green manuring with *Dhaincha* (the leguminous shrub *Sesbania bispinosa*) before rice/wheat and have experienced similar positive results.

Ecological farming practices could, therefore, help reverse the trend towards depletion of soil organic matter, a problem already apparent in Bihar (Thorpe 2007). Higher application of animal FYM (farm yard manure) onto croplands, for example, can build up soil organic matter and further contribute to soil health and balanced fertilisation of soils. The apparent conflict with other uses of FYM, for domestic fuel for example, would be minimised once energy needs can be satisfied with other renewable energy sources which are much more efficient than dung cakes (see section below). Other practices that build up soil organic matter and contribute to ecological fertilisation without chemicals are the growing of green manures, application of composted residues (other crop residues, weeds like water hyacinth, etc.).

These practices are often labour intensive and can help in increasing employment opportunities for rural communities.

A large study comparing examples of organic and conventional agriculture in Asia found that food security is significantly higher for farmers using organic practices. Organic farmers have a more diverse, nutritious and secure diet. Organic farmers have on average, higher net incomes that have increased since 2000 in contrast to stagnant or declining incomes for conventional farmers. Net incomes per hectare for farmers applying organic practices are one and a half times higher than those of conventional farmers; as a result organic farmers are less indebted than farmers relying on agrochemicals. In summary, farmers achieve higher productivity and have a much more stable financial base on organic farms as compared to conventional farms (Bachmann et al., 2009).

Some of the farmers interviewed in India in this study practice organic agriculture or at least minimal chemical fertiliser application on food grown for their own consumption. They grow crops on a separate patch of land for themselves and apply little or no chemical fertilisers or pesticides, using indigenous or *desi* seeds. They are aware of the ill-effects of the chemical inputs and do not wish to consume food grown with them. They also feel that in terms of nutrition and taste, traditional *desi* crop varieties are better. In addition, using low-external inputs they can grow their own food cheaply.

Many scientists together with institutions like FAO, UNEP and local or regional farmers' associations are documenting remarkable success from organic agriculture both in achieving high yields and fighting poverty (Scialabba, 2007, Nellemann et al, 2009, UNEP and UNCTAD, 2008, IAASTD, 2009). More research and development and further funding to develop modern organic farming technologies are undoubtedly needed but nevertheless, there is much evidence already that farming without chemical fertilisers can still produce enough food for all. This is especially true if we consider a vision aimed at farming with biodiversity, at closing nutrient cycles and at recycling nutrients from non-conventional sources (sewage, residues, etc.).

Cabbage in a field in Khagaria district – Bihar is a top producer of vegetables in India
© Karan Vaid / Greenpeace

Farmers applying organic fertiliser to Vinay Yadav's wheat crop

Livestock and the need to increase yields

Crop and livestock production are deeply interlinked at the household level in Bihar farming systems. Livestock rearing combined with cropping provides a more secure outlook for farmers where they face a variety of risks. Examples of such risks include a high incidence of flood events and soil waterlogging. At the other end of the risk spectrum, farmers may face droughts coupled with a lack of secure irrigation services. In such cases, maintaining some animals on the farm reduces risks as well as helping stabilise incomes through converting low value crop residues (the main animal feed) to higher value milk, live weight and dung. Even so it has been noted that the "contributions of these crop-livestock interactions to livelihoods were not allowing families to escape the apparent poverty web in which the majority are trapped" (Thorpe et al., 2007).

It may be the case that inherent low productivity and lack of resources are acting together to prevent farmers taking full advantage of the added benefits conferred by a mixed crop-livestock system. In Bihar, high demand for biomass resources cannot be met fully from the low productivity agricultural systems, effectively minimising the benefits of livestock as risk insurance. Crop residues are the main feed for animals and are in high demand. Most farming households need to buy crop residues to supplement the livestock diet. Consequently, low livestock productivity is often associated with inadequate feeding (Thorpe et al., 2007). A holistic ecological farming system would provide opportunities for better optimising livestock resources.

As a first step, increasing biomass production using ecological farming practices is necessary. As outlined above, many low-income regions have seen increases in yields with the adoption of such methods. Increasing biomass production need not be simply in the form of achieving increased yields of rice and wheat grains. Alternative options to improve grazing and increase forage production in parallel need further promotion and development. For example, agroforestry using N-fixing trees or growing green manure as forage can provide green fodder for animals over a time-window during which land is otherwise unproductive. A collateral benefit of such approaches is an increase in nitrogen and organic matter in the soil. Many ecological farming practices work towards enhancing productivity and resilience in times of drought and water limitation. These are among the major constraints to increasing biomass production in the Bihar region. To achieve these broad goals of increased yields much more research is needed into ecological farming solutions, together with funding for scaling up and adapting local solutions.

In conclusion, livelihood options that integrate crop-livestock systems provide a means of improving rural livelihoods in the Indo-Gangetic Plain. Overall, mixed systems based on robust principles of ecological farming practice offer the highest potential in securing livelihoods that are economically and environmentally sustainable.

4.2. Clean water, improved public health and cheap local fertilisers: Eco-sanitation

"The loop of nutrients – from land to land – needs to be restored once again." (Narain, 2012)

Sanitation and sewage systems in rural areas in India such as Bihar have improved in recent years. A level of 2.3% of the public covered by sanitation systems in 1990 rose to 16.2% in 2004, but this is still very low and ranks among the lowest coverage rates in South Asia (Jha, 2010). Sewage pollution of ground and surface water is common and a high incidence of waterborne diseases is often associated with poor sanitation in villages. Open defecation continues to be widespread, seemingly deeply rooted in the socio-cultural realities of rural communities. It continues to persist after almost six decades of efforts to eradicate the practice. The problem of sanitation is two-fold: a lack of proper sanitary infrastructure coupled with a widespread societal resistance to indoor sanitation.

Paradoxically, the poor overall situation actually provides a perfect opportunity to reinvent sewage treatment and sanitation paradigms, simply because the infrastructure is not already there. Accordingly, there is no requirement to design new systems which must take account of any existing infrastructure. Sanitation systems can be designed which are based on new ways of dealing with excreta *and* which work in synergy with the needs of agriculture and renewable energy requirements.

Currently, even though it is a highly nutrient rich resource, it is estimated that globally only 10% of global human excreta is recycled, either intentionally or unintentionally, to agricultural or aquacultural systems (Cordell et al., 2011). Current sanitation systems ('flush and forget' systems) in industrialised countries largely treat human excreta as a useless residue, wasting large quantities of clean water (of potable quality) and energy in sewage plants built to treat and manage it. Domestic sewage is also often deliberately mixed with industrial wastes. At the same time, about half of the people living on the planet, 72% of them in Asia, do not have access to adequate sanitation facilities (Mihelcic et al, 2011) hence exposing them to risks of various waterborne infectious and parasitic diseases. Historically, agriculture has often relied on nutrient input from human excreta to increase food production. In China and Japan, for example, it was once an essential input for the high food production that underpinned social development in these countries.

There is an increasing appreciation that chemical fertilisers (e.g. synthetic N and mineral P) depend on limited non-renewable resources and are expensive as inputs in farming. This has raised awareness of the potential to treat human excreta as a resource rather than as a pollutant or waste. The outlook for the recovery of N and P from human excreta is promising. Firstly, the lack of existing sanitation and sewerage facilities in many places provides an opportunity for creating truly sustainable systems with nutrient recovery as an explicit goal. Secondly, nutrient recovery can be very efficient since up to 90% of the P and N in urine and faeces could be potentially recovered and used to fertilise agricultural lands.

Accordingly, the best long-term solution for recovering nutrients from human excreta is through the rapid creation of ecological sanitation systems that work simultaneously to close nutrient cycles, save water and energy, and thereby improve both livelihoods and living standards in a cost effective way. According to the Stockholm Environment Institute, the cost of implementing ecological sanitation systems globally could be entirely offset by the commercial value of the nitrogen and phosphorus they yield (Cordell et al, 2009). About 60-70% of the phosphorus and nitrogen in human excreta is found in the urine fraction while 30-40% is found in the faeces. Human urine is generally sterile, containing very few, if any, pathogens.

There exist many examples of eco-sanitation initiatives in operation which simultaneously improve agricultural yields and public health while reducing environmental pollution. Scaling up these eco-sanitation programmes could also increase the sustainability of farm systems and the livelihood of millions of farmers in developing countries. In practice, effective ecological sanitation relies on separating waste streams to optimise their potential for re-use. A way to overcome initial rejection of the idea of using human excreta as fertiliser could involve starting with an initial phase of separating and using urine as fertiliser. Faeces could be used in local biogas plants that produce bioenergy (while the remaining digestate could later be applied to fields as fertilisers). It is important also that human sewage resources are not deliberately mixed with industrial effluents for supposed co-treatment. This can contaminate the sewage with industrial chemicals making it unusable in beneficial applications.

The example of Sulabh[4] toilets offers some good options for further development. Sewage from many Sulabh toilets fuels street lights and cooking stoves through its use in the production of biogas, and the wastestream is treated and recycled to the maximum extent possible. Another example is the Ecosan (ecological sanitation) project in rural Tamil Nadu. Ecosan "is a system that integrates sanitation and agriculture by using human waste as a fertiliser and soil conditioner. Ecosan toilets collect urine and faeces separately. The urine is applied to fields either undiluted or diluted with water. The faeces are stored and composted before use. Ecosan toilets are low cost because they do not use traditional plumbing. Instead they have a dual pit system where the faeces flow into a sealed pit where they are retained for about 1.5 years. The toilet is then switched to the second pit. After the faeces in the first pit have fully decomposed, the user is left with odourless manure that can be used for fertilisation. This cycle can be repeated indefinitely. By also economising on water use, Ecosan promises several clear advantages over the traditional water borne sanitation systems. It also puts human "waste" to a beneficial use" (Jha, 2010).

A scientific evaluation of the Ecosan process in providing organic fertilisers derived from urine for banana cultivation in Karnataka showed very positive results. Yields were highest with application of urine-derived fertilisers as the only source of nitrogen. The authors concluded that the "ecosan system helps to provide better sanitation, helps farmers to save the cost on fertilisers without affecting the crop yields and thus helps to achieve food security"(Sridevi et al., 2009).

Using music to spread the Ecosan message across Mozambique, Feliciano dos Santos – a Goldman Prize winner in 2008 – has helped remote rural communities achieve cleaner water and higher food security. "Families using ecological sanitation report markedly fewer diseases, a 100 per cent improvement in crop production, and improved soil retention. Before ecological sanitation, many villages used costly artificial fertilisers on their crops, and often were barely able to feed their families. By using the Ecosan compost instead of artificial fertiliser, many are able to produce more food than they need and can generate a small income by selling some of their harvest." With his internationally recognised band, Massukos, Santos uses music to promote the importance of water and sanitation in Mozambique. His programme is now serving as a model for other sustainable development programmes around the world.[5]

"It would not be wrong to say the technology of toilets – an equipment to handle human excreta in a safe and hygienic manner – has been the least researched in the world. It is clear we need technologies for diverse ecosystems, which also meet the twin objectives of equity and sustainability. This will require toilets to be engineered, or re-engineered, so that they are affordable and function to reuse and recycle the excreta generated." (Narain, 2012).

4.3. Energy access, food production and rural livelihoods: Potential for holistic win-win-win solutions.

Approximately 85 per cent of poor people in rural India rely on a mixture of non-conventional/ traditional sources and fossil fuels for lighting and cooking. These include wood, cow dung and kerosene. About 45 per cent of this population does not have access to electricity and relies on kerosene for lighting. In Bihar these figures are even higher. About 89 per cent of the state population (12.6 million households) resides in the rural areas and almost 95 per cent of these households are dependent on kerosene for lighting. These fuel resources used in this way are harmful to the health of the user and also contribute to pollution and to environmental degradation. Reliance on these resources also restricts potential economic growth. Many income-generating activities require reliable access to energy. Non-availability of reliable power supplies is a key constraint on economic development in rural India. Providing electricity to this population is the first step towards significant economic growth (Greenpeace India 2010).

Limited access to reliable energy supplies in Bihar negatively impacts life at the domestic level and the aspirations of local communities, as well as overall potential economic development. Significantly, in the context of this report, it also affects the potential for increasing agricultural productivity, the main income generation activity in the state. For example, lack of a reliable source of power for water pumps makes crop irrigation dependent on expensive diesel and, therefore, both expensive and erratic. In addition, use of cow dung cakes as the main fuel used for cooking limits the potential for its use as a fertiliser and soil conditioner for better soil health. These interactions between energy, agriculture and livelihood exemplify the need for holistic solutions that look at the system as a whole and which integrate into a multi-sector approach centred around people's needs (Erenstein and Thorpe, 2011). Needs for livelihoods, food, fertilisers, animals and energy can be looked at in an integrated way in order to find synergies and to implement inclusive policies that bring about systemic solutions.

If energy needs in the rural communities of Bihar could be met using a decentralised system[6] based on locally-available renewable sources of energy (solar, wind, rice husk biomass, etc.), then livestock manure currently used as cow dung cakes for cooking could be fully utilised as fertiliser and soil conditioner, and hence potentially contribute to increasing crop productivity. This would also reduce farmers' expenses in purchasing chemical fertilisers. In addition, a decentralised renewable energy system could also provide a more efficient and reliable energy source for irrigation, hence likely improving agricultural productivity. It has been shown in Sub-Saharan West Africa, for example, that solar-powered drip irrigation significantly augments both household income and nutritional intake, particularly during the dry season, and is cost effective compared to alternative technologies (Burney et al., 2010) thus providing substantial economic, nutritional, and environmental benefits to populations in a low-income region. These schemata should, however, like any irrigation scheme, aim at conserving groundwater resources and using them judiciously. Clearly considerable capacity building and technical support will be needed for the construction and implementation of decentralised renewable energy projects like this, but evidence shows that these are more cost effective and bring more economic benefits to local communities than conventional energy schemes in the medium to long term. While the present government in Bihar has taken several positive steps to bridge the gap between demand and supply of electricity in rural areas, it still faces several economic, technological and financial constraints in reaching its stated goal. In addition, there continues to be an urgent need for more research and development towards agriculture systems that incorporate provision of renewable energy and equitable livelihoods into their goals.

Examples of increasing energy access in Bihar exist, based on using local raw materials from crop residues (rice husk) to generate electricity for rural communities. It is important to note, however, that crop residues function as multifunctional resources: they are seldom a 'waste' but more a 'co-product' of food crop production with their own roles, revenue streams and demand. Intended uses of crop residues, therefore, must prioritise food production or functions in the farm system that enhance food production (use as fertiliser or soil conditioner) over uses to provide energy *per se*. Crop residues with lesser multifunctional roles (like rice husk) can be directed towards bioenergy generation. Decentralised power generation from renewable energy must be highly localised in both its design and implementation, with detailed assessment of, and sensitivity to, local requirements and the availability of local resources. With this in mind, two examples from Bihar State are outlined below.

Fodder for livestock being carried back through mustard and wheat fields

A farmer stands in his field of maize, with mustard fields in the background © Karan Vaid / Greenpeace

Rice husk

In Bihar, the company Husk Power Systems is providing electricity to over 100,000 people using the only waste products generated in the villages: the leftover husk of rice grains. HPS pays under one rupee per kilogram for rice husk, and by loading fifty kilograms per hour into one of their 32kW power plants, can produce enough power to sustain a load of 700 typical rural households at the same time. The model seems robust: this year, Bihar will produce 1.8 billion kilograms of rice husk. If extended to the whole of India, as HPS has plans to do, it could be possible to generate 27GW of power from just the waste rice husk that is produced in the country. This amounts to around one sixth of the total installed generating capacity of the country (Greenpeace India 2010).

Cattle dung biogas

Cattle dung biogas is readily acknowledged to be a highly effective renewable energy system for parts of rural India, and indeed, in many countries in Asia and beyond (Jones et al., 2011). However, the cost of building a suitable unit is still beyond the budget of most rural families, especially families of daily wage labourers.

A biogas unit comprises a domed chamber buried under the yard of a rural household. The dung from the family's cows, mixed with water is loaded through the top of the unit. The dung digests in the anaerobic chamber, producing biogas rich in methane. This is an excellent cooking fuel and can be piped to the kitchen, where it burns cleanly on an adapted stove, replacing the need for wood as a fuel. The residual slurry from the domed digester makes a nutrient-rich fertiliser for the family's yearly crop.

Through the biogas unit the cow, already heavily depended upon in villages for its milk, becomes an even more important source of income. Its dung creates not just a clean, free cooking fuel, but frees up time from gathering firewood in which women are free to do other things (Greenpeace India 2010). It is possible that such an approach could be applied at a similar small scale to human excreta as outlined above in the discussion on sewage treatment.

Photo panels below, taken from Jones et. al. (2011) summarise the multidimensional impacts and benefits of installing biogas plants based on animal and human wastes.

Figure 5. Impacts avoided by installing local biogas plants based on livestock and human wastes. Panel taken from Jones et al. (2011) published by The International Institute for Environment and Development (IIED) and the IUCN Commission on Environmental, Economic and Social Policy (CEESP).

Figure 6. Benefits of installing biogas plants based on livestock and human wastes. Panel taken from Jones et al. (2011) published by The International Institute for Environment and Development (IIED) and the IUCN Commission on Environmental, Economic and Social Policy (CEESP).

SECTION 5

THE WAY FORWARD

This report describes how chemical fertiliser-dependent farming in the state of Bihar makes farmers' livelihoods vulnerable to fluctuations in the international market prices of these chemicals, which in turn are a function of volatile global fossil fuel prices. It also highlights the trends in chemical fertiliser usage in the state and shows how the state appears currently to be treading the same path as the first Green Revolution states such as Punjab and Haryana. If this trajectory continues to be followed, degradation of natural resources will result, causing significant economic losses for the farmer as well as for the Government while simultaneously creating risks to human health. Accordingly there is an urgent need to check this trend before it is too late. What can be termed a "mission mode" approach is imperative.

The Agriculture Road map for the next 10 years (2012-2022) announced by the Government of Bihar is a step forward in the right direction. The Government's stated intentions to promote organic farming and eco-fertilisation are to be broadly welcomed. The Agriculture Road Map for the next 5 years (2012-2017) also made good provision for composting, biofertilisers, green manure promotion, organic farming, etc. However, the reality on the ground will likely prove challenging to the effective implementation of these policies. For example, limited biomass availability and low crop productivity might preclude effective solutions. In the course of the field work described in this report, many vermi-composting structures in villages were observed left unused and abandoned. The reasons for this are not entirely clear, but this serves to illustrate that well intended solutions promoted in isolation and without wider consideration of community needs and practices, can fail to address the full range of challenges encountered in the field. In order to bring about a real effective shift towards sustainable ecological agriculture in Bihar, there is a need for convergence in, and integration of initiatives designed to address issues in agriculture, livelihood, energy and sanitation. Some guiding principles are suggested below that can help in designing effective efforts to improve agriculture and livelihood in Bihar:

Farmer Chhotan Prasad,
Badi village, Katrisarai block, Nalanda district will benefit greatly by adopting ecological fertilisation for his crops
© Swapan Nayak /Greenpeace

1. A holistic approach to address rural livelihoods and agriculture issues

Work carried out in sectoral, isolated "silos" will not effectively produce the much-needed changes. A people centred, multi-institutional and transdisciplinary approach will be required (Jones et al., 2011). As an example, the case of biomass management, vital for ensuring an effective ecological fertilisation and eco-farming strategy, can be considered. At present, different sectors compete for whatever biomass is available. Green biomass is used as fodder for cattle. Cow dung cakes, pressed leaf litter, crop residues, and indeed all forms of biomass that are available are used as cooking fuels in rural areas in the absence of alternative renewable fuel sources. Crop residues are also used as thatching material, and a small proportion is used in decentralised energy production systems. It is very important to adopt a "win-win" strategy to ensure that sufficient biomass goes back to agricultural soils. Livelihood needs require protection by a variety of alternative means as discussed in section 4.

2. Research and funding in agroecological systems and holistic solutions

For decades, research has been directed towards an agriculture model that is intensive in relation to required external inputs, aimed at increasing yields of a limited number of staple grains, while often detrimental to the environment (Foley et al., 2011). Less attention has generally been focussed on research into scaling up low-input local practices, or into solutions that improve overall food production, nutrition and livelihoods at the local scale. Many examples exist: what is lacking is the research and development to scale up and adapt these solutions to different local realities (IAASTD, 2009).

An agro-ecological knowledge framework offers an alternative. Agro-ecology involves a contextually specific set of principles and methods to understand and analyse given agro-ecosystems. The focus is on the dynamism of both ecological and social processes. There is no universal formula or "silver bullet" for maximising the productivity, well-being and sustainability of any agro-ecosystem. Nonetheless, the fundamental principles of agro-ecological knowledge offer a framework for analysis and design of technologies and appropriate policy interventions. The framework emphasises the continuous evolution of knowledge along with changes in ecological and social systems together with the multiple roles and functions of farms and farmers. Drawing heavily from the ecological sciences, it makes a case for recognising and promoting both collaborative behaviour and competitive behaviour across scales and diverse agro-ecosystems. (Report of the Working Group on NRM and Rain fed Farming, Planning Commission, 2011) Within Bihar, the ground reality varies from locality to locality. Hence, there is a need to examine a vast range of possibilities of permutation and combination of farming systems. It is necessary to do this in the context of the regionally differentiated socio-economic conditions, demands, and availability of natural resources. The importance of agro-ecological knowledge generation and the access that farmers have to this knowledge base is crucial. Currently there is limited capacity within the agricultural research community and its extended systems in order to enable this.

This could be overcome through the creation of a School of Agro-ecological Systems Analysis, in the two existing State Agriculture Universities so as to:

(i) ensure convergence in research, development and implementation across departments, at the block and district level,
(ii) enable research into local level participatory farming systems and ecological agriculture,
(iii) develop capacity for knowledge based development - scaling up of findings from these farming systems based on research and on the principles and best agro-ecological practices for sustainable agriculture.

3. Regeneration of common pool resources

In rural communities worldwide, common pool resources play a critical role in sustainability, livelihoods and resilience in times of uncertainty and scarcity (Ostrom and Nagendra, 2006). In India, for example, studies on common pool irrigation resources in Tamil Nadu show that farm profit and productivity increase when farmers incorporate community-managed common irrigation resources (Sakurai and Palanisami, 2001). Community management of common pool ecological fertilisation resources might similarly underpin the sustainability of farming in Bihar. Common resources like village ponds and tanks that provide sedimentary silt to fertilise farm soils and less productive lands used communally that could integrate production of forage and bioenergy in agroforestry, are two examples of essential natural capital for livelihood development (Marothia, 2002). The regeneration of common pool resources and their management by rural communities might be one of the appropriate strategies useful to develop ecological fertilisation initiatives in Bihar. More participatory and multidisciplinary research in common pool resources for improving rural livelihoods will be required.

4. Convergence of policies

While the State Government's Agricultural Road Map is a good step forward, the Central Sector schemes also offer a potentially good funding platform for promotion of ecological agriculture. The comprehensive district-level agriculture plans (CDAP), in which the Central Government supports agricultural development in the States through its flagship programme, Rashtriya Krishi Vikas Yojana (RKVY) could be a good instrument to facilitate location-specific projects promoting ecological farming and fertilisation. However, a perusal of the last four years of RKVY balance sheets for the state does not present a rosy picture. During the last 4 years, only 6 out of the total 241 projects implemented under RKVY supported ecological farming or fertilisation and only 7.7% of the total amount spent under RKVY was utilised for the promotion of organic farming (Table 7). The projects were mostly for promotion of vermi-compost or green manure crops, and did not follow a holistic approach. It's also not clear whether projects were implemented in contiguous farmlands or in isolated locations. It is also revealing that the total amount spent on promotion of ecological or organic farming over 4 years (141 Rs. crore) is less than 10% of the subsidy amount for urea N fertiliser that is lost in non-recovered N in Bihar (1,529 Rs. crore, Table 6).

Comprehensive district-level agriculture plans (CDAPs) are potentially excellent policy instruments for the development of holistic location-specific plans. As outlined earlier, these should reflect the local constraints, advantages and measures relevant to implementation. This is likely only to be possible when plans are prepared at the local level (block – village-community level) with appropriate support, and then aggregated at district level. CDAPs could support the plans of the Bihar Government to create organic villages in the State, as envisaged in the Agricultural roadmap. It could also help in the setting of district level targets to reduce the use of chemical fertilisers.

By facilitating and enabling a proper participatory approach, it could help ensure that at least 25% of the total funds under RKVY are used to promote ecological farming and fertilisation in contiguous farmlands with progressively raised targets set during the subsequent plan periods.

It is also important to ensure that the Bringing Green Revolution to Eastern India (BGREI) programme of the Central Government, which is presently funded through RKVY, follows a sustainable path and does not promote resource-exploitative agriculture in the State. In addition to RKVY, the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) also offers a good option to promote ecological fertilisation. The MGNREGS 2.0 launched recently has provisions to provide labour support for small and marginal farmers to adopt ecological fertilisation. This represents a huge opportunity as these practices are more labour intensive and unavailability of labour is often cited as a reason for non-adoption of new practices.

Finally, in order to help leverage the policy options available, it is important that these policies converge at the implementation level, which should be at the block level or lower.

An example of a state level institutional mechanism with grassroots level presence aimed at coordinating the implementation of ecological farming practices was developed through extensive consultation organised as part of Greenpeace India "Living Soils" campaign. This example is presented in Appendix A.

Table 7. Summary of Rashtriya Krishi Vikas Yojana (RKVY) projects in Bihar supported by the Central Government during the last 4 years. Information compiled from http://rkvy.nic.in.

Year	Number of projects on agroecology	Total number of projects	% Number of projects on agroecology	Amount spent on agroecology (Rupees – crores)	Total amount spent (Rupees – crores)	% Amount spent on agroecology projects
2011-12	2	68	2.9	101.05	977.04	10.3
2010-11	3	49	6.1	32.64	398.21	8.1
2009-10	0	50	0	0	78.48	0
2008-09	1	47	2.1	7.44	173.73	4.3
Total in 4 years	6	241	2.5	141.13	1815.27	7.7

A farmer toils in his field in Lantan village, Muzaffarpur district. The Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS) and other such schemes could hold great potential for providing labour support for labour-intensive practices in states like Bihar

GREENPEACE RECOMMENDATIONS:

1) Launch a State Ecological Farming and Fertilisation Mission, converging relevant Central and State Government policy instruments, and enabling a dedicated institutional mechanism with grassroots presence. The Mission should find synergy with livelihoods, bio-energy, regeneration of common pool resources and eco-sanitation initiatives in the state (example given in Appendix A).

2) Create School of Agro-ecological Systems Analysis in the two Agricultural Universities in the State with regional, block level holistic research and extension programmes.

3) Enable effective district level planning to ensure that 25% of RKVY funds are earmarked to promote ecological farming and fertilisation to start with and with an objective to progressively raise the amount to 50% of the funds by the end of the five year plan period.

4) Set targets for systematically replacing chemical fertilisers with ecological fertilisation during the five year plan period.

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ENDNOTES

[1]Below Poverty Line (BPL) is a poverty threshold used by the Government of India to indicate economic disadvantage and to identify individuals and households in need of government assistance and aid. BPL thresholds are often subject to debate, see e.g., “Now, Planning Commission lowers the poverty line” The Hindu, March 20, 2012 http://www.thehindu.com/news/national/article3013870.ece

[2]http://www.business-standard.com/india/news/india%5Cs-potash-import-faces-price-hurdle/438818/

[3]Gross cropped area represents the total area sown once and/or more than once in a particular year, i.e. the area is counted as many times as there are sowings in a year. See e.g. http://eands.dacnet.nic.in/PDF_LUS/Concepts_&_Definitions.pdf

[4]“Founded in 1970, Sulabh is a pan-India NGO that has gained international recognition for its model of urban sanitation. It has come up with a solution to the twin issues of rehabilitating members of hereditary scavenging subcastes and providing well-maintained sanitary facilities for toilet-less urban residents upon payment of a nominal fee. The first of its nearly 6,000 toilets – and counting – was built in the city of Patna, the state capital of Bihar.” (Jha, 2010).

[5]http://www.goldmanprize.org/2008/africa

[6]A decentralised energy system will provide the best option for energy access in the state, given the following situation: a) huge supply and demand gap, b) low capacity of the state to bridge the gap, c) difficulties in centralised supply due to lack of infrastructure, capital and human resource, and d) low availability of a reliable supply of conventional fossil fuel. Decentralised systems have more positive, holistic and developmental impact on the society because of their local and socio-economic dynamics. Decentralised systems will enhance energy security, commercial activity, foster economic development and empower people. For more details see 2010 Greenpeace India report “Empowering Bihar: Policy Pathways for Energy Access”.

APPENDIX A

A state level institutional mechanism with grassroots level presence

Participatory and locally-run institutions, like the Farmers Field Schools provide a good example of the role of institutions in bringing about changes on the ground (Van den Berg and Jiggins, 2007, FAO, 2002). Capacity building and participatory research on locally relevant ecological farming techniques are essential for rural agricultural development. These local institutions can integrate the support needed by farmers, for example, in the currently deficient agricultural extension services into new models of capacity building in ecological farming systems.

Jeevika, the Bihar Rural Livelihoods Project (BRLPS), with a vibrant grassroots level infrastructure is a good model that could be strengthened to deliver on the eco-farming vision of the State. Jeevika focuses on institutional development, capacity building, social development, microfinance and livelihoods. Through the women's self-help groups, Jeevika has already initiated several projects to promote ecological farming and fertilisation. However these initiatives need to be strengthened through a dedicated mission on ecological farming and fertilisation where different policies and agro-ecological research systems converge.

As a result of extensive stakeholder consultations across different states in the country, organised as part of the "Living Soils" campaign of Greenpeace India in 2010 and 2011, a model institutional mechanism has been developed. This model could be further modified and strengthened, based on further stakeholder consultations if necessary.

The goal of this mechanism would be to coordinate and ensure coherence and efficient implementation of policies touching different departments within relevant institutions working for agriculture and rural development. The model proposes a State level mission on eco-fertilisation and farming with a dedicated Mission Director. The Mission Director will be independent of various line departments such as Agriculture, Rural Development, etc., but with executive powers to draw in expertise from the various departments to effectively implement a cross-functional holistic programme.

The model also proposes an advisory committee to the Mission Director, consisting of successful practising organic farmers, agriculture university scientists, policy experts, state coordinators of relevant development programmes such as RKVY and civil society think tanks. Institutions that are subsequently proposed can either be created or integrated through re-modelling of existing and available institutions. Bihar state can definitely make effective use of the Jeevika infrastructure which already exists in various districts.

In addition, a School of Agro-ecological systems Analysis needs to be created with block/taluk level programmes, which should be integrated with the State Mission on Ecological Farming and Fertilisation.

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Figure 7. Model institutional mechanism for a state-level mission on ecological fertilisation and ecological farming with a dedicated Mission Director, who is independent of various line departments such as Agriculture, Rural Development, etc., but with executive powers to draw in expertise from the various departments to effectively implement a cross-functional holistic programme. An advisory committee comprising of practising successful organic farmers, Agriculture University scientists, policy experts, state coordinators of relevant development programmes such as RKVY and civil society think tanks is also proposed to advise the Mission Director.