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Economic analysis of strengthening the governance of pesticide management in Uganda's agriculture sector

Eseza Kateregga *

Makerere University, College of Business and Management Sciences, P.O. Box 7062, Kampala, Uganda

Abstract

In this study we seek to compare the benefits and costs of strengthening the regulatory framework for pesticide management in the agriculture sector. Strengthening of chemical use in the country is in line with the Strategic Approach to International Chemicals Management. The costs of the actions proposed to improve pesticide use in the agriculture sector are weighed against the expected benefits. The net present values and benefit cost ratios are computed for a period spanning 15 years. Results showed that strengthening the governance of pesticide management has potentially huge economic, social, human health and environmental quality benefits. This is highlighted by the huge difference between estimated monetized social and environmental benefits and the costs of investments proposed for sound management of chemical in the sector.

Keywords: Pesticides, Fertilizers, herbicides, Net present value, Benefit-cost ratios

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* Corresponding author. *E-mail address:* ekateregga@fema.mak.ac.ug, esezakat@gmail.com

1. Introduction

Chemicals are important inputs and materials in the day to day production and consumption processes worldwide. In a number of countries, the chemical sector is a significant contributor to national income, employment, and international trade. OECD (2001) shows that international trade in chemicals was projected at 15% of total manufactured output in 2003. Global output of chemicals was projected to increase by 85 percent over 1995 levels by 2015, with the largest increases expected to occur in developing countries (OECD, 2001).

The notable features in the trend of chemicals production and management are: (i) the production of chemicals is becoming more evenly distributed internationally; (ii) the growth in production and use of chemicals in developing countries is outpacing their ability to implement regulatory regimes for sound management of chemicals; and (iii) hazard information is lacking for the vast majority of chemicals (Arseneau, 2005). The large increase in global output of chemicals has raised concerns on the impacts on the environment's chemical waste assimilative capacity, pollution and the pollution related human illnesses. This has highlighted the need to reexamine the chemical management profiles in various countries in order to assess whether they conform to the principles of sound management of chemicals as stipulated in their local and international laws. More specifically assessment has been on whether their chemical governance conforms to the Strategic Approach to International Chemicals Management (SAICM). SAICM was adopted in 2006 with the aim to ensure that, by the year 2020; chemicals are produced and used in ways that minimize significant adverse impacts on the environment and human health (www.saicm.org). This created a need for countries to: (i) assess their sound management of chemicals (SMC) regimes; (ii) put in place plans to begin addressing gaps in the national chemical management policies and, improve the incorporation of national sound management of chemicals priorities into the national development discourse and planning agenda.

The objective of sound chemical management is to prevent and reduce the potential for human population and ecosystems to be exposed to toxic and hazardous chemicals (UNDP, 2009). Where, the life cycle of a chemical spans the time of its extraction, from the earth until the time of return of the substance (disposal) to the ecosystem. SMC initiatives emphasize importance of taking a comprehensive approach to chemical management where the chemical impacts on human health and the environment of goods produced using basic chemicals, downstream consumers of chemicals, formulators, distributors, and retailers of chemicals, in addition to chemical products, and polluting agents are reviewed concurrently.

In UNEP (2009), the necessity for close collaboration among agricultural, health and environmental sectors for sound chemicals management is stressed. This is essential for the achievement of sustainable agricultural development and public health protection covering chemicals at all stages of their life cycle. For this reason there has been increasing support for improved environmental management of chemicals taking into account their life-cycle as a cross-cutting issue that deserves global attention because now chemicals are produced throughout the world and spread globally through international trade and through emissions into the atmosphere and the oceans. Further, chemicals may aggravate global environmental concerns, such as biodiversity loss, land degradation, climate change and fresh water scarcity.

The SAICM initiative takes into account the fact that many chemical issues are complex and global in nature, and multilateral efforts and bilateral relationships are critical to successfully addressing these issues (Arseneau, 2005). It also attempts to strengthen SMC governance issues across all relevant sectors for purposes of achieving the goals of the 1992 World Summit on Sustainable Development (WSSD). Two major value-added features of the Strategic Approach, relative to the international management of chemicals initiatives that preceded it, are that it (i) strengthens focus on improved cross-sectoral governance for the sound management of chemicals at the national and local levels (i.e. rather than addressing chemicals on a chemical by chemical for chemicals class basis exclusively); and (ii) takes cognizance of the need to create much stronger links with the development planning priorities, processes and plans of developing countries (http://www.saicm.mk).

There is political commitment for Uganda to pursue SMC. The country is party to a number of protocols for the sustainable management of chemicals. The challenge however is to fully streamline the goals of these conventions in the national development goals. There is also an urgent need for information on the expected benefits from strengthening the governance of chemical in agriculture sector so as (i) to rationalize public sector spending for this cause and (ii) the agriculture sector employs more than 70% of the country's population.

This paper seeks to estimate the net benefits from strengthening the governance of chemical use in the agricultural sector by using the cost benefit analysis tool The results of this study will enable those with mandates for chemicals management/use, policy makers, stakeholders and others to: appreciate the costs to human health and the environment of an option without SMC for the Agriculture sector.

2. Background

2.1. Chemical imports and use

Chemicals in Uganda are mostly used in the agriculture sector, health sector, energy and mining sector, water supply and sanitation sector, academic and mining sector, and research sectors and most importantly, in industry. Muyambi (2007) shows that the most common pesticides that have been in use by the agriculture sector include; organophosphates (Bromophos, DDVP (*Dichloro dimethyl vinyl phosphate*), Diazinon, Dursban, Dimethoate, Malathion, Parathion), organochlorines (Malathion, Parathion), organochlorines (Aldrin, BHC, DDT, Dieldrin, Lindane, Thiodan Thiodan, Toxaphene), Carbamates (Dithane M45, Dithane M22, Furadan), Pyrethrins/pyrethroids Pyrethrins/pyrethroids (Ambush CY (P*ermethrin*), Ripcord (C*ypermethrin ypermethrin*), Decamethrin), Phenoxy Acetic Acid (2 Acetic Acid (2-4-D, (*Dichlorophenoxy acetic acid*), 2-4-5-T, (*Trichlorophenoxy acetic acid*), MCPA (*Monochlorophenoxy acetic acid*), Inorganic Metals (Shell copper (*copper oxide*), Lead), Lead arsenate Arsenic trioxide, Phenylmercuric Acetate) and Bipyridyls (Grammoxone (*Paraquat*), Weedol, Diquat).

The tendency for a significant proportion of poor households being involved in agricultural production has called for attention to be focused on raising incomes of farmers. The introduction of farmers to better methods of production via improved extension services, the use of improved seeds, increased use of agricultural chemicals have all been means used to achieve the above objective [Plan for Modernization of Agriculture (PMA)]. As noted in the Situational analysis report (NEMA, 2009) for the agricultural sector, increased cultivation and livestock production have encouraged the rise in pest populations and epidemics. Farmers, through search for control mechanisms for pests and the re-establishment of the production potential of land have responded by using agrochemicals and pesticides. The rapid increase in agricultural chemical imports can be observed in Figures 1 and 2. Between 2002 and 2007 imports of insecticides grew by 14%, fungicides by 619%, herbicides by 49% and fertilizers by 744% (MAAIF, 2008). The decline in imports of pesticides between 2002 and 2006 may be explained by the recorded declines in prices of crops like coffee and vanilla, and the long droughts and floods in different parts of Uganda during the same period. Imports of pesticides begin to increase after 2006. The dangers of this rapidly increasing use of pesticides have been acknowledged in FAO (2007), where it was broadly concluded that there was urgent need to introduce sustainable and environmentally sound agricultural practices that reduce human health and environmental risks associated with the use of pesticides.

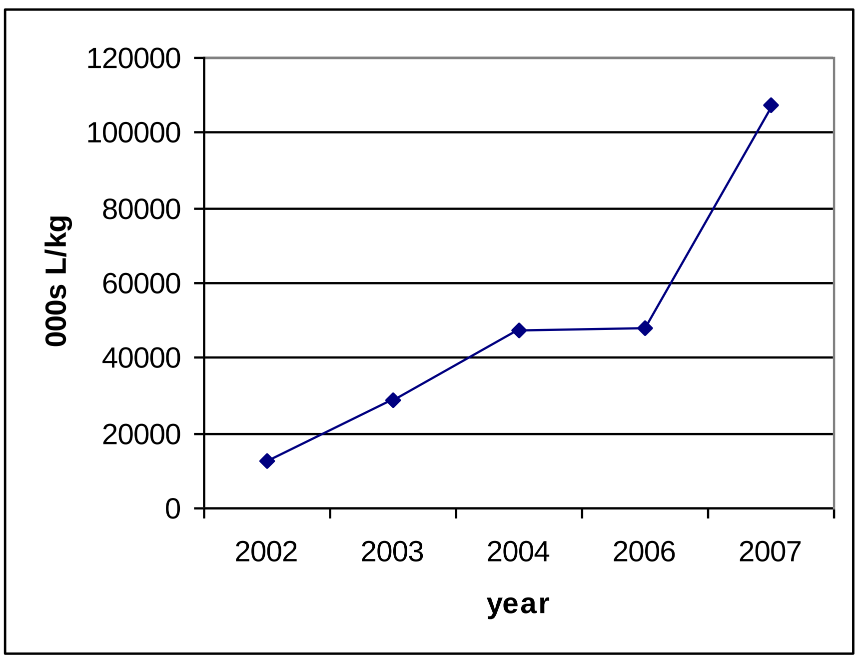

Figure 1. Imports of agricultural fertilizers 2002 - 2007

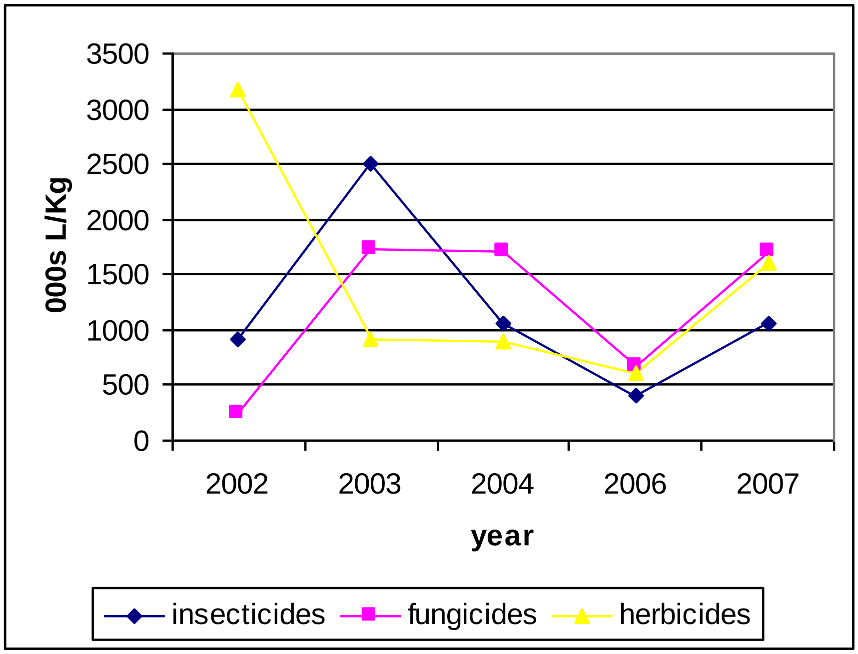

Figure 2: Imports of agricultural pesticides 2002–2007 (NEMA, 2009)

Agricultural chemical management in plantation farms tends to be more organized than it is in small holder farms (NEMA, 2009). Plantation farmers tend to import a greater bulk of their chemical requirements.

They have better storage facilities than most of the private agricultural chemical importers and distributors. Most of these farms also provide chemical protective gear to their employees, reducing the health risks from agricultural chemical use to some extent. However, because they apply chemicals in bulk, the risks of environmental contamination are higher from these farms.

The small holder farmers, however, often satisfy their agricultural chemical demands by purchasing from many of the registered and unregistered distributors, which poses its own risks. Increased use of chemicals in small farms has resulted in significant expansion in output, but it has also created a number of problems for both the farmers and the regulators in chemical management. The recorded excessive use of pesticides has had undesired side effects on both human health and the environment (NEMA, 2009).

2.2. Chemicals regulatory framework in Uganda

With regard to the regulatory framework for chemicals management in the Agriculture sector, the key player in chemical governance is the Agricultural Chemical Board (ACB). The board is in charge of the national legal, institutional, administrative, and technical infrastructure for agricultural chemicals management. Other institutions involved in chemical management linked include Uganda National Bureau of Standards (UNBS), National Environmental Management Authority (NEMA) and National Drug Authority (NDA). UNBS does not directly oversee the management of agricultural chemicals but have a significant role to play at points of entry of chemicals into the country. NEMA has the mandate to the control and monitor impacts that various chemicals and chemical wastes have on the environment and human health. It is noted in the national situation analysis on chemicals management (NEMA, 2009) that the strengths of this regulatory framework are that: (i) they allow for the apprehension of any individual/firm that illegally engages in the manufacturing, packaging and labeling of agricultural chemicals; and (ii) the Agricultural Chemical (Control) Act is implemented simultaneously with the National Environmental Act allowing for effective synergies in enforcement.

There are however, several shortcomings and challenges for the current agricultural chemical management noted in the NEMA study, including: (i) the use of DDT in agriculture is banned but the chemical is accepted for public health vector control by NDA; (ii) there are ozone depleting agrochemicals (e.g. *Aldrin*, *Endrin*, *Toxaphene*, *Endosulfan* and *Methyl Bromide*) that are still in use. These are Persistent Organic Pollutants (POPs) which must be phased out in accordance with international conventions and protocols where Uganda is a signatory; (iii) not all aspects of chemicals management are covered by the available legal instruments.

2.3. Challenges and problems of pesticide use in the agriculture sector

According to NEMA (2010) the challenges for the current agricultural chemicals governance include: (i) the inadequate information and awareness on agricultural chemicals; (ii) inadequate compliance with transportation standards of Agricultural chemicals; (iii) Inadequate and inappropriate storage facilities for agricultural chemicals and non compliance with storage standards; (iv) inappropriate use, handling and application of agricultural chemicals; (v) lack of containment and emergency facilities for salvaging of contaminated materials and handling of emergency cases; (vi) inappropriate disposal techniques for empty packaging and or unused or expired products; and (vii) pesticide contamination of wells, streams and water ways, cultivated lands (present or succeeding crops) and non cultivated lands (wildlife and flora).

With regard to pesticide management, significant concerns are: pesticide quality and illegal trade of pesticides; use of pesticides on pollinators, wildlife (reptiles, birds, game), fish and useful organisms, especially the auxiliary insects that can naturally reduce the effects of the pest predators (regulatory effect); poor utilization of pesticides due to; the use of excessive doses; poor application techniques in particular product spraying far from targets; the emptying of remaining pesticides mixtures into water reservoirs trenches, ditches or near water points; the careless handling during preparation of pesticides mixtures which contaminate the soil; and poor or insufficient ploughing-in of treated micro-granules or seed in the sowing lines.

It is estimated that almost 30 percent of pesticides sold in 2008 were substandard, and pesticide poisoning remains a big problem (NEMA, 2009). The national situation analysis for the agricultural sector puts the figure of reported human pesticide contamination (acute poisoning) cases at 300,000 per annum and an estimate of 4000 fatal cases per annum. Note that estimated annual damages could be higher due to the fact that some effects from exposure may be evident only in the long run, and because the impacts of some pollutants on the food chain and on the environment may not be immediately detected.

3. Cost-Benefit Analysis (CBA)

3.1. CBA literature

The literature on CBA is vast, and a number of Cost-benefit studies have been widely conducted to assess net returns to investments in the agricultural sector and investments geared towards improved environmental resources utilization. A few of these studies are mentioned below. For example CBA studies have been conducted to determine how scarce resources should be allocated to the prevention and control of pests and unwanted species (Mumford et al., 1995; Nunn, 1997); to assess the net benefits of air and water pollution control (Freeman, 1982); to assess the net benefits of private sector environmental investments (Karmokolias, 1996; Suthiwart-Narueput, 1998); to determine the economical and technical convenience of GIS applications on local scale in extension services (Fais and Bonat, 1997); to improve the development impact of public spending (UNDP 2009); to assess the economic impacts of reducing or eliminating pesticide residues in groundwater in areas identified as having significant real or potential problems (Taylor et al., 1991).

The novelty of this study is that it the first attempt estimate net returns of improved chemical governance in the agricultural sector.

3.2. CBA framework

In this study the cost-benefit analysis is conducted for the proposed investments for strengthening governance for chemical use in the Agriculture sector. The cost benefit analysis is a method used to identify, analyze and present the costs and benefits of various options of activities, policies or scenarios to decision makers (Arrow et al., 1996). In this case it is used to analyze the benefits of cost of taking up the option of sound chemical management in Uganda's agriculture sector. CBA is based on the economic theories of welfare, and economic efficiency is at the core of the analysis. The cost side of the equation consists of the proposed policy/investment implementation costs, the added costs to the public that may be generated by a proposed change in policy. The benefit side of the equation consists of the estimated value of all benefits expected to arise from implementation of the regulations or investments. The key problem in evaluating benefits arising from regulation changes and investments chemical utilization is that many benefits are not fully captured by market prices, or even in some cases there are no markets for particular services provided by public goods. In this case methods of non market valuation of such benefits have been applied.

Two key measures of option, policy or project viability are the benefit to cost ratios and the net present worth of the option (NPV) makers (Arrow et al., 1996). The ratios measure the monetary cost per unit of benefit while the NPV is net discounted worth of the option being considered. This is basically total discounted benefits arising due to change in policy or option minus the total costs that accrue from the change. Therefore conducting a CBA is equivalent to finding the NPV of the various options. NPV is:

$$NPV = \int_{0}^{T} \left(B_t - C_t\right) e^{-rt} dt$$

where B_t is the benefit flow in period t, C_t is the costs in period t and e^{-rt} is the discount factor. The integral sign takes care of the fact that we are aggregating benefit and cost flows over the life span of the proposed investments which is 15 years.

A positive of NPV is the basis over which the project is declared beneficial. The main advantages of a quantitative CBA are: its ability to aggregate impacts from various sources into one monetary measure of net benefits; providing transparency and resulting accountability of policies; the provision of a consistent framework for data collection; and the identification of gaps and uncertainties in knowledge.

4. Scope of the Study

Due to the limitation of resources (manpower, funds, among others) we assume that the implementation of the proposed measures will be a gradual process where initially a target number of farmers is selected per district. Over time as resources increase and as the initially targeted farmer group chemical management practices are improved, focus can be geared towards extending the programs to cover new farmers. We note that there could be external benefits in implementation where those initially included in the proposed programs share knowledge on SMC with farmers outside the program. When this happens, there will be a tendency to lower the average costs of implementation over time.

A discussion with Agricultural sector team members revealed that initially the pesticide use governance program will target 300,000 farmers, and new ones will be introduced into the program at a rate of 10% per annum for the next 15 years. The recommended regions and the category of farmers to be targeted are as follows:

- *Central Region*: Flower farmers, and Small Scale fruits and vegetable growers in Wakiso and Mukono districts (90,000 farmers).
- *Eastern and Northern Region*: Cotton farmers (90,000 farmers).
- *South Western Highlands*: Farmers engaged in fruits and vegetables production (50,000 farmers).
- *Western Region*: Plantations and small Scale Tea growers, farmers engaged in fruits and vegetables production (70,000 farmers).

The target group will consist of both small-holder farmers and plantation farms. The farm sizes for small-holder farmers range from 0.15 – 3.0 ha (Hill, 2000). Plantation farms' land size is on average greater than 8 ha. The average farm land size varies across regions in Uganda with the northern region having the highest average farm size, approximately 11.9 ha (Nabbumba and Bahigwa, 2003). Zake et al. (1999) reported that the average farm size for small-holder farmers was 2.5 ha. It is rather difficult to make an accurate projection of land area that will be impacted upon by the proposed investments. For this reason we assume that all farmers that will be involved in the program have farm sizes that are 2.5 ha. This gives us an estimate of the target land size of 750,000 ha. It is assumed that over the considered period this will increase at the rate at farms are increasing.

5. Data on benefits and costs

The identification of indicators for the cost and benefit streams arising from SMC is crucial. The benefits and costs of environmental regulations may vary widely (Hann and Dudley, 2004). The benefits include reduced human and wildlife mortality, improved water quality, species preservation, and better recreation opportunities (Arrow et al., 1996), while costs result from higher prices for consumer goods and/or higher taxes that come with regulation. The latter are market effects readily measured in monetary terms, while the former are non-market effects (public goods) for which prices are not available.

The lack of markets for health and environmental services makes it difficult to price those (Arrow et al., 1996). Their monetary worth is not easily observable, but there non-market valuation techniques that provide acceptable values that have been useful in making comparison among programs, and policies. Indeed, worldwide, valuation studies on environmental quality have been undertaken, and their results used to make decisions pertaining to whether to change policy pertaining to various issues of the environment and in litigation. The consistent measure of the benefits of an environmental regulation are the risks avoided, expressed as, for example, numbers of lives saved or critical ecosystems protected (UNDP, 2009).

There are studies that have attempted to monetize some of the benefits from improved environmental quality for Uganda. The results of these studies are used to monetize some of the expected benefits of improving the governance of agriculture chemicals. The key benefits monetized in this study are improved air, soil and water quality, crop yield improvements and human health gains. The choice of these attributes was based on data availability. The values of improved water quality were derived from Bonabana –Wabbi and Taylor (2008); the value of improved air quality is from Kateregga (2010); computations for improved soil quality were derived from FAO (2007); the crop yield gains due to better pesticide management were derived from PAN-Africa, 2000. The data on human health improvements due to improved information/education in the handling of pesticides was derived from Uganda National Household survey (UNHS) (2010).

Bonabana–Wabbi and Taylor (2008) estimate the willingness to pay (WTP) for water quality improvements due better use pesticides in the range US$ 0.096 to 0.164 per month. This implies individual household annual payments in the range US$ 1.2 – 1.966. The average is US $ 1.58. The mean WTP from this study is used to monetize both the water use and non-use benefits that will arise from strengthening the governance of agricultural chemicals management. Kateregga (2010) estimates the WTP for improvement in air quality to be of US$ 4.45per month. This implies an annual WTP of US$ 53.36for each household. The average estimate gain in crop yield due to avoiding the use of synthetic pesticides is 20% (PAN-Africa, 2000).

We use the value of work time lost due to illnesses related to respiratory infections, and skin infections as a proxy for output loss due to misuse of chemicals by farmers as the gain due to SMC in the sector. The average daily work hours for a worker in the agriculture sector are 5. The UNHS (2010) shows that the percentage of 15-30 days of work lost due respiratory and skin infections is 3.4 and 5.5 respectively. The average days of the period considered is about 23. We use this information to compute the number of work days each farmer loses annually due to respiratory and skin infections. (*Days lost annually due to respiratory diseases* = 23*0.034*12= 9.4 *Days lost annually due to skin diseases* = 23* 0.055*12 = 15.2). This gives an average of 47 hours lost by each worker due respiratory diseases, and 76 hour lost due skin infection, annually. Data on output per hour for agriculture sector is not available. What is available however is the data on median monthly nominal wage for agriculture and fisheries workers. The median monthly nominal wage for agriculture workers in the public sector was US$ 276.67 in the public sector and US$ 129.52 in the private sector in 2009/10. This gives a median daily wage of US$ 11.06 in public sector and US$ 5.18 in the private sector. These figures are used to construct a proxy for output loss due to pesticide mishandling.

The estimated total costs of the proposed National actions for SMC in agricultural sector are estimated at US$17.2 million for next 15-year period (Ogaram report, not yet published). The report provides estimates of the costs to be incurred implementing the recommended actions for the period 2010/11 - 2024/25. In order to compute the net present value of the benefits from strengthening pesticide governance in the sector we have to identify an appropriate social discount rate. In the next section we discuss how we selected the discount rate.

6. The social discount rate

The social discount rate is a rate appropriate for discounting social costs and benefits, and it is the rate recommended for evaluating social investments. The rate should incorporate both the current and future generation's preferences into the analysis. As noted in the literature computing the appropriate discount rate can be a complicated task. This is because of the huge information requirements and market imperfections. For this study two rates were identified; the bank rate (currently at 10%) and the rates at which the government borrows from foreign sources. This is in the range 2-4% (Bank of Uganda, Research Department). An average interest rate of 4% is used discount the monetized benefits and costs here.

7. Results and discussion

The UNDP (2009) framework is followed in reporting our results. The results of the economic analysis appear in Table 5. The monetized benefits are those benefits from air and water quality improvements, from reduced illnesses due to better handling and use of chemicals by the farm workers and crop yield gains due to better soil quality as a result of reduced or improved use of synthetic pesticides. Those costs and benefits for which monetization is infeasible are described in the lower rows of the table.

As mentioned above, the initial target group is 300,000 farmers for the year 2010/11. This is to increase at a rate of 10% per annum through to 2025. To compute the number of farmers that will be covered by the end of the analysis period we apply the formula: $f_t = (1+r) f_{t-1}$

Where, *f* is the number of farmers and *r* is the growth rate of the number of farms that are tapped by the proposed actions for strengthening the governance of agricultural chemical governance.

Table 1. Discounted Benefits and Costs (4%) 2010 – 2025 (Million US $)

Year	**2010/11**	**2011/12**	**2012/13**	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
Water Quality gains		0.50	0.53	0.56	0.59	0.63	0.66	0.70
Farm labour output loss (due to chemical related illnesses)		40.44	42.78	45.25	47.85	50.61	53.53	56.62
Crop Yield gains		37.88	40.07	42.38	44.82	47.41	50.15	53.04
Total Discounted Benefits		78.82	83.38	88.19	93.26	98.65	104.34	110.36
Total Discounted Costs	1.04	1.26	2.23	1.07	0.87	0.84	0.80	0.77
NPV	**-1.04**	**77.56**	**81.15**	**87.12**	**92.39**	**97.81**	**103.54**	**109.59**

Year	**2018/19**	**2019/20**	**2020/21**	**2021/22**	**2022/23**	**2023/24**	**2024/25**
Water Quality gains	0.75	0.79	0.83	0.89	0.93	0.99	1.04
Farm labour output loss (due to chemical related illnesses)	59.89	63.35	67.68	70.86	74.95	79.28	83.85
Crop Yield gains	56.10	59.33	62.76	66.38	70.21	74.26	78.54
Total Discounted Benefits	116.74	123.47	131.27	138.13	146.09	154.53	163.43
Total Discounted Costs	0.74	0.72	0.69	0.66	0.63	0.61	0.59
NPV	**116.00**	**122.75**	**130.58**	**137.47**	**145.46**	**153.92**	**162.84**
Total NPV	**1617.14**						

What is not incorporated in this analysis is uncertainty regarding the listed outcomes/benefits. The fact that some of the predicted outcomes may not be fully realized in the considered period warrants us to incorporate risk analysis in our CBA framework (assign probabilities to outcomes). However, we have not come across studies that have attempted to determine/measure the probabilities of the outcomes where environmental factors are changed. Therefore we have considered outcomes to be certain. Of course this may not be plausible, but at least the computed values can be used to raise a case for mainstreaming sound management of chemicals in the National Development Plans.

As shown in Table 1 the NPV of the proposed investments is approximately US$ 1.62 billion. This is huge and shows that investing in the actions proposed to strengthen the governance of agricultural chemical management is socially beneficial. The figure also serves as indicator of the foregone benefits (and therefore costs) if the no action is taken toward SMC. It is important to not here that due to information availability constraints all benefits and costs strengthening the governance of pesticide use could not quantified and monetized. An outline of quantifiable, non-quantifiable and non monetized benefits and costs appears in Table A1 in the appendix.

The benefit-cost ratios (BCR) for the proposed actions appear in Table 2. These capture only the monetised benefits and costs. The BCR are calculated for each financial year as the ratios of the present value that year's benefits to the corresponding present value of costs. The ratios depict the total financial return for each dollar invested in improving the governance of chemicals for the agriculture sector. These range from 37 to 277. These ratios are quite huge showing that the returns to a dollar invested in actions aimed at SMC in agriculture sector are attractive. The returns to investments in improving chemical governance are therefore huge.

8. Conclusion

An economic analysis has been conducted to evaluate the costs and benefits of the proposed actions to strengthen the governance of agricultural chemical management. The selected decision criterion for this study is the NPV of the proposed changes, though the benefit cost ratios for the proposed investments have been computed as well. This criterion is recommended when identifying public policies or projects that promotes efficiency (Fuguitt and Wilcox, 2006). It follows from the Kaldor-Hicks criterion for assessing a policy change where a project or policy change is considered to be socially desirable when the expected social benefits from the change outweigh the social costs. Note that, both the environmental costs and benefits of the proposed change are fully incorporated into the analysis.

The conclusions we draw from this study are first, the costs of the foregoing investments in SMC in the agriculture sector are immense. These include increases in rates of degradation of both human and environmental health. The human health chemical contamination cases were estimated at 300000 lives per annum in 2004, with 4000 cases of death. Because of the acknowledged huge increase in imports and utilization of chemicals in the agriculture sector, over the period 2005 – 2009, there is a high likelihood that casualties and death from unsound chemical management in the sector could have more than doubled. Besides, the strategy to modernize agricultural production (PMA) encourages farmers to use more chemicals (fertilizers, pesticides, and so forth). There is a high risk to both human health and the environment of farmers many whom are not literate enough to follow the chemical handling, application and disposal instructions and continue to poorly manage chemicals. This is detrimental to their own health and to many of the water ecosystems in the rural areas.

Table 2. Computed Benefit-Cost Ratios

Year	***Benefit – Cost Ratio***
2011/12	63
2012/13	37
2013/14	82
2014/15	107
2015/16	117
2016/17	130
2017/18	143
2018/19	158
2019/20	171
2020/21	190
2021/22	209
2022/23	232
2023/24	253
2024/25	277

Second, as demonstrated in the CBA, strengthening the governance of chemicals management has potentially huge economic, social, human health and environmental quality benefits. This is highlighted by the huge difference between estimated monetized social and environmental benefits and the costs of the action proposed for sound management of chemical for the next 5-year period. It is worthwhile to not that many of the benefits from SMC were not quantified and monetized because of the lack of the appropriate money metric measures. A development of good indicators of these benefits would improve the results in this study.

Third, because the misuse and mishandling of chemicals often results into irreversible damages to human and environmental health, there is an urgent need to mainstream SMC in the National Development Plan. This will not only create conditions for reducing the degradation risks, and improving the human and environmental health, but it will help cut down the proportion of the government budget that goes into treatment chemical misuse related illnesses.

Fourth, given the current trend in population growth, the demand for materials (food, energy, water, medicine and other commodities), is expected to grow exponentially. The use of chemicals is expected to follow suit. This is exacerbated by the government's strategy to alleviate poverty (PMA). Thus the consumption of chemicals is expected to increase tremendously as has been recorded over the last 5 years. This calls for more frequent reexamination of the governance challenges of chemicals in all sectors.

Lastly, the estimated amount of money for implementing the activities proposed for strengthening the governance of agricultural chemicals is US $ 17.2 million for the next 15 year period. Due to the fact that the returns to investments in sound chemical management were found to be high, doubling or even tripling this budget would leave the NPVs of the proposed in billions. It would seem appropriate to devote greater efforts towards improving the public's awareness of misusing chemicals and informing them on the safeguards and the merits of the improved measures available.

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Appendix

Table A1. Quantified unmonetized and non-quantified benefits and costs

Quantified but Unmonetized

Benefits related to human health

(i) Reduced risk of death from chemical contamination (estimated at annual rate of 4000 deaths, NEMA 2009);
(ii) Reduced number of individuals subjected to illnesses related to chemical exposure (short and long term effects). This is estimated to be 300000 individuals annually (Pesticide Action Network – Africa, 2000).
(iii) Better water and air quality improvements (both the farm and non-farm communities and firms)

Economic Benefits

(i) Reduced risk of fish poisoning and pesticide residues in fish, and therefore minimized chances of subjecting the country's exports to bans. (The loss from the 1999 EU fish ban was estimated at (i) US$36.9 million export revenue loss; (ii) US$4.25 million short fall in the fishing community incomes due to lower fish prices; Unemployment due to reduced fishing activity and the closure of fish processing plants resulting into laying off 60% to 70% of their labor force.

Costs

(i) Opportunity costs of the resources devoted to improved chemical governance (their values in their next best alternative uses). That is, the foregone consumption and production opportunities if the funds that are used to improve chemical governance in the agriculture sector imply reducing expenditure elsewhere (e.g. reduced spending on health and education issues among others).

Non-quantified Benefits and Costs

- **Benefits related to the health of the environment**

(i) Reduced chemical waste load (and contamination) in ground and surface waters (reduced risk of ecosystem disturbances due to poisoning);
(ii) reduced risks of:
  - chemical pollutants in air;
  - Contamination of soils;
  - Exposure of ecosystems to eutrophication, and the associated dangers of mortality of fish and other aquatic animals,
  - widespread presence of pesticide residues in wildlife, food, and even in humans

(iii) Non-use and indirect use benefits from protecting (or improving) natural habitats and

Biodiversity from contamination of water and air quality. This includes existence values, option values and ecological functions of ecosystems;

(iv) Reduced risk of unintended die-off of beneficial insects;

(iv) Regional and global gains in improvements in environmental quality.
(v) General reduction in deleterious effects on bio-diversity

- **Economic Benefits due to improved Environmental quality (SCM)**

(i) Improved farmer incomes due to setting chemical use within the acceptable limits (livestock product gains);
(ii) Enhancement of the country's competitiveness in international markets and increased export earnings, and the eventual boost in economic growth;
(iii) Savings on health sector expenditure that can be channeled into productive activities leading a general economy growth;
(iv) Increased employment and higher incomes to people whose livelihoods are heavily dependent on natural resources that have been adversely affected by unsound chemical management, (e.g. farmers and fishermen). Reduced poverty levels for these groups
(v) Savings on water purification costs by water provider firms;
(vi) Reduced water collection costs (time and reduced or regulated use) due reduced risk of polluting close water sources (e.g. the Kiteezi case);
(vii) Reduced morbidity from chemical contamination and reduced loss of work force productivity.
(viii) Increased recreational opportunities from facilities (lakes, rivers, parks, etc) that are subjected to reduced risks of chemical contamination;
(ix) Reduced medical bills for households.

Costs

(i) The damages to human health that may persist with improved agrochemical governance;
(ii) The damages to the health of environment that may persist with improved agrochemical governance (irreversible effects).