Study on the effects of taxes and subsidies on pesticides and fertilizers

Background document to UNEA-5 Review Report on the Environmental and Health Effects of Pesticides and Fertilizers

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Acknowledgments

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The study was undertaken in the context of a UNEP-led project on Environment, Health and Pollution which seeks to provide the needed understanding, capacities and tools to help countries and stakeholders take effective action to address pollution. As part of this project, a series of studies have been carried out which explore the effective use of fiscal policies for pollution reduction. These fiscal studies contribute to the Implementation Plan 'Towards a pollution-free planet' adopted at the Third UN Environment Assembly (UNEA-3) which identifies stimulating good practices through fiscal policy as an accelerator for implementation.

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Executive summary

With the world population expected to reach almost 9.7 billion by 2050, a key question is how to sustainably improve agricultural productivity to meet increasing demand for food. Historically, pesticides and fertilizers have been perceived as key agricultural inputs, capable of generating and maintaining high yields from available agricultural land and increasing agricultural productivity. However, pesticides and fertilizers contain toxic content which can adversely affect the environment and human health. In particular, the over- or misuse of pesticides and fertilizers can lead to run-off, leaching and consequent nutrient surpluses in soil and water. This has negative impacts on human health including through the consumption of contaminated drinking water and death by self-poisoning from pesticides, particularly in low- and middle-income countries, with corresponding economic costs.

The use of agricultural inputs is stimulated through various policies, including different types of fiscal policy instruments. Certain fiscal policies can support agricultural development, for example through public investments in innovation, infrastructure and services. Such support can create enabling conditions for the agricultural sector more broadly and/or strengthen capacities to address environmental challenges, for instance providing incentives for resource-efficient or climate-smart practices. However, the ineffective/inefficient design and implementation of certain fiscal policies can also create perverse incentives that exacerbate the adverse environmental and health impacts associated with the over- or misuse of pesticides and fertilizers.

Countries have adopted various fiscal instruments that affect the use of pesticides and fertilizers such as direct agricultural input subsidies, taxes, charges and fees, and implicit subsidies from tax exemptions and reductions. The approach taken differs between developed and developing countries. Following a long period of distortionary agricultural commodity price support, in the 1990s developed countries started moving towards less or non-distortive farm income support. In general, developed countries no longer provide significant direct subsidies to fertilizers and pesticides. Some developed countries have introduced taxes on fertilizers and pesticides, reflecting concerns with the environmental and health impacts of pesticide and fertilizer use. At the same time, increasing concerns of food security and rising energy prices have placed agricultural input subsidies at the centre of agricultural development strategies in non-OECD countries with many developing countries relying heavily on agricultural input subsidies, especially for fertilizers. Despite concerns with the design and implementation of such programs, many developing and emerging economies continue to use such distortionary and costly input subsidies. In addition to these explicit subsidies, several countries including many developed economies apply reduced VAT rates to fertilizers and pesticides. Without specific conditions, such tax exemptions act as an implicit subsidy and may go against commitments in other areas including to reduce pollution.

Agricultural input subsidies for fertilizers and pesticides are used to meet different policy objectives which range from short-term responses to enhance food security, income and avoid poverty traps; maintain affordable prices of major crops, avoid high costs of agricultural inputs; to long-term structural objectives such as addressing market imperfections and supporting the adoption of new technologies. However, available evidence suggests most of these programs have only partially achieved their intended objectives and have resulted in unintended negative socio-economic and environmental impacts. In general, input subsidies lower costs to producers which increase the risk of their over- or misuse, with potentially harmful consequences for farmers' and consumers' health and the environment. Available literature suggests agricultural input subsidies lower the per unit variable cost of inputs and create strong incentives for increasing the intensity of their use, leading to an increase in nitrogen runoff at farm level and subsequent deterioration of water quality as well as increases in GHG emissions at the national level. In terms of wider social impacts, available evidence suggests larger farms (often headed by men) benefit more from subsidy programs than small farmers which are often owned by women and landless tenants. Moreover, studies suggest subsidy programs have had a limited effect on poverty incidence among smallholder farm households, have generally failed to accomplish widespread distributional benefits and other policy instruments, such as investments in R&D and infrastructure may be more effective in reaching poverty reduction objectives. In terms of economic costs**,** input subsidies account for a large share of public resources and reduce funds for other development priorities. Furthermore, as agricultural input subsidies are in direct competition with investments with positive marginal returns, empirical evidence suggests they undermine welfare maximization.

Many countries have taken steps towards reforming their producer subsidy programs. In general, transitioning from input subsidies to de-coupled agricultural support reduces environmental degradation and pollution and consequently improves human health outcomes. Growing recognition of the high fiscal costs of subsidy programmes and the need to rationalise fiscal expenditures have provided the strongest incentive to reform input subsidy programs in many countries. Reform efforts have also been driven by increasing awareness of the limitations of central planning approaches, pressure from international organizations such as the World Bank and the IMF, changes in macroeconomic and trade policy, growing recognition of distributional impacts and limited effectiveness of the subsidy programs. These reform efforts provide insights for other countries considering reform including among others the importance of a well-managed process of phasing out/reforming input subsidies and designing self-sustaining agronomic practices with a long-term horizon.

Taxes on pesticides and fertilizers are another important fiscal policy instrument which can create incentives for producers and consumers to shift their behaviour towards less polluting products or substances, stimulating innovation and driving cost-effective reductions in pollution while generating revenues which can be used for different purposes. Despite this potential, in practice the use of such taxes on pesticides and fertilizers remains limited to date reflecting various challenges including political barriers and difficulties in setting the right tax rate and tax base among others. The adoption of such taxes is further complicated by the fact that both pesticides and fertilizers are dispersed non-point pollutants and the approach to taxing diffuse pollutants is still quite recent with most countries relying more on command and control or voluntary measures. Beyond general ad-valorem taxes, only a handful of countries levy taxes on pesticides and fertilizers with the intention of reducing pollution. Nordic countries have been front runners in the application of such taxes, driven by underlying objectives of supporting soil conservation, diversifying the crop structure, reducing pollution and addressing environmental and public health risks inherent in pesticide use. Beyond taxes, some countries apply charges and fees to pesticides and fertilizers, mostly to finance the administration of regulatory and registration frameworks. Some countries also use fiscal incentives such as tax reductions and exemptions for organic fertilizers and/or pesticide products applicable under organic farming practices to encourage the use of less polluting alternatives.

The effectiveness of these taxes varies across countries and depends on how they are designed including the structure of incentives created, tax rates adopted, the demand price elasticity, and precision in targeting among other factors. For example, the banded pesticide tax system in Norway is considered effective as it not only encourages the more conservative use of pesticides but also provides an incentive to use less harmful products. Similarly, the pesticide tax in Denmark has led to a significant reduction in the sales of pesticides and a reduction in pesticide load on human health, nature and groundwater for all cases except fungicides where the health indicator is positive. There is also evidence that suggests using fertilizer taxes (or phasing out VAT exemptions) on chemical fertilizers decreases their overall use with reported improvements in groundwater quality, reductions in the excessive application of fertilizers as well as in phosphorus and cadmium content. These country experiences provide some insights on good practices in the effective design of such taxes. For example, tax rates should reflect damage/risks to the environment and human health, as in the case of the banded pesticide tax system in Norway. Assessing the toxicity of a commodity is also useful for setting clear targets and measuring impact. For example, pesticide load indicator is a measure of the load on human health, nature and groundwater and used to set objectives of the Danish pesticide tax.

Based on available literature and country experiences, it is apparent that the efficiency and effectiveness of agricultural input subsidies largely depends on how subsidy programs are designed and implemented. A critical first step in the design of subsidy programs is identifying clear policy objectives. The approach to subsidy implementation will largely depend on the final policy objective. Clear targeting of input subsidies is another critical factor determining their effectiveness. It is important that support is repurposed/reformed in a way that rewards sustainable behaviour or creates positive incentives. For example, in contrast to input subsidies, agri-environmental payments for complying with fertiliser application constraints have been shown to decrease levels of nitrogen application and improve environmental outcomes.

Political economy considerations are other critical factors in the effectiveness of pesticide and fertilizer taxes. The introduction of such fiscal instruments faces numerous barriers. Most concerns are based on competitiveness grounds while distributional aspects also play an important role. Addressing such concerns are critical to ensure political feasibility and often requires close engagement with affected stakeholders. How revenues from such taxes are used and how this is communicated can determine the political acceptability of a measure. Current taxes on fertilizers and pesticides often include a mechanism to redistribute tax revenues as a form of compensation for farmers (e.g. in Austria). Earmarking tax revenue for further environmental uses and/or rebating it to the affected population and/or the sector have been found to increase public acceptance as with the case of the Danish pesticide tax where revenues from the pesticide tax are reimbursed to the agricultural sector and helped reduce resistance to the tax among farmers. Communication campaigns financed by tax revenues can also help build public support for policies aimed at decreasing the use of fertilizers and pesticides.

Although the use of such taxes has been limited to a handful of countries to date, growing recognition of the environmental and health costs from uncontrolled use of fertilizers and pesticides will provide further pressure for more efficient policies to address these impacts. In this context, well-designed taxes on pesticides and fertilizers can play an important role going forward. When carefully designed, such instruments can provide a cost-effective tool to prevent and reduce pollution and associated health impacts from the use of pesticides and fertilizers, as part of a wider toolbox of complementary policies. Working together this toolbox can effectively stimulate the systemic and behavioural changes needed to prevent and reduce pollution and associated health impacts. Such fiscal instruments can be linked with farmer training and education programs to improve the efficiency with which farmers use fertilizers and pesticides in the context of more comprehensive soil fertility management and integrated pest management programs. Such fiscal instruments could also contribute to other policy objectives including on climate change by helping to reduce GHG emissions from the agriculture sector. This contribution to wider policy objectives could result in increasing up-take of such instruments in the years ahead. There is also scope for wider use of other types of fiscal incentives such as reduced tax rates on organic fertilizers and/or pesticide products applicable under organic farming practices to encourage the adoption of sustainable farming practices and reward certain types of activities as part of a comprehensive approach to a sustainable food systems transformation.

List of Acronyms

FOB	Free on Board
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GHG	Greenhouse gas
GSSE	General System Services Estimate (as defined by the OECD)
IMF	International Monetary Fund
IPCC	International Panel on Climate Change
MPS	Market Price Support
N	Nitrogen
N_2O	Nitrogen Oxide
NO_3	Nitrate
OECD	The Organisation for Economic Co-operation and Development
PSE	Producer Support Estimate (as defined by the OECD)
SDG	Sustainable Development Goals
TSE	Total Support Estimate (as defined by the OECD)
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
VAT	Value-added Tax
WHO	World Health Organisation

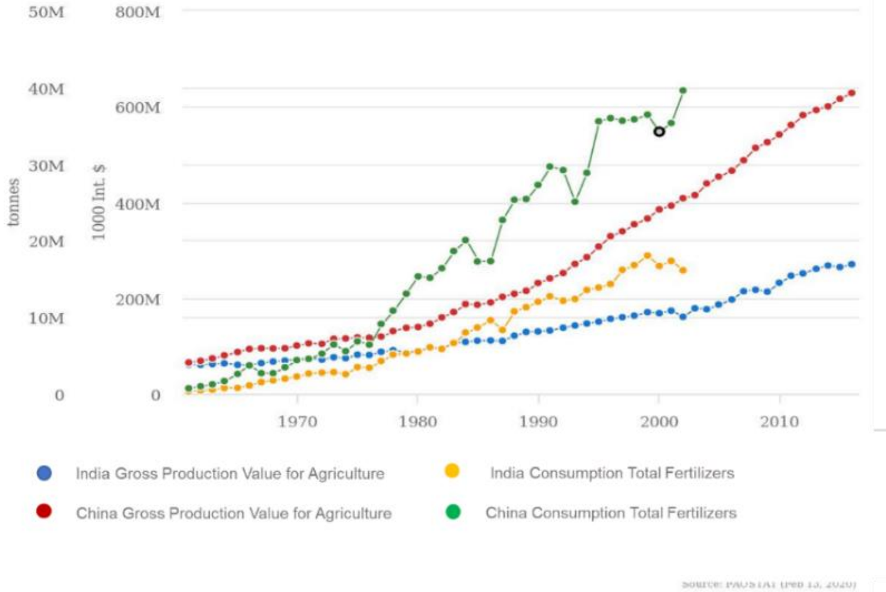
1. Introduction

1.1 Brief background on environmental and health impacts of fertilizers and pesticides

Current projections indicate that the world population will reach almost 9.7 billion by 2050, implying a 50 percent increase in the demand for food, relative to demand in 2012 (United Nations Department of Economic and Social Affairs Population Dynamics 2019, FAO 2017). Moreover, around 90 percent of the expected population increase will take place in developing countries and economies in transition, which are relatively more affected by food insecurity. As three out of four poor people in developing countries live in rural areas and depend directly or indirectly on agriculture for their livelihood, the sector remains critical in both ensuring countries' food security and in providing a source of income for significant parts of the population. In this context, a key question is how to sustainably improve agricultural productivity to meet increasing demand?

Historically, pesticides and fertilizers (see Box 1) have been perceived as key agricultural inputs, capable of generating and maintaining high yields from available agricultural land and increasing agricultural productivity. Hence, the use of agricultural inputs has been stimulated through various policies, with fiscal policy instruments playing an increasingly important role. In several countries the use of pesticides and fertilizers, in combination with high yield seed varieties and advanced irrigation technology, led to dramatic increases of land productivity, rural income and food production. For example, West African cotton-producing countries tripled their yields from about 310 to 970 kg/ha between 1960-1985 by increasing fertilizer use combined with related intensification practices (Pieri 1989). Similarly, China and India nearly tripled their food production between 1965–2000 by, among others, adopting more resilient seed varieties, modernizing agricultural practices and boosting the use of fertilizer (International Center for Soil Fertility and Agricultural Development (IFDC), 2006). Although it is impossible to isolate the effects of increased fertilizer use on agricultural productivity, Figure 1 below demonstrates the overall positive relationship between a rise in fertilizer consumption and overall gross production value for agriculture in India and China between 1960-1985 (FAOSTAT 2019).

Figure 1: Gross Production Value of Agriculture and Fertilizer Consumption in India and China (1960-2017)



Source: FAOSTAT 2019.

Box 1: Definitions of pesticides and fertilizers

Pesticide: means any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying or controlling any pest, or regulating plant growth (FAO and WHO 2014).

In general, pesticides help preserve food and protect crops from excessive damage by pests and diseases and can protect human and livestock health from vector-borne diseases. Pesticides also play important roles in the protection of fresh produce during transport over long distances, in ensuring that shipments of fresh food do not carry unwanted pests and diseases into importing countries and in the preservation of stored bulk foods such as grains (Rotterdam Convention Secretariat 2017). Intensification of agricultural production has thus far involved increased use of pesticides that aim to control pests and diseases - which are considered one of the major causes of yield losses.

Fertilizer: a substance that is used to provide nutrients to plants, usually via application to the soil, but also to foliage or through water in rice systems, fertigation, hydroponics or aquaculture operations. (FAO 2019). In the International Code of Conduct for the sustainable use and management of fertilizers, the term is used to refer to a chemical or natural substance or material that is used to provide nutrients to plants. Thus, multiple nutrient types and sources are considered in the Fertilizer Code including chemical and mineral fertilizers; organic fertilizers such as livestock manures and composts; and sources of recycled nutrients such as wastewater, sewage sludge, digestates and other processed wastes.

There are different types of fertilizers loosely categorized into organic and inorganic, based on their source and production. Typically, organic fertilizers include animal manure, household wastes, plant materials (including crop residues), and compost made from one or more of these sources. In addition to providing nutrients, organic fertilizers contribute to soil quality by improving the structure, chemistry, and biological activity level of soil. Mineral fertilizers include two broad groups: straight fertilizers (containing one of the three major nutrients) and complex fertilizers (containing at least two out of the three major nutrients). Using both organic and inorganic fertilizers can improve long-term integrated soil fertility management.

At the same time, pesticides and fertilizers contain toxic content which can adversely affect the environment and human health, generating negative externalities such as soil and water contamination and impacts on human health (UNEP 2017). According to the WHO, pesticides are among the leading causes of death by self-poisoning, particularly in low- and middle-income countries. The use of illegal pesticides, which are estimated to make up 25 percent on the global pesticide market, may contain unapproved/unknown impurities and can lead to significantly negative effects on farm yield, farmer health, and environmental systems (TRACIT 2019). The use of fertilizers can also damage aquatic ecosystems, while fertilizer production is very energy intensive, adding to its environmental impact. There are also associated economic costs. For example, the estimated annual illness costs of acute poisonings in Nepalese farmers due to pesticide use was nearly one third of total annual health-care costs. In Parana, Brazil, for each dollar spent on pesticides, approximately $1.28 may be spent on health care and sick leave arising from occupational poisoning (WHO 2016).

These negative externalities are often not visible as they are not traded in the market and do not have a market price (TEEB 2015). This non-internalisation of externalities leads to under-pricing which has significant socioeconomic and environmental impacts, influencing the decisions and actions of individual farmers, fishers, businesses, and consumers, as foods produced with large environmental, economic, and social costs often appear cheaper than those produced more sustainably.

1.2 Overview of the use of fiscal policy instruments for fertilizers and pesticides

Governments world-wide intervene in agricultural markets using a range of regulatory and fiscal policy instruments (see Box 2). Subsidies and taxes are widely employed across countries in various forms and with diverse objectives ranging from revenue collection, to market steering, correction of existing market imperfections and addressing externalities. By lowering the costs of production, subsidies aim to increase output of a specific commodity or non-competitive industry. However, subsidy programs may lead to excessive market entry and insufficient exit which in the case of fertilizers and pesticides could prop-up demand and lead to higher emissions and associated externalities. In contrast, taxes increase the final price of production and as such discourage production which in the case of fertilizers and pesticides tend to reduce emissions/externalities in the long run.

Certain types of fiscal policies can support agricultural development, for example through public investments in R&D, innovation and infrastructure and through public financing of services that create enabling conditions for the agricultural sector overall. Such so-called General Services Support (GSS) in the OECD's framework of measuring agricultural support, on average accounts for 4 per cent of total support to the sector (OECD 2019). Sometimes support is tied to specific production practices to encourage producers to adopt practices that may improve the environmental performance of farming or animal welfare, e.g. in Chile, the European Union (under the CAP), Switzerland and the United States (OECD 2019). However, only a limited amount of current support generates such positive externalities and a large share of support is considered potentially environmentally-harmful with the most distorting agricultural support measures (based on output and variable input use) accounting for as much as 70 percent of gross producer transfers, including budgetary transfers and those resulting from Market Price Support (OECD 2019).

Box 2: Definitions of fiscal policy instruments

Taxes are compulsory unrequited payments to general government. Taxes are unrequited in the sense that benefits provided by government to taxpayers are not normally in proportion to payments (OECD n.d. a).

Taxes and charges are all compulsory, unrequited payments whether the revenues accrue directly to the government budget or are destined for particular purposes (e.g. earmarking) (EC 1997).

Environmental taxes are taxes imposed for environmental reasons, e.g. to provide an incentive to reduce certain emissions to an optimal level or taxes on environmentally harmful products (OECD n.d. b).

Subsidies are measures that keep prices for consumers below market levels or keep prices for producers above market levels or that reduce costs for both producers and consumers by giving direct or indirect support. Subsidies can be paid per amount or value of output usually from the public treasury. Subsidies can also take the form of price guarantees, raising producer prices over the free market price, as is common with agricultural price support schemes, as well as cost-reducing measures. Finally, the definition embraces all transfers to producers, regardless of whether they are targeted on products or simply take the form of cash sums pay-able to producers.

Environmentally harmful subsidies are subsidies deemed harmful to the environment if they "encourage more environmental damage to take place than what would occur without these subsidies". In other words, they lead to levels of waste and emissions that are higher than what they would be without the support measure (OECD 1998).

Agricultural input subsidies can differ in terms of a) the point of application of the subsidy (e.g., farmer, trader, domestic fertilizer producer), b) the form of the subsidy (e.g. cash payment, voucher / coupon, reduced market price, transport subsidy) and c) the type of the subsidy (e.g. direct or indirect), see Dalrymple (1975), Hamilton and Kunte (1997). Other forms of subsidies include exchange rate adjustments, subsidized interest rates on credits to purchase fertilizers or pesticides, higher write-offs allowed for farmers on fertilizer related costs, combination of favourable exchange rates, tariff and tax exemptions and preferential rail freight rates or port fees.

Tax exemptions are another common example of a hidden subsidy. Many developed countries and an increasing number of developing countries exempt or reduce (zero rate) general and import taxes on fertilizers and pesticides

The approach taken, the way taxes and/or subsidies are levied and how they affect agricultural markets differs between developed and developing countries. Following a long period of distortionary agricultural commodity price support, in the 1990s developed countries started moving towards less or non-distortive farm income support, leading to a reduction in the most distorting support from over 80 percent in 1990 to around 50 percent 2015 (OECD 2019). A few developed countries such as Finland, Sweden and Austria have also introduced taxes[1] on fertilizers and pesticides, reflecting concerns with environmental and health impacts of pesticide and fertilizer use.

At the same time, increasing concerns of food security and rising energy prices placed agricultural input subsidies at the centre of agricultural development strategies in non-OECD countries with many developing countries relying heavily on subsidies for agricultural inputs such as fertilizers, pesticides, seeds and credits. Developing countries continue to use distortionary and costly input subsidies partly offsetting remaining taxes levied on agricultural output. Moreover, in many developing countries, much of the taxation remains implicit in the form of price controls, manipulated exchange rates and heavy tariff protection among others.

Input subsidies are explicit or implicit payments reducing the price paid by farmers for variable inputs such as fertilisers, feed, seeds, pesticides, energy, water, transportation or insurance. Fertilizer subsidies account for the largest share of agricultural input subsidies (Gregory et al., 2000; Debrah and Breman, 2002). Reportedly, around half of the world's fertilizer consumption is subsidized in some way. Countries have been using fertilizer subsidy programs since the 1950s (see Box 3). Some countries also subsidize the production of agricultural inputs, e.g. China provides subsidies to transport and production of fertilizers, see Segura et al. (1986), World Bank (1989). This study mainly focuses on input subsidies to farmers for the purchase of fertilizers and pesticides given the focus of available literature[2]. It is worth noting however that in practice, subsidy programs often target a package of inputs (including hybrid seeds, fertiliser and irrigation) rather than one specific input (Baltzer, 2011). The study also explores country experiences with the use of taxes on fertilizers and pesticides.

Box 3: Selection of country experiences with fertilizer subsidy programmes

- In ***sub-Saharan Africa*** large-scale universal subsidy programmes for fertilizer use were pursued from the early 1960s to the 1980s by several governments in Benin, Burkina Faso, Burundi, Cameroon, Chad, Djibouti, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Seychelles, Sudan, South Sudan, Tanzania, Togo, Zambia and Zimbabwe.
- Similarly, several countries in ***Asia*** developed fertilizer subsidy programs for farmers including Afghanistan, Bangladesh, Cambodia, China, India, Indonesia, Iran, Korea, Nepal, Pakistan, Philippines, Vietnam and Sri Lanka. Among emerging economies, Russia has a fertilizer subsidy program and Malaysia offers a small subsidy program.
- In ***South America,*** relatively few countries have direct subsidy programs including Chile (which was one of the first countries to adopt a general fertilizer subsidy in 1952), Jamaica and Uruguay. Mexico has a small fertilizer subsidy program. Brazil and Venezuela also subsidize the use of fertilizers.
- In ***developed countries***, subsidies have been quite small recently, representing only about $US 5.5 million out of total agricultural support of $US 140 billion in the EU (Mamun, Martin and Tokgoz

[1] Finland, Sweden and Austria introduced taxes on fertilisers as early as 1976, 1985 and 1986 respectively, with rates of taxation varying from 10% to 72% of the fertiliser price.
[2] There are other important farm inputs targeted by the subsidies in several countries such as e.g. seeds.

2019). Iceland, where the government provides financial assistance to farmers for the purchase of fertilisers, is an exception[3].

1.3 Objectives of the study and approach

This study aims to improve understanding of the scope and effects of subsidies and taxes on fertilizers and pesticides globally based on a review of available literature. Based on a review of existing research, the study provides an overview of the scale and role of fiscal policy instruments, such as taxes and subsidies, in countries' regulatory frameworks on pesticides and fertilizers and their impact on the availability, access and use of fertilizers and pesticides by farmers around the world. Drawing on available literature, the study evaluates the contribution of tax and subsidy programs to different policy objectives to assess the effectiveness and efficiency of such instruments in providing access to agricultural inputs and their role in encouraging their (in)appropriate use. The study provides insights from country experiences with using such fiscal instruments and in reforming inefficient/ineffective fiscal policies in the agriculture sector, comparing different policy designs adopted to identify good practices and lessons learnt on how to reform inefficient/ineffective subsidies and introduce taxes to reduce pollution and associated human health impacts from the use of pesticides and fertilizers in the agriculture sector. The study serves as a background document to a UNEA-5 Review Report on Environmental and Health Effects of Pesticides and Fertilizers (2020 forthcoming).

The report is structured into five chapters. The introduction sets the scene for the analysis, briefly outlining some of the environmental and health impacts associated with the mis-/over- use of pesticides and fertilizers and a brief overview of the use of fiscal policy instruments for fertilizers and pesticides. Chapter 2 offers an overview of fiscal instruments (taxes and subsidies) commonly employed to (dis)incentivise pesticide and fertilizer application and sets out the policy objectives, rationale and wider context for their use. Chapter 3 maps out the global scale and trends in the use of such instruments. Based on available literature, Chapter 4 outlines some key insights on the impacts and effectiveness of taxes and subsidies on pesticides and fertilizers including social, health, environmental and economic impacts. Based on the literature reviewed in the report, Chapter 5 sets out some key lessons learnt and insights on the design of subsidies and taxes as a complimentary tool aimed at incentivizing optimal and responsible pesticide and fertilizer application. This chapter also points to persisting knowledge / data gaps and areas for further research.

[3] Since 1990 the *Soil Conservation Service of Iceland* covers 85% costs if farmers use their machinery, time and skills on land improvement projects. Currently only minority of farmers participates in this program, see Arnalds and Thorsson (2012) http://www.soilconservation.eu/assets/newsletter_2_2012.pdf and OECD (2014), Environmental performance reviews: Iceland 2014

2. Fiscal policy instruments for fertilizers and pesticides: Objectives, rationale and policy context

2.1 Policy objectives and rationale for fertilizer and pesticide subsidy programs

The policy objectives behind agricultural input subsidy programs vary considerably across countries depending on their macroeconomic situation, degree of inequality, and environmental conditions [4]. The timeframe of subsidy programs is another important consideration. While some countries mainly intend to address pressing short-terms issues or increase a country's food self-sufficiency, others focus on more long-term structural objectives. The choice between short and long-term policy objectives is critical. While the long-term focus is in general preferable, in low-income countries due to weak institutions and endemic market failures; price support, price stabilisation, and input subsidies have been used as ways of addressing short-term objectives on income, poverty and food security, with a perspective to promote long-term economic development. Some of the main policy objectives behind agricultural input subsidy programs are set out below in Table 1.

Table 1: Overview of policy objectives and rationale for the use of fertilizer and pesticide subsidies

Policy objective	Rationale	Example
Short-term response to enhance food security, agricultural production and avoid poverty traps	In many least developed countries, large agricultural subsidy programs seek to boost food production and income of rural subsistence farmers, often as a response to unexpected external events such as droughts or sudden food shortages. These programs involve targeting specific vulnerable groups such as low-income, small-scale and risk-averse farmers[5].	Legislative framework for the agricultural input subsidy program in Malawi (2005) underlined the importance of social objectives such as poverty reduction and the provision of safety nets for poor and vulnerable farmer populations among its key goals.
Maintain affordable prices of fertilizers and major crops	Agricultural and energy commodity prices are typically highly volatile. The stimulation of demand through subsidy programs is expected to decrease vulnerability to commodity price fluctuations on world markets. Historically, world energy (fossil fuels) price volatility was an important trigger of government subsidy programs in several countries.	Ghana launched its fertilizer subsidy program in 2008 following a sudden food price increase. Other countries responded with a combination of input subsidies such as fertilizer price controls or fixed the price of fertilizers as in Bangladesh for example. Some countries, such as India and Nepal consistently adopt policies to maintain fertilizer prices around a desired level.
Avoid high costs of agricultural inputs	In several countries, purchasing fertilizers, particularly related transport costs, represent a significant cost to farmers.	Banful (2010) estimates transport costs in sub-Saharan Africa can reach around 50 percent of fertilizer costs. This is much higher than, for example, in Thailand, where transport represents 20 percent of the fertilizer retail price (Chemonics/IFDC 2007, Morris et al. 2007).
Address market imperfections	There are a myriad of market failures agricultural markets face in developing countries including limited access to	

[4] Bardhan and Moorkherjee (2011)[4], World Bank (2007)

[5] Sachs 2005; Carter and Barrett 2006; Sanchez et al. 2007; 2009; Denning et al. 2009

	information, access to credit, and risk aversion. Constrained access to credit is recognized as a priority to support agricultural input purchases as risk-averse farmers may otherwise be discouraged from using fertilizers up to the optimal level.	
Economic transformation	The adoption of new agricultural technologies is critical for increasing outputs efficiently. Thus, some countries use subsidies to kick start innovation and stimulate market development	Induced technological and institutional innovation was very effective in stimulating rural development through the 1960s and 1970s in Asia (Ruttan and Hayami (1984), Hazell (2010).

2.2 Policy objectives and rationale for taxes on fertilizers and pesticides

Taxes on pesticides and fertilizers create incentives for producers and consumers to shift their behaviour towards less polluting products or substances, stimulating innovation and driving cost-effective reductions in pollution. In practice, although the use of taxes on fertilizers and pesticides has been increasing it remains limited to a handful of countries, moreover the use of taxes on fertilizers declined in the 1990s (OECD 2017).

Most taxes on pesticides and fertilizers have been introduced as part of a broader policy framework for the sustainable use of pesticides and fertilisers in agriculture, complementing regulatory frameworks and standards on chemical and toxic content (e.g. nitrogen and phosphorous in fertilizers). In the European Union (EU), for example, fertilizer taxes and charges were implemented mainly to support implementation of the EU Nitrates and Water Directive (1991) or regulation of nitrates content in EU waters. However, out of the six Northern European countries[6] that implemented fertilizer taxes in the 1980s and the 1990s only the Danish tax remains in place (OECD 2017).

The **underlying objectives** behind the adoption of taxes on pesticides and fertilizers varies from supporting soil conservation, to diversifying the crop structure, and reducing pollution caused by the pesticides and fertilizers run-off. The need to address environmental and public health risks is an important driver in several countries with reduction commitments referring to a range of indicators including health and environmental risks inherent in pesticide use (Norway, Switzerland), pesticide load[7] (Denmark), volume or quantity of the pesticides use per annum (Finland, France, Sweden), see Table 2 for an overview.

Table 2: Reduction commitments on pesticide use by certain countries which have adopted pesticide taxes

Country	Reduction target	Deadline	Base year
Denmark[8]	40 % (PLI = 1.96)	2015	2011
Finland	50 %	mid 1990	average 1987 – 1991
France	50 %	2025	
Norway[9]	50 %		
Sweden[10]	50 % + 50 %	1990 / 1996	average 1981 - 1985
Switzerland[11]	30 % + 25 %	2027	2012 - 2015

Raising additional fiscal revenues is another factor driving the introduction of pesticide and fertilizer taxes. Countries use revenues raised from pesticide and fertilizer taxes in different ways (see Table 3). However, the scale of revenues raised from such instruments remains small to date (see Box 4) reflecting various factors including the low tax rates applied and the limited responsiveness of farmers to changes in price (elasticity of demand). While demand for fertilizers and pesticides is relatively inelastic in general, empirical studies indicate that demand for nitrogen and for pesticides is inelastic in the short-term, while in the long term, demand tends to become less inelastic (Aubertot et al. 2005), Carpentier 2010, Dutarte et al 2014) with variations across crops and farming types.

Box 4: Revenues from pesticide and fertilizer taxes

In EU countries, revenues from environmental taxes have oscillated between 4% and 11% of overall tax revenues since 1995[12]. Taxes on pesticides and fertilizers are reported as part of countries taxes on pollution and reached a maximum of 5% of overall revenues from environmental taxes.

- In **Austria**[13] revenues from fertilizer tax increased between 1986/87 and 1993/94 reaching 53.6 and EUR 85.5 million respectively.

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[6] Austria, Denmark, Finland, the Netherlands, Norway and Sweden.

[7] Pesticide load indicator PLI is the total load for the year divided by the area under conventional agriculture in 2007, see https://www2.mst.dk/Udgiv/publikationer/2012/03/978-87-92779-96-0.pdf

[8] https://ieep.eu/uploads/articles/attachments/504788d7-db01-4dd8-bece-ee7b9e63979e/DK%20Pesticide%20Tax%20final.pdf?v=63680923242
https://ec.europa.eu/food/sites/food/files/plant/docs/pesticides_sup_nap_dan-rev_en.pdf
http://ec.europa.eu/environment/enveco/taxation/pdf/ch17_pesticides.pdf
http://www.europarl.europa.eu/cmsdata/149097/EC%20overview%20report%20on%20sust%20pesticides%202017.pdf

[9] https://www.regjeringen.no/globalassets/upload/lmd/vedlegg/brosjyrer_veiledere_rapporter/action_plan_on_reducing_risk_connected_to_the_use_of_pesticides_2004_2008.pdf

[10] The first Swedish NAPs adopted during the 1980s focused on the reduction of overall pesticide use. In the context of the current NAP the reduction of the environmental risk associated to the application of pesticides is more important. Hence the policy goals are defined in terms of reduction of residues in surface water or food and the establishment of less pesticide dependent farming techniques.

[11] See: https://www.newsd.admin.ch/newsd/message/attachments/49600.pdf

[12] Data are considered excluding imputed social contributions. For data see Eurostat, Environmental tax revenues: https://ec.europa.eu/eurostat/data/database?node_code=env_ac_tax

[13] http://ec.europa.eu/envronment/enveco/taxation/pdf/ch9_fertilisers.pdf More analysis on the Austrian fertilizer tax can also be found in *Hofreither and Sinabell (1998)*.

- In **Finland**[14] annual revenues from the administrative charge on pesticides and the tax on fertilizers together have oscillated between EUR 8 and 88 million. The fertilizer tax accounts for the biggest share of this total tax revenue. Since the fertilizer tax was abolished, annual revenues declined to EUR 2 million[15].
- Annual revenues from the price regulation charge in **Sweden** in 1985 and 1988 reached EUR 31 million and EUR 56 million[16] respectively.
- In **Denmark** annual revenues from the pesticide tax were around EUR 60 – 67 million during 2007 – 2010[17]. Expected annual revenues from the tax introduced in 2013 were between EUR 67 million and EUR 87 million[18], see *Danish Economic Councils (2015)*[19].
- **Norway's** pesticide tax raises around EUR 7.2 million per annum[20].

Table 3: Options for the use of revenues from taxes, charges and fees on pesticides and fertilizers

Revenue use option	Description	Country examples
Tax shift	Some countries use revenues to reduce other taxes or support subsidies	- In **Denmark,** revenues from pesticides / fertilizers taxes are used to compensate for reduced income from lower land tax for farmers - **Austria and Finland** use fiscal revenues from fertilizers taxes to fund agricultural export subsidies
Raise revenues for general budget	In a few countries revenues accrue directly to state budget	- **Sweden** - **Netherlands** - **Norway** (tax revenues accrue to general budget, but around 90% are reimbursed back to farmers)
Cover costs of pesticide control	Some countries use revenues to finance pesticide registration schemes	- **Sweden** introduced a pesticide registration charge consisting of annual (1.8 % of sales value) and application charges in 1986 to cover costs of pesticide control by the National Chemical Inspection[21]. - A fee of 3% of pesticide wholesale price was introduced in **Denmark** to cover the costs of pesticide control. - **Finland** applies an administrative charge to finance the control and registration costs associated with the use of pesticides at 3.5% since 1998[22].
Earmarking (full or partial)	Some countries earmark revenues from pesticide/fertilizer taxes and charges towards specific projects, e.g. to address	**Norway**[23] **Kenya**[24]

[14] https://core.ac.uk/download/pdf/16390346.pdf, see also here: Per Mickwitz (1998) Implementation of key environmental principles.
[15] No specific data on revenues from the pesticide tax are available since 2008.
[16] See Chapter 9 Fertilizers, page 137. Tax revenues from pesticide charge and fertilizer tax were reported within the period 1980 and 2007. Subsequently the classification was changed without specific reference to the taxes on environmentally related taxes on agricultural inputs. For data see: http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin_Passiivi/StatFin_Passiivi__ymp__yev/statfinpas_yev_pxt_901_201300.px/
[17] https://mst.dk/media/mst/69742/1.%20Lea_pr%C3%A6sentation%20af%20afgiften%20og%20strategi.pdf
[18] https://ieep.eu/uploads/articles/attachments/504788d7-db01-4dd8-bece-ee7b9e63979e/DK%20Pesticide%20Tax%20final.pdf?v=63680923242
[19] Danish Economic Councils (2015) Økonomi og Miljø 2015. Danish Economic Councils, Copenhagen
[20] https://www.pan-europe.info/old/Archive/publications/PesticideTax.htm
[21] For details see page 99 http://ec.europa.eu/environment/enveco/taxation/pdf/ch8_pesticides.pdf
[22] Schou and Streibig, Pesticide taxes in Scandinavia http://files.foes.de/de/downloads/tagungvilm2005/scandinaviastudy.pdf
[23] Nordic Council of Ministers (2001), An evaluation of the impact of green taxes in Nordic countries, page 81, quoted in Berg (1995, page 305), accessed here: https://pure.au.dk/portal/files/56716516/NMR2001_566.pdf
[24] Government of Kenya (2020), PCPB Fees, http://www.pcpb.go.ke/pcpb-fees/

	environmental impacts, support more sustainable agriculture practices, research on innovative practices, improve efficiency, communications/outreach or activities, e.g. training and inspections	
	In some countries revenues are channelled into a specific fund under the regulatory control of farmers associations and used to finance agricultural and environmental projects supporting the objectives of pesticide / fertilizer policies. These funds serve as a form of compensation to affected farmers[25].	**Denmark**
	In some countries, revenues are attributed to specific ministries. Particularly suitable could be ministries in charge of agriculture, the environment and health.	**Mozambique** (Mozambique, Council of Ministers 2007)

These different revenue use options reflect governments response to some of the concerns associated with pesticide and fertilizer taxes and public support which varies among different groups and countries. Typically, NGOs and the scientific/academic community are strong supporters of such taxes while farmers associations generally resist proposals to adopt taxes on fertilizers and pesticides. Most concerns are based on competitiveness grounds while distributional aspects also play an important role. As a result of these concerns, current taxes on fertilizers and pesticides often include a mechanism to redistribute tax revenues (e.g. in some countries financing export subsidies) as a form of compensation for farmers (e.g. in Austria). Such revenue redistribution mechanisms can help ensure political viability of the tax by addressing its distributional impacts and contribute to policy goals, see e.g. Andersen (1994)[26].

Some countries offer further **fiscal incentives to encourage organic farming practices** through reduced tax rates. For example, Norway fully exempts from taxes any pesticide product applicable under organic farming practices. In Denmark organic farms are entitled to receive benefits from tax revenues. France introduced a combined tax system with preferential treatment of organic farming practices, whereby a reduced tax rate on pesticides is applied in organic farming[27]. Italy, Germany, France, and Austria apply a lower VAT on organic fertilizers compared to chemical ones.

2.3 Policy context

Governments with support of UN agencies and other global initiatives[28] attempt to address some of the key issues linked to unsustainable use of fertilizers including existing nutrient imbalances, excessive, insufficient or polluting use of fertilizers[29]. **International initiatives** such as the Brundtland Report and the Rio Conference highlight the role of economic instruments in achieving the sustainable

[25] Note also that Denmark was facing EC state aid case in 1995.
[26] Andersen M.S., (1994), Governance by green taxes. Making pollution prevention pay, Manchester University Press
[27] See Art. 278 bis Code général des impôts.
[28] See e.g. International Code of Conduct for the Use and Management of Fertilizers
[29] http://www.fao.org/global-soil-partnership/resources/highlights/detail/fr/c/1141549/

use of agrochemicals, noting that the use of subsidies stimulating the use of fertilizers and pesticides should not be excessive or unjustified.

In contrast, **regional initiatives** such as the *Millennium villages program* and the *Alliance for green revolution in Africa* support calls for increasing agricultural production and fertilizer use in sub–Saharan Africa with the support of government subsidy programs if necessary. For example, at the *Africa Fertilizer Summit* in Abuja in 2006, the *Abuja Declaration on Fertilizer for Green Revolution* called for an increase in fertilizer use in member states to 50 kg/ha by 2015 with participating governments committing to adopting a *smart subsidy* plan and investing 10% of their national budgets in agriculture by 2008. The *Malabo Declaration* signed in 2014 in Equatorial Guinea reiterated national public spending targets and called for enhanced investments in agriculture to end poverty and hunger. Similarly, regional initiatives such as *Green revolutions* in Asia and Latin America have strongly relied on a combination of public spending on infrastructure investments and agricultural input subsidies. These regional initiatives have contributed to the wide popularity of subsidy programs in many developing countries (Denning et al. 2009). For example, in 2011 10 sub-Saharan African were spending over US$ 1 billion annually on fertilizer subsidies (Jayne and Rashid 2013)[30].

2.3.1 Country policy contexts: Insights from Sub-Saharan Africa

1960s-1970s: State-led development

Large-scale subsidy programs were a prominent feature of agricultural development policies in developing countries between the 1960s and 1970s. This period was characterized by heavy government intervention and control in many **sub-Saharan African countries** with state-led development strategies granting a pivotal role to governments in the economy. Government agricultural policies were characterised by controlled input (and output) marketing systems in which farmers were supplied with agricultural inputs (fertilizers, pesticides, seeds) at controlled and subsidised prices.

In the early 1960s, governments in many sub-Saharan African countries committed to increase agricultural production mostly through **agricultural input subsidy programs[31]**. Before the introduction of market reforms, 22 out of 26 sub-Saharan countries had fertilizer subsidies (World Bank 1994*).* Some of these programs were implemented in response to world price shocks and were usually implemented in an ad-hoc fashion, driven mostly by short term objectives (e.g. to increase production of food crops such as maize, rice). Fertilizer subsidies were typically the major component of large subsidy programs.

Governments also introduced **price controls and subsidies on fertilizer retail prices** setting administrative prices which were often pan-territorial and pan-seasonal. Subsidies were provided to various groups along the fertilizer marketing chain, particularly farmers followed by distributors and manufacturers. From 1975, an increasing number of agricultural input subsidies in sub-Saharan Africa were applied at the level of input distributor leading to declines in subsidies provided directly to farmers. Subsidy programs also became more selective in terms of addressing specific type of farmers (e.g. smallholders) or specific crops.

Such programs were often **combined with heavily subsidised credit** to farmers with negative interest rates in real terms, e.g. in Malawi, fertilizer subsidies were coupled with subsidized credit in 1970s and 1980s. Most credit was received by estates, large farmers, or commercial cash crop growers, not small farmers. Fertilizers provided as aid-in-kind by donors, often made up all or a substantial part of fertilizer imports. Additional incentives for fertilizer use stemmed from **overvalued local currencies** which

[30] These countries include Burkina Faso, Burundi, Chad, Djibouti, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Seychelles, South Sudan, Tanzania and Zambia.
[31] This included Burkina Faso, Burundi, Chad, Djibouti, Ethiopia, Ghana, Kenya, Lesotho, Malawi, Mali, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Seychelles, South Sudan, Tanzania and Zambia.

provided an implicit subsidy for fertilizer imports which were also sometimes given preference in the allocation of scarce foreign exchange resources.

This first generation of agricultural input subsidies were not targeted, but rather implemented as **price support for specific crops** and distributed as part of the large-scale government programs either across the board or to a category of farmers. After initial increases in employment and GDP growth, by the mid-1970s government interventions became increasingly dysfunctional. Rather than helping African countries to achieve economic diversification and growth, they led to unsustainable macroeconomic instability and high debt burdens.

1980s-1990s: Neo-liberal thinking

In the 1980s, widespread recognition of the problems with ineffective, unsustainable and often counter-productive state intervention in developing countries, particularly in Africa and to some extent in Asia, led to a shift in international development policy thinking towards a Washington consensus-based reliance on liberalized markets (Williamson 1989). Against this wider shift in development policy thinking, there was a **growing recognition of the failures of subsidy programs to deliver on objectives and their unsustainable budgetary costs**. For example, agricultural credit subsidies provided through agricultural banks and other state organisations were widely considered to have been generally ineffective in achieving stated objectives—reducing rural poverty and food insecurity while increasing total agricultural output (Morris et al. 2007). In many cases, the programs were costly, exceeding the value of output produced (Howard and Mungoma 1997, World Bank 2007b) and contributing to government budget deficits and macroeconomic imbalances, thus considered unsustainable (Adams et al., 1984; Von Pischke et al., 1983).

Recognition of these failings led to a shift in focus from dispersing cheap credit to creating sustainable institutions (Meyer, 2011). This scepticism of agricultural subsidies is supported by analysis of the efficiency and effectiveness of agricultural subsidies in post-green revolution Asian countries (see for example Rashid et al. 2008, Wiggins and Brooks 2012 and declining returns to subsidies in India reported by Fan et al. 2007. Apart from **environmental problems** with the intensive use of water and fertiliser encouraged by energy and fertiliser subsidies, subsidies were seen to either offer **negative or lower economic returns** than public investments in agriculture.

Subsidy programmes were phased out in the 1980s in the context of implementing structural adjustment programs. This was followed by a period of policy liberalization to the 1990s with markets for producing agricultural inputs such as fertilizers and pesticides privatized and liberalized in many African countries. Existing fertilizer promotion schemes were reformed with the removal of price controls, reduction or elimination of subsidies and a withdrawal of public agencies and parastatals from their procurement and distribution roles in the market. However, in many countries, the emerging private markets were unable to respond in a timely and appropriate manner to the reforms, thereby leading to high costs and unreliable supply, with demand for fertilizers declining, leading to subsequent reversals in certain countries. For example, in Malawi the phasing out its fertilizer subsidy program in the early 1990s contributed to a severe food crisis caused by the constrained uptake of fertilizers by poor farmers leading the government to subsequently re-introduce agricultural subsidies in 1998.

1990s-to date: A shift towards SMART subsidies

Renewed interest in agricultural input subsidies in sub-Saharan Africa re-emerged in the 1990s. Unlike the first generation of agricultural input subsidies, governments started to implement more targeted subsidy programs operating within an open market environment. These '**smart subsidy' programs** redefine the role for the public sector, by targeting input subsidies to selected farmers, while allowing the private sector to freely distribute inputs on commercial terms and are part of a broader market strengthening/development strategy, targeting specific farmers and promoting economic efficiency by reducing existing market barriers. State distribution programs attempt to target farmers lacking the income to purchase fertilizer at market prices, while the private sector reaches farmers with commercial demand. This approach has been pursued for example in Zambia, Nigeria, Zimbabwe among others. Malawi served as a showcase for a new wave of smart subsidy programmes that has emerged across sub-Saharan Africa since 2007.

From early 2000, the combined effect of production stagnation, declining fertility and rising food insecurity triggered renewed interest in using agricultural input subsidies as a tool for addressing food insecurity. In 2010, at least 10 SSA countries adopted programs costing USD0.6-1.0 billion per year and representing 14-26 percent of public expenditures on agriculture in these countries (Jayne et al. 2018). Note that governments typically pursued a range of policies. Therefore, the measure of the scale of subsidies might include some bias. Additional implicit subsidies were provided through overvalued exchange rates and subsidized interest rates for the credit.

Implementation of the subsidy programs varied among the countries with the private sector largely side-lined in several countries, see Minde et al (2008), Morris et al (2007), Minde and Ndlovu (2007) For example, in Malawi the private retailers, who were supposed to benefit from the scheme and expand their activities were in fact in most years excluded from the distribution of fertilizers[32]. Similarly, in Zambia private retailers were never involved in the subsidy program. In both countries, farmers could effectively obtain fertilizer only from government-arranged depots. In contrast, in Kenya private retailers were involved in the fertilizer distribution program. Overall, the new subsidy programs did not live up to their 'market smart principles' and have several design shortcomings including unclear or complex objectives, failure to diagnose the characteristics of the economy and identify market failures/externalities, and their ineffectiveness in reaching targeted farmers, among others. While a clear exit strategy is a key design principle of subsidy programs, this is often neglected in practice. Empirical studies suggest current programs are more 'sticky' than 'smart' due to a power trap (elite capture) as the lion's share of benefits from subsidy programs benefit diverters. Thus, the second generation of subsidies have only partially achieved their intended impacts and have led to several unintended negative impacts (Holden 2018).

2.3.2 Country policy contexts: Insights from Asia

In the 1960s, **Asian governments** introduced **generous subsidy programs mainly on pesticides and fertilizers** to address missing/imperfect markets as part of the 'Green Revolution'[33]. For example, in Afghanistan from late 1960s-early 1970s, subsidy rates were around 50% of fertilizer costs. In Indonesia, subsidy rates varied among different fertilizers and oscillated around 40% of total farmer costs. Somewhat lower rates were offered in South Korea which started at 10% in the late 1960s and slowly increased. In India, a subsidy program for nitrogenous fertilisers (urea) was adopted in 1977 (Rashkit, 2018) while at the same time subsidies to phosphatic and potassic fertilisers were withdrawn. These subsidies contributed to a radical increase in fertilizer use among Asian countries and have been important drivers of the Asian "green revolution", supporting rising agricultural yields and food security. Expanded use of fertilizers combined with improved seed varieties, irrigation and other chemical inputs led to dramatic increases in crop yields.

Agricultural input subsidies mainly on fertilizer but also pesticides became a major development policy instrument in rural areas between 1960 – 1980. However, there were also negative environmental impacts associated with the subsidy programs including the excessive and inappropriate use of fertilizers and pesticides that pollute waterways and destroy insects and other wildlife, input pricing and subsidy policies that reduced the price of modern inputs and encouraged excessive use.

[32] Certain input wholesalers were allowed to sell fertilizer directly to farmers during the 2006/2007 and 2007/2008 seasons,while retail shops were prohibited from doing so in all years of the program. Since 2007/2008, farmers have been able to redeem their subsidy. vouchers in exchange for fertilizer only from government and/or national cooperative depots (Dorward and Chirwa 2011).

[33] Holden 2018

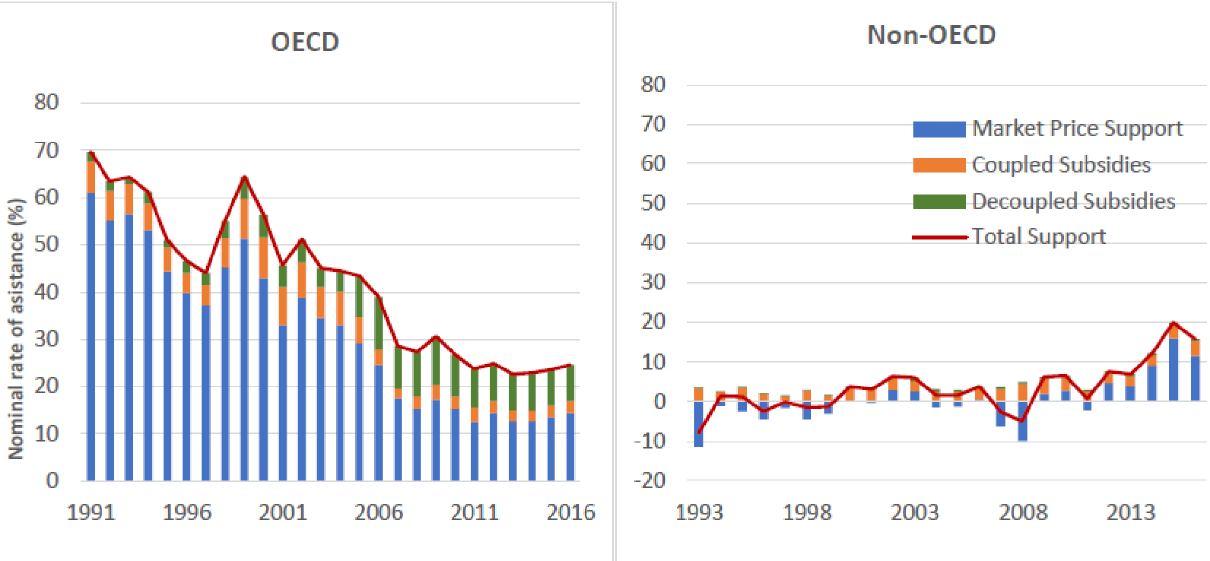
3. Global scale and trends in the use of taxes and subsidies for fertilizers and pesticides

This chapter reviews some key global trends in the use of taxes and subsidies on pesticides and fertilizers. Main features of such instruments such as choices on tax base, tax rates and use of tax revenues are also presented. Based on literature reviewed, the socio-economic and environmental impacts of taxes and subsidies on pesticides and fertilizers including their contributions to stated policy objectives are discussed in Chapter 4.

3.1 Subsidies on fertilizers and pesticides

Historically, **developed countries** employed agricultural subsidies mostly in the form of distortive price support for both domestic production and exports (see Maene, 2000*)*. Following agreement under the Uruguay Round of multilateral trade negotiations in the early 1990s, developed countries gradually reformed their agricultural support, which have shifted from domestic support measures considered to distort production and trade (the amber box in WTO terminology) towards measures that are considered to not or only minimally distort trade such as income support for farmers (the green box) (see World Trade Organization 1995, FAO 1994, 1998, Bumb et al. 2001). This shift has resulted in a sharp decline in assistance provided through market price support and an increase in decoupled subsidies (i.e. subsidies which are not based on current output levels) - see Figure 2. Similarly, subsidies coupled to output or input use declined from almost 7 percent of agricultural production value in 1991 to 2.6 percent in 2016 (Mamun, Martin and Tokgoz 2019). In general, developed countries do not provide significant direct subsidies to fertilizers and pesticides.

Figure 2: Nominal Rates of Assistance for Agriculture, by type of support



Source: Mamun, Martin and Tokgoz 2019, pp. 6

In contrast, **developing countries have relied more heavily on input subsidies**, especially fertilizer subsidies (see Gregory et al., 2000; Debrah and Breman, 2002). Fertilizer subsidies were prevalent in the 1950s and 1960s, concentrated mostly on export crops. Rising fertilizer prices following the 1974 energy crisis (which saw the price of urea increase from $48/tonne in 1970 to over $300/tonne in 1974) led many developing countries to introduce fertilizer subsidies. By 1980 all primary fertilizer-using developing countries including India, China, Indonesia, Egypt, Turkey, Nigeria, Kenya, Tanzania, Zambia, Brazil, Mexico, and Venezuela, were subsidizing the use of fertilizers. Subsidy rates for fertilizers in the early 1980s were rarely below 30 percent and in some cases reached up to 80-90 percent (e.g. in Nigeria) of farm gate prices. Rates of 50-70 percent were common (e.g. in Saudi Arabia and Venezuela farmers paid half the ex-factory or landed cost price, urea was sold at 56 percent below production cost in Sri Lanka and at 60 percent below production cost in Gambia). By the late 2000s, 10 SSA countries were spending over US$800 million annually on input subsidy programs. Indonesia alone was spending about US$221 million in fertilizer subsidies[34]. Currently, coupled subsidies[35], account for about a quarter of total support provided to the agriculture sector in non-OECD countries (Mamun, Martin and Tokgoz 2019). Such subsidies are a significant fiscal burden in many countries, for example China spent US$16.6 billion under its Input Subsidy Program in 2014 and India spent close to US$ 11.5 billion in 2016. These large subsidies have also contributed to adverse environmental and climate effects. For instance, in 2015, fertilizer emissions accounted for 17.8 and 29.2 percent of all agriculture related GHG emissions in India and China compared to the world average of 13.4 percent (Mamun, Martin and Tokgoz 2019). This share has only increased since 2005 for both countries.

Fertilizer subsidies have been popular with politicians as they provide a demonstrable way to show support to a concentrated group of constituents. Furthermore, as beneficiaries of input subsidy programs are easy to identify, whereas losers are the general public, these programs have proven notoriously difficult to reform. In the 1980s, many developing countries started to phase out these subsidies in the context of implementing structural adjustment programs (SAPs) and broader economic and political reforms towards market-based economies. At the turn of the century, a second-generation of subsidy programs were introduced with the aim of improving targeting and there has been a resurgence of input subsidy programs particularly in Africa even though evidence on the production and welfare impacts of these new subsidy programs remains sparse (Mamun, Martin and Tokgoz 2019). For example, in 2011, at least ten countries (accounting for over 60 percent of sub-Saharan Africa's population) spent roughly US$ 1.05 billion (28.6 percent of their public expenditures on agriculture) on input subsidies (Jayne and Rashid 2013). Thus, fertilizer subsidies and input subsidies more broadly remain relevant in many developing countries.

3.2 Implicit subsidies on fertilizers and pesticides

Agricultural inputs are subject to general ad-valorem taxes as applied to other commodities. For example, EU Member States levy general taxes such as VAT on pesticides and fertilizers with standard rates varying between 17 percent and 25 percent. However, **several countries apply reduced VAT rates to fertilizers and pesticides** among other select goods and services. For example, Italy levies a reduced VAT rate on pesticides and fertilizers of 4 percent. Cyprus, Poland, Portugal, Romania, Slovenia and Spain apply reduced VAT rates on pesticides and fertilizers[36]. Switzerland[37] applies a reduced VAT rate on pesticides at 2.5 per cent. South Korea completely exempts fertilizers from VAT. There are a complex set of exemptions from sales taxes for pesticides and fertilizers across the US,[38] while Canada exempts some pesticides from the federal goods and services tax (GST)[39]. Some developing countries also exempt or reduce (zero rate) general and import taxes on fertilizers and pesticides, for example Thailand[40], Kenya[41], and India which pursued a policy of price controls for many years until world

[34] For references see *Tan (2005)* Decreasing environmental pollution through reducing environmentally damaging subsidies: The case of agricultural input subsidies

[35] Coupled support policies include all payments tied to current production and/or crop area (OECD 2019). Examples of such policies include support coupled with input use, such as fertilizer subsidies for consumers.

[36] https://ec.europa.eu/taxation_customs/sites/taxation/files/resources/documents/taxation/vat/how_vat_works/rates/vat_rates_en.pdf

[37] See Art. 25 VAT Act

[38] https://www.uaex.edu/farm-ranch/economics-marketing/docs/Presentation%201.pdf
Also Arizona lawmakers approved tax exemption (sales tax) for pesticides and fertilizers. The measure will be further discussed in the Senate. https://azcapitoltimes.com/news/2019/02/25/house-gives-preliminary-approval-of-tax-exemption-for-pesticides-fertilizers/

[39] https://www.canada.ca/en/revenue-agency/services/forms-publications/publications/gi-048/fertilizer-pesticides.html

[40] https://www.eylaw.com.hk/Publication/vwLUAssets/ey-thailand-tax-facts-2018/$FILE/ey-thailand-tax-facts-august-2018.pdf

[41] Historically the agricultural pest control products (insecticides, rodenticides, fungicides, herbicide, anti-sprouting products and plant growth regulators, disinfectants and similar products) were subject to zero rate VAT until 2013. The Act 2013 (2nd September 2013) changed the tax status of agricultural pest control products from zero rate VAT to exempt until 3 April 2017. Subsequently the VAT status of such

fertilizer prices were nearly three times the price at which they were sold to farmers. A similar case is Mexico, where the losses made by selling fertilizer imports to farmers below production costs were absorbed by the local petrochemical monopoly. Without specific conditions, such tax exemptions act as an implicit/hidden subsidy and may go against countries' commitments in other areas including to reduce pollution.

3.3 Taxes on pesticides and fertilizers

Taxes on pesticides and fertilizers can incentivize producers and consumers to behave in a more environmentally sustainable way by placing an additional cost on the excessive use of fertilizers and pesticides to reflect negative externalities (OECD, 2018). Despite this potential, the use of taxes within regulatory frameworks for fertilizer and pesticides remains limited to date. Tables 4 and 5 provide an overview of countries that had instituted a tax, fee, duty or charge on pesticides and/or fertilizers. To date only a few countries have levied taxes on fertilizers and pesticides beyond the general form of ad-valorem taxes with the clear intention to reduce pollution. Nordic countries were front runners in the application of taxes to incentivise a reduction in pesticide use. France and Italy introduced taxes on pesticides in 1999 and 2001 respectively. The most recent country to adopt a tax on pesticides was Mexico in 2014. In addition, some countries have adopted other taxes, charges and levies, such as a differentiated import levy on pesticides in Mozambique which was primarily introduced for revenue raising purposes but could have co-benefits for the environment and health (Mozambique, Council of Ministers 2007). This section will focus on taxes introduced with the objective of reducing pesticide and fertilizer consumption and use. Tables 4 and 5 provide an overview of countries which have adopted such taxes on pesticides and fertilizers.

Table 4: Overview of taxes on fertilizers, as of April 2017

Country	Introduced in	Abolished in	Tax design	Revenue use
Austria	1986	1996	ATS 3.5 per kg nitrogen ATS 2.0 (~EUR 0.15) per kg phosphate	Support grain production sector through export subsidies
Denmark	1998	-	DKK 5 per kg nitrogen, with broad exemptions for agriculture	Reductions in land use tax
Finland	1976	1995	Revised multiple times, level lower than in Denmark and Austria	Finance export subsidies
The Netherlands	1998	2005	Tax per kg nitrogen and phosphate in excess of a regulated threshold	Feeds into general budget
Norway	1988	2000	Ad valorem for nitrogen-based fertilizers, gradually increased from	Finance environmentally friendly cultivating practices and

products changed to zero-rated through the Finance Act, 2017. From the tax law (amendment) Act 2018, agricultural pest control products have been deleted from second schedule Part A which subsequently subjects all pesticides to 16% VAT.
https://www.capitalfm.co.ke/business/2018/08/govt-urged-to-remove-newly-introduced-16-vat-on-pesticides/
http://farmbizafrica.com/pests/2223-government-urged-to-remove-the-newly-introduced-16-per-cent-vat-on-pesticides

			1% to 20% in 1991	information measures
Sweden	1984	2010	~20% of the fertilizer price	Reduce negative impacts of chemical use in agriculture, finance R&D measure for agriculture

Source: OECD 2017, p.40.

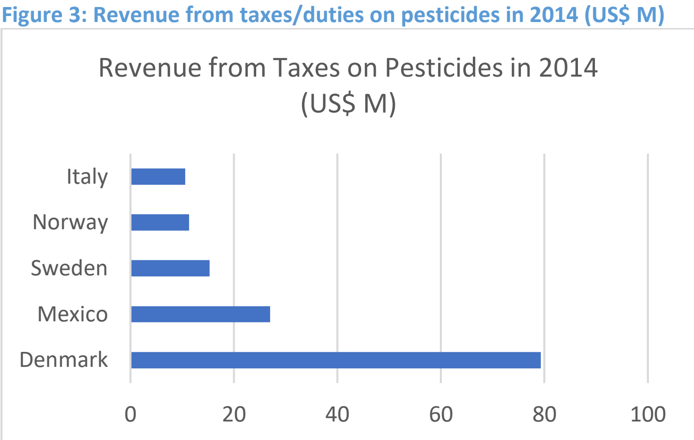
Table 5: Overview of pesticide taxes in place, as of April 2017

Country	Introduced in	Point of imposition	Revenue use
Denmark	1996	Producer/importer	General budget
France	2000	Retailer	Compensation measures for farmers
Mexico	2014	Producer/importer	General budget
Norway	1988	Producer/importer	General budget
Sweden	1984	Producer/importer	General budget

Source: OECD 2017, p.41.

As taxes on fertilizers and pesticides are often incorporated in larger policy packages, such as the French General Tax on Polluting Activities, isolating the revenue from taxes on pesticides and fertilizers is particularly difficult. Estimating the revenues from taxes on pesticides was possible for only five countries in the OECD PINE database: Denmark, Italy, Mexico, Norway, and Sweden (Figure 3). In 2014, revenues from pesticide taxes amounted to US$ 143.5 million in these five countries combined. In Denmark, 100 percent of the revenue from the pesticides tax is earmarked for environmental purposes and to compensate farmers with the tax revenue amounting to USD 78.1 million in 2016 (see box 6).

Figure 3: Revenue from taxes/duties on pesticides in 2014 (US$ M)



Source: Author's calculations based on OECD PINE database

Some countries use **fiscal incentives such as tax reductions to encourage the use of organic fertilizers and therefore reduce pollution.** For example, organic fertilizers in Italy, Germany, and Austria are subject to lower VAT rates than chemical fertilizers. France abandoned reduced VAT rates for pesticides and fertilizers in 2012 and introduced a combined tax system with preferential treatment of organic farming practices. Norway fully exempts any pesticide product applicable under organic farming practices from the tax. Meanwhile, organic farms are generally entitled to receive benefits from tax revenues in Denmark. The substitution of mineral fertilizers towards organic fertilisers, such as manure, can not only contribute to a reduction in polluting pollution run-off, but also to a reduction in N_2O emissions. A strong tax rate differentiation could help make organic fertilizer relatively more attractive to farmers as cost-perception is a statistically significant determinant in the choice of fertilizer (Chen, Zeng, Xu and Fan 2018).

3.4 Charges and fees on pesticides and fertilizers

Beyond taxes, some countries apply other **charges and fees to pesticides and fertilizers, mostly to finance the administration of regulatory and registration frameworks**. Charges are treated differently in countries national accounts; however, the main distinguishing features between taxes and charges is the existence of a link between payment and service provided and the proportionality of the charge and costs of the service. Pesticides are typically subject to registration procedures and their use is subject to permission. Several countries charge registration fees to finance such regulatory frameworks. This includes European countries such as the UK[42], Germany[43], Sweden, as well as Australia, Canada and the US among others. Some countries apply import permit fees on pesticide and fertilizers. For example, Mozambique issues import permits with prices varying by pesticide toxicity class from 0.2 percent of the FOB Value for Class I pesticides (highly toxic) to 0.15 percent of the FOB value for Class II and III pesticides (moderately toxic and slightly toxic) (Mozambique, Council of Ministers 2007). In Kenya, an import fee of 0.8% of F.O.B. Value of pesticide imports is applied with part of the revenues used for training and inspections (Government of Kenya PCPB, 2020). Generally, such charges and fees are paid by the producer, distributor or importer of a given pesticide.

3.5 Design of pesticide and fertilizer taxes

Although the **form of taxes** varied among countries, the central tendency was to move from uniform ad-valorem taxes (for example, Sweden, Finland) towards specific differentiated taxes. Originally more countries (e.g. Denmark, Norway[44,45], Finland) opted for ad-valorem formulation of pesticide taxes charged on pesticides wholesale / retail (import) price. Most of the ad-valorem tax rates were later transformed into a specific and differentiated tax. For example, in Denmark the transformed tax was differentiated into categories reflecting different pesticide environmental load[46] and calculated for each plant protection product[47].

The **choice of tax base** varies considerably. For example, fertilizer taxes are levies on an ad-valorem basis, fertilizer volume, use of specific nutrients such as nitrogen and phosphorus or associated pollutant such as cadmium or excess use of nutrients above a specific threshold value. Pesticide taxes are levied on a dose of pesticide, kg of active ingredient, pesticide risk perception, or on an ad-valorem basis. Pesticide treatment frequency has also been considered as an alternative tax base. Sweden for example attempted to target the nutrient surpluses of nitrogen and phosphorus in soil. Norway and Denmark developed a banded tax addressing varying characteristics of pesticides in use.

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[42] The consists of a fee for a registration of a new active ingredient and a general fee the companies have to pay towards the costs of post-approval monitoring of pesticides, see: https://ec.europa.eu/environment/enveco/taxation/pdf/eimstudy.pdf
[43] See Pflanzenschutz - Gebührenverordnung.
[44] https://read.oecd-ilibrary.org/agriculture-and-food/evaluating-agri-environmental-policies/taxes-as-a-tool-to-reduce-health-and-environmental-risk-from-pesticide-use-in-norway_9789264010116-21-en#page3
[45] *Boecker and Finger (2016)* page 6, see also https://read.oecd-ilibrary.org/agriculture-and-food/evaluating-agri-environmental-policies/taxes-as-a-tool-to-reduce-health-and-environmental-risk-from-pesticide-use-in-norway_9789264010116-21-en#page1
[46] The environmental load indicator reflected on the i) human health risks linked to the exposure ii) environmental load (toxicity to non-target organisms in the environment), iii) environmental impact (degradation, bioaccumulation, leaching to groundwater). See *MoT (2015), Pedersen and Nielsen (2016)*.
[47] See Danish Fourth Pesticide Action Plan (2010 – 2015)

Typically, taxes are levied on manufacturers and importers. Exports are exempt from taxes due to their potential negative impact on competitiveness. Commercial and non-commercial pesticide use can be treated differently e.g. in Denmark the governments' intention is to ban pesticide use in private gardens and public areas while in Norway a very high rate of tax (50 to 150-times the base rate) was imposed on private pesticide use. There are also differences in who pays the tax. In France the tax is paid by farmers and collected by pesticide distributors. This practice contrasts with other countries which require manufacturers and importers to pay the tax.

In terms of the **tax rate applied,** some countries classify pesticides according to their public health/environmental risks or toxicity and assign a specific tax rate accordingly, e.g. Norway, Denmark or France where different tax rates are adopted per active substance reflecting its toxicity for human health and the environment taking into the account other characteristics such as its degradability in soils, bioaccumulation and leaching potential.

There are **various challenges in applying taxes on pesticides and fertilizers and inherent trade-offs in the design of such instruments**. To be cost-efficient, the taxes should target the damage caused, while at the same time have low administrative and monitoring costs. However, as the degree of harm/pollution is location specific, this implies that optimal tax rates would be geographical differentiated. However, such complexity increases emission control costs and complicates the design of the tax. Moreover, due to the diffuse character of pollution caused by fertilizers and pesticides, actual pollution is not always proportionate to actual use, see Segerson (1988), Hrubovcak et al. (1990), Hansen (2002). For example, up to a specific threshold, nitrates, unlike pesticides, are an essential nutrient necessary for plant's growth and only considered a pollutant beyond the threshold level.

These and other challenges have limited the use of such policies to date. In addition, tax policies continue to face strong opposition linked to concerns of impacts on competitiveness and distribution. Moreover, in some cases, the current policy framework may limit the scope for further consideration of such instruments; for example, European environmental policies are mainly based on regulatory instruments, with frequent use of BAT requirements and emission standards which effectively limits the space for using more flexible economic instruments such as taxes (OECD, 2007, Suton et al. 2011)[48,49].

Nonetheless, **the use of environmentally related taxation in general is widening in both OECD and non-OECD countries**. In fact, environmentally related taxes, such as taxes on energy products, motor vehicles and transport services, emissions and certain non-point sources represent about a third of the instruments included in a database of 70 OECD and non-OECD economies on Policy Instruments for Environment (PINE) (OECD 2017). Various biodiversity-relevant taxes, including taxes on pesticides, fertilizers, forest products and timber harvests, have been implemented in 49 countries[50] covered in the PINE database with the number of countries adopting such taxes growing steadily since the 1980s (OECD 2018). There is scope for further use of such instruments in other countries which can benefit from the experiences and lessons learnt to date with the design and effective use of such instruments.

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[48] Sutton et all (2011), The European Nitrogen assessment, Sources, effects and policy perspectives, https://www.researchgate.net/publication/51997325_The_European_Nitrogen_Assessment_Sources_Effects_and_Policy_Perspectives

[49] OECD (2007), Instrument mixes for environmental policy, OECD, Paris,
Sutton Mark et al. (2011), The European Nitrogen Assessment, sources, effects and policy perspectives

[50] The OECD PINE Database covers 70 countries in total: 35 OECD member countries and selected non-OECD economies (although data on these countries might not be comprehensive). To view the full list, refer to the online database.

4. Understanding impacts of taxes and subsidies on pesticides and fertilizers

4.1 Insights on the impacts and effectiveness of subsidies for pesticides and fertilizers

This section reviews available assessments of agricultural input subsidies to identify environmental, economic and social impacts, as well as political economy considerations, effectiveness and efficiency of such instruments. It also identifies elements in the design of subsidy programs which impacts their effectiveness such as the degree of targeting, market competition, risk of pollicisation, and fiscal sustainability among others. It is important to keep in mind that timing and external economic conditions are critical in the evaluation of the impact of a given subsidy programs and it is possible to differentiate impacts in different contexts/phases.

The impact of fertilizer and pesticide subsidy programs is linked to their effect on the use/consumption of fertilizers and pesticides. However, it is not a straightforward task to estimate the impact of subsidy programs on total fertilizer and pesticide use which is dependent on various factors including market prices, existing networks, transport infrastructure, adequacy and reliability of supply, and crowding-in/out of commercial fertilizer and pesticide sales, and program diversion. These last two variables are particularly relevant (see Box 7).

Box 5: Understanding key factors affecting how subsidy programs impact fertilizer and pesticide use

Whether or not a fertilizer subsidy program leads to an increase in fertilizer use depends on farmers' income, local farming practices and the availability of commercial sales of fertilizers. For example, in relatively poor regions with less commercial networks, **crowding-in** might occur whereby a government intervention increases demand for a subsidized product and as such incentivizes greater private investment in the sector. A study by Liverpool-Tasie (2012) confirmed crowding-in of commercial fertilizer demand in a pilot subsidy scheme in one district of Nigeria. The success of this subsidy scheme was related to the fact that fertilizer vouchers were mainly targeted in areas where private commercial markets were relatively weak and to households that were relatively poor.

Crowding-out[51], whereby, the private sector is pushed out of the market due to government intervention, undermines the effectiveness of subsidies. A study by Xu et al. (2009) in Zambia concluded that in areas where private input distribution systems were active, the distribution of subsidized fertilizer almost totally crowded-out commercial purchases, resulting in no increase in total fertilizer use. In Zambia the degree of crowding-out was largely determined by existing infrastructure for commercial fertiliser supplies. No impact on private markets was observed in regions with minimal infrastructure whereas in other regions, existing commercial activity was almost totally crowded-out.

Diversion of subsidy programs is another challenge influencing effectiveness. Diversion refers to fertilizers/subsidies procured by the government for a subsidy program which is illegally diverted at the wholesale level and thus not forwarded through the government subsidy program distribution channels. The magnitude of such diversion is difficult to measure. Some studies have however attempted to quantify this. For example, Mason and Jayne (2013) identify the illicit diversion of Zambia's Fertilizer Support Programme by authorities before it was distributed to intended recipient farmers estimating that between 13 percent and 63 percent of the fertilizer program was diverted based on annual surveys conducted between 2002/2003 and 2011/2012. Similarly, Lunduka et al. (2013) evaluated the Malawi 2009 / 2010 subsidy program and concluded that between 15% and 42% of the fertilizer imported for distribution though the subsidy program was illicitly

[51] Many studies attempting to measure the extent of crowding out omit taking into the account the impacts of illegal diversion of program fertilizers. Hence the reported amount of commercially purchased fertilizers can be less than the total amount of fertilizers purchased by farmers through commercial channels. Mason and Jayne (2013) estimate the magnitude of illegal diversion of program fertilizer reaching from 13 % in 2007 / 2008 up to 63 % in 2004 / 2005 in case of Zambia. The magnitude of diversion is difficult to measure. In Malawi 2009 / 2010 the amount of the diverted fertilizers under the subsidy program was estimated between 25% and 42% of the fertilizer imported Lunduka et al. (2013). From Nigeria's subsidy program in the late 2000s reportedly more than 50% of the quantity of fertilizers distributed was likely to have been diverted by the authorities, Liverpool and Takeshima (2013).

diverted. Liverpool and Takeshima (2013) conclude that more than 50% of the quantity of fertilizer distributed through Nigeria's subsidy program in the late 2000s was likely to have been diverted by authorities.

Available literature remains largely divided on the benefit-cost ratio of fertilizer and pesticide subsidy programs. The drawbacks include high fiscal costs, mismanagement of funds, elite capture, and ineffectiveness in reaching poor smallholder farmers. The benefits, although often not achieved due to poor design, involve responding to external pressures (for example, unexpected weather events), addressing food security, increasing use in risk-averse farmers (where use was at suboptimal levels), and propping up the private sector (which would lead to lower input prices in the future).

4.1.1 Insights on social impacts including on poverty reduction and gender dynamics

Some evidence indicates that **larger farms (often headed by men) benefit more from subsidy programs than small farmers.** Larger farms have been observed to gain first adopter advantage at the expense of small farms which are often owned by women and landless tenants. Typically, households with larger landholdings are more likely to acquire subsidized fertilizers, although this effect has subsequently lessened. For example, in sub-Saharan African countries, wealthier farmers tended to receive proportionately more subsidized fertilizer than resource-poor households—up to seven times more in the case of Zambia (Dorward et al. 2008, Jayne et al. 2011). Available research indicates that in several countries, wealthier households tended to be beneficiaries of subsidized fertilizers. For example, in Zambia as much as 55 percent of ISP fertilizer has been allocated to only 23 percent of households cultivating larger areas (Jayne and Rashid 2013)[52]. Several studies concluded that in Malawi the most vulnerable households are not sufficiently included in government subsidy programs and that the targeting system is not particularly effective (Lunduka et al. 2013, Chibwana et al. 2014, Holden and Lunduka 2012, Ricker-Gilbert et al. (2011). The concentration of food production in the hands of a small proportion of relatively better-off farm households may explain why rural poverty rates have not declined in either Malawi or Zambia between the early 2000s and 2010 (Ricker-Gilbert et al. 2011 and

There also appears to be **a gender-bias in the targeting of some subsidies.** Female-headed households are likely to receive less subsidized fertilizer than male-headed households, although improvements have been recorded recently (Lunduka et al. 2013). In Malawi female-headed households were less likely to be targeted in practice (Chibwana et al. 2014, Dorward et al. 2008, Ricker-Gilbert et al. 2011. Moreover, studies carried out by Banful (2011) indicate that political considerations played a key role in the targeting of fertilizer subsidies to particular areas. In Tanzania's Kilimanjaro region, decentralized targeting reportedly led to distribution effects that favoured political elites and relatively wealthy households (Pan and Christiaensen 2012).

Fertilizer use efficiency can also differ among farmers. Although there is no consensus in the literature on whether larger producers tend to obtain higher crop response rates to fertilizer use, studies by Marenya and Barrett (2009) and Tittonell and Giller (2012) argue that many households in lower income distribution quintiles appear unable to generate a substantial response from subsidized fertilizers. This may be due to yield gaps generated by degraded and poorly responsive soils that make up most poor farmer fields in certain regions. As soils with low carbon content are more pervasive among poor farmers and generally available fertilizers simply do not work on degraded soils, poor farmers might suffer from inferior fertilizer use efficiency (Marenya and Barrett 2009, Tittonell and Giller 2012). Burke (2012), however concluded that no such pattern of gap yield could be identified among smaller Zambian farmers. Capturing the level at which degraded soil quality might affect fertilizer use efficiency in poor farmers is an important point for future research to inform policy

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makers of the potential trade-offs between promoting efficient use of fertilizers to raise national food supplies (by focusing on larger producers) and reducing rural poverty (by targeting poor smallholders).

Agricultural input subsidy programs could affect poverty levels through various channels. Lower fertilizer costs are expected to generate additional demand for fertilizers, improving soil nutrient content leading to higher crop yields and farmers' income. Wider benefits include impacts on commodity prices: as more food crops are produced consumer prices are lowered, strengthening the purchasing power of the poor. Hemming et al. (2018) summarize evidence from 15 experimental and quasi-experimental studies covering Malawi, Nigeria and Zambia and find that fertiliser and seed subsidies are associated with increased use of these inputs, higher agricultural yields and increased income among farm household. They calculate that average income increased by 15 percent for recipients compared to non-recipients of input subsidies. However, their models indicate that the way subsidies are funded, world input prices and beneficiary targeting all have important influences on predicted outcomes. The evidence of fertilizer subsides on poverty overall is limited.

The distribution effects of subsidies appear to be limited. Mason and Tembo (2015) estimate the effects of an increase in fertilizer subsidies on smallholder farm household incomes, poverty incidence and poverty severity in Zambia. Their results suggest that although fertilizer subsidies raised incomes and reduced the severity of poverty, the **program had no statistically significant effect on poverty incidence among smallholder farm households** in Zambia. More specifically, the increase in the total household income by approximately 7.7 percent was not large enough or widely distributed enough to reduce the probability of household income falling below the poverty line. Mason and Tembo (2015) outline multiple suggestions on reforming subsidy design to increase participation of poorer households including improved targeting. The **importance of better targeting** is also supported by Kato and Greely (2016). Their evidence drew from five countries and a detailed study in Ruvuma Region, Tanzania and concluded that both from the efficiency and the poverty reduction perspective, focusing on lower-income households is imperative, as marginal productivity might be expected to increase most on farms using lower levels of input use per hectare, which tend to be smaller lower-income farms.

Furthermore, **it is crucial to assess the efficiency of other policy programs in reducing poverty.** Jayne and Rashid (2013) provide a synthesis of micro-level evidence (after 2005) on input subsidy programs in SSA and conclude that the costs of subsidies not only generally outweigh their benefits, but that at least a partial reallocation of expenditures from fertilizer subsidies to R&D and infrastructure would provide higher returns to agricultural growth and poverty reduction. Moreover, Douillet (2013) assesses the effectiveness of different policies in addressing rural poverty in Malawi and finds that **although input subsidies have increased maize production, they have not had significant effect on rural poverty.** As social welfare payments (cash transfers) appear to compete for the same government funding but have complimentary policy objectives as input subsidies, Douillet argues that it is by combining these two programs: social support for the most vulnerable and productive support for poor farmers that Malawi could better respond to the diverse needs of its population.

4.1.2 Insights on health impacts

In general, input subsidies lower costs to producers which increases the risk of their over- or misuse, with potentially harmful consequences for farmers' and consumers' health and the environment (OECD 2019). Health impacts occur through **ingestion of chemicals accumulated in water or the food chain and through direct exposure**. For example, excess nitrogen and phosphates can leach into groundwater or via surface runoff into waterways (FAO and IWMI, 2017). Globally, 1 in 6 people are at high risk of nitrogen pollution and 1 in 4 people are at high risk of phosphorous pollution, with most of these at-risk people living in developing countries in Asia (White paper by VEOLIA and IFPRI). For example, in several parts of India, unbalanced use and overuse of nitrogenous fertilizers, along with unlined and open storage of livestock wastes, and unsanitary disposal of human wastes have led to high concentrations of NO3 in groundwater (Mukherjee 2012). According to estimates from the Rajiv Gandhi National Drinking Water Mission, the number of households affected by drinking water with NO3 concentration above WHO guidelines increased from 4,003 in 1999 to 19,387 in 2006. Consumption of NO3-contaminated drinking water has methemoglobinemia (blue baby syndrome) as the main acute effect, whereas effects on the thyroid have been reported after longer-term exposure (WHO 2016). Considering that between 85 and 90 percent of the rural population depends on groundwater for drinking purposes, the risks involved are significant and most pronounced for poor and marginal sections of the population (DDWS 2008 as cited in Mukherjee 2012).

Moreover, acute pesticide poisoning causes significant **human morbidity and mortality** worldwide – especially in developing countries, where poor farmers often use highly hazardous pesticide formulations (FAO and IWMI 2017). Pesticides are among the leading causes of death by self-poisoning, particularly in low- and middle-income countries (WHO 2018). Loss of human life and disease incidence due to pesticide poisoning impose significant burdens on national economies.

In addition, **subsidies focusing on a single crop can lead to negative impacts on nutrition.** For example, in Zambia, more than 50 percent of the budget of the Ministry of Agriculture is allocated to subsidies mainly for the production and marketing of maize. This has led to a lack of food diversification and monotonous, deficient diets which have contributed to 35 percent of children under the age of five being affected by stunted growth[53]. Excessive focus on maize growers is also observed in Malawi which has been criticised for creating and perpetuating widespread dependency on maize and could lead to a maize poverty trap, increasing smallholder vulnerability to drought and encouraging an unhealthy diet (Harrigan 2008, Holden and Mangisoni 2013).

4.1.3 Insights on environmental impacts[54]

As elaborated in a forthcoming report for UNEA-5, the use of pesticides and fertilizers can have adverse effects on the environment leading to soil degradation/acidification, polluting groundwater sources, causing eutrophication of surface waters, affecting biodiversity and contributing to global warming[55]. To what extent subsidies exacerbate these adverse environmental impacts depends to a large extent on how the subsidy program is designed.

Available literature suggests **agricultural input subsidies lower the per unit variable cost of inputs and create strong incentives for increasing the intensity of input use**. Henderson and Lankoski (2019) demonstrate that payments based on variable input use (such as fertilizers and pesticides) lead to an increase in nitrogen runoff at farm level and subsequent deterioration of water quality as well as national-level increases in GHG emissions. A caveat relates to crops with negative nutrient balances (e.g. soybeans) whereby support policies encouraging production of such crops can reduce environmental impacts driven by nutrient surpluses, such as GHG emissions and water quality deterioration (Henderson and Lankoski 2019). As noted in Steenblik (1998), **input subsidies are more prone to input overuse and consequent biodiversity loss**. In India for example, large-scale leaching of

[53] IIED (2019) Sustainable diets for all: Beyond maize – Exploring agricultural diversification in Zambia from different perspectives, Discussion Paper, https://pubs.iied.org/pdfs/G04422.pdf

[54] https://www.researchgate.net/publication/286042190_Effects_of_Pesticides_on_Environment
http://www.peelregion.ca/health/topics/pesticides/why-reduce/why-reduce4.htm
https://foodprint.org/issues/pesticides/?cid=263

[55] UNEP (2020 forthcoming) Environmental and health effects of pesticides and fertilizers – Review report

nitrogen and pesticides into aquifers was reported in intensively cultivated areas during the post-Green revolution period, leading to environmental damage (Kushwaha 2008[56], Hazell 2009).

In terms of **impacts on GHG emissions from agriculture**, a study by Laborde, Mamun, Martin and Piñeiro (2019) found that abolishing all coupled subsidies would reduce overall farm output by close to one percent which translates into a reduction of 34 million tons of CO2 equivalent (around -0.6 percent of all agricultural emissions). The largest component of this reduction is from cuts in the use of synthetic fertilizer which make up a significant share of GHG emissions from the agriculture sector – see Table 6 below which illustrates the share of GHG emissions from fertilizers in total agricultural emissions for selected countries. These figures illustrate how the share of emissions from fertilizer use is much higher in certain countries, notably China and India both of which have large fertilizer subsidy programs. For example, under the Agricultural Input Comprehensive Subsidies program, China spent a total of $US 16,590 million US$ in 2014, while in India under the Fertilizer Subsidy Program the Government has spent approximately US$ 11,470 million in 2016 (OECD, 2018 cited in Mamun, Martin and Tokgoz 2019).

Table 6: Share of GHG emissions from synthetic fertilizers in total agricultural emissions (CO2eq)

Country	1995	2000	2005	2010	2015
Brazil	0.022	0.031	0.032	0.053	0.055
China	0.244	0.225	0.267	0.285	0.292
Ethiopia	0.006	0.009	0.008	0.011	0.010
European Union	0.161	0.162	0.164	0.166	0.175
India	0.119	0.128	0.142	0.171	0.178
United States	0.205	0.197	0.205	0.205	0.223
World	0.109	0.109	0.118	0.128	0.134

Source: Mamun, Martin and Tokgoz 2019

However, lowering GHG emissions through reduced use of fertilizers **could entail potential trade-offs with other objectives such as biodiversity**. If the policy objective is to increase overall agricultural output, under the current paradigm of agricultural production, this would require either changing the amount of land in agricultural use or more intensive use of inputs such as fertilizers and labour (Laborde, Mamun, Martin and Piñeiro 2019). The extension of agricultural lands has significant impacts on GHG emissions, biodiversity and protected areas with the conversion of forests, rainforests, and wetlands to agricultural production (Laborde, Mamun, Martin and Piñeiro 2019, Mamun, Martin and Tokgoz 2019).

Such potential trade-offs can be addressed through complimentary instruments designed to meet multiple policy objectives. As noted in Laborde, Mamun, Martin and Piñeiro (2019), "*the best solution to the problem of achieving both efficiency, environmental and nutritional goals would involve three instruments for these three goals. One instrument set might involve tariffs designed to target efficiency of resource allocation; emission taxes designed to discourage production of more emission-intensive goods; and consumption taxes to target nutritional goals".* Supporting research on technology improvements and practices to reduce emissions can also contribute to multiple objectives without setting in motion offsetting effects. Moreover, switching to organic fertilizer would be a way to decrease GHG emissions as synthetic fertilizers are the single most important input contributor to total GHG emissions from the agriculture sector (Laborde, Mamun, Martin and Piñeiro 2019).

[56] hwaha, Niru,2008."Agriculture in India: Land use and sustainability", International Journal of Rural Studies, 15(1);1-10

Box 6: Environmental impacts of fertilizer and pesticide subsidy programs

Agricultural input subsidies lower the cost of inputs creating strong incentives for increasing their use intensity (Henderson and Lankoski 2019). Since excessive use of pesticides and fertilizers can have adverse effects on the environment, subsidies on pesticides and fertilizers can contribute to soil degradation, pollution of groundwater sources, biodiversity degradation and global warming.

Modelling studies have shown that subsidies for pesticides and fertilizers **increase nitrogen runoff** at farm level, lead to subsequent **deterioration of water quality** and national-level **increases in GHG emissions** (Henderson and Lankoski 2019).

In terms of impacts on GHG emissions, modelling studies have shown that if all coupled subsidies are abolished, overall farm output would fall by 1 percent, resulting in a **reduction of around 0.6 percent of all agricultural GHG emissions.** The largest component of this reduction is from cuts in the use of synthetic fertilizer which make up a significant share of GHG emissions from the agriculture sector (Laborde, Mamun, Martin and Piñeiro, 2019).

4.1.4 Insights on economic impacts

Fertilizer and pesticide subsidies also have fiscal implications, **accounting for a large share of public resources and reducing funds for other development priorities**. For example, in India, fertilizer subsidies accounted for the second-largest government transfer at over INR 700 billion (US$10 billion) in the 2018/19 (IMF, 2019). Reforming such subsidies can lead to significant fiscal savings for Governments – see Box 9.

Input subsidies also entail **foregone public expenditures on investments that could have provided greater payoffs to agricultural growth and poverty reduction.** For example, Fan et al. (2008) used empirical evidence across different states in India and over time to estimate the returns in agricultural GDP from government expenditures. By differentiating between investments (roads, education, irrigation infrastructure, and agricultural research and development) and subsidies (fertiliser, credit, irrigation and energy), the study tracks differences in marginal utility of expenditure. The returns on subsidies for irrigation, credit and fertilizer were positive in the earlier years of the green revolution (1960-1970) but then declined and finally resulted in negative returns in the 1990s. Meanwhile, roads, agricultural R&D and education continued to give the highest returns. Fan et al. (2009) conclude that as input subsidies are in direct competition with investments with positive marginal returns, they undermine welfare maximization.

Box 7: Fertilizer Subsidy Savings through Zero Budget Natural Farming, Andhra Pradesh

The government of India allocates a significant portion of its budget to agricultural subsidies – with fertilizer subsidies being the most dominant, amounting to close to USD 9,758 million in 2018–19 and expected to increase by 14 percent in 2019-20 to USD 11,110 million. In Andhra Pradesh alone the annual outlay on fertilizer subsidies was US$490 million in 2017-18.

The Zero Budget Natural Farming project (ZBNF) being implemented by the state of Andhra Pradesh, aims to incorporate 6 million farmers and 8 million hectares of land to synthetic- and chemical-free agriculture by 2024. The estimated avoided fertiliser consumption from ZBNF varies by crop type. For rice, the estimated reduction of fertilizers ranges between 83 and 99 percent. For groundnuts, there is an expected reduction of almost 70 percent in urea and 91 per cent in DAP. Meanwhile, for maize, there is an expected reduction of 84 and 79 percent in urea and DAP respectively.

The benefits of ZBNF are multi-fold and include: a) provision of low cost bio-inoculants, b) consistent yields, c) restoration of ecosystem services, d) conservation of biodiversity on farms, e) use of local seeds, f) multi-cropping with tree cover, g) ability of farms to withstand extreme climatic events, h) safe and nutritious food,

i) improvements in health and j) empowerment of women farmers. The potential fiscal savings from the reduction in fertilizer subsidies will depend on the take-up of the program with estimated savings ranging from **US$72 million to USD$300 million**.

Source: Gupta, Tripathi and Dholakia 2020.

The health effects of using pesticides and fertilizers can lead to further economic impacts through **magnified health care costs and reduced productivity** in the labour market, among others. For example, the estimated annual illness costs of acute poisonings in Nepalese farmers due to pesticide use was nearly one third of total annual health-care costs. In Parana, Brazil, for each dollar spent on pesticides, approximately $1.28 may be spent on health care and sick leave arising from occupational poisoning (WHO 2016).

Subsidies, to the extent that they provide incentives to increase production, impact agricultural trade balances either by reducing import requirements or increasing exports from the subsidizing country. The resulting increase in supply on global markets may lead to a reduction in global prices which in turn affects domestic market prices. Proponents have thus argued, especially in the SSA context, that input subsidies can reduce food prices and thereby benefit Africa's population— including poor farmers— who are buyers or net buyers of staple foods (Jayne and Rashid 2013). However, the few rigorous applied studies measuring the effects of fertilizer and pesticide subsidies on food prices in Malawi, Nigeria, and Zambia have found very weak and small effects on food prices (Takeshima and Liverpool 2013, Ricker-Gilbert 2012 as cited in Jayne and Rashid 2013). The **impact of input subsidies on food prices and food security thus remains ambiguous** and depends on numerous factors including the national context.

Other economic impacts of subsidies relate to issues of **smuggling, leakage and hoarding** of subsidized fertilizers faced by some countries. Such practices result in either no increase in fertilizer use or inflated prices for targeted recipients. For example, in some Asian countries black markets for fertilizers flourished when fertilizer use was subsidized with many reports revealing how farmers resort to buying agricultural inputs on black markets at inflated prices and the widespread smuggling of fertilizers, e.g. from Bangladesh to India.

4.2 Insights on the impacts and effectiveness of taxes on pesticides and fertilizers

It is challenging to assess the impact of pesticide and fertilizer taxes given their relative recent introduction in only a handful of countries. Impacts depend on tax design including the structure of incentives created, tax rates adopted, the demand price elasticity[57], and precision in targeting among other factors. The use of tax revenues, influence on public awareness and the signalling function of taxes are other important impact channels. Moreover, as countries often introduce a complex package of policies to address the use and management of pesticides and fertilizers, it is difficult to disentangle the contributions of specific instruments from the impact of the wider policy package. Political economy also plays an important role as efficient design needs to be aligned with political viability[58].

Several studies suggest the overall impacts of these taxes as currently designed has been rather limited to date and there is a broad perception that existing tax rates have been too low to foster significant changes in the use of fertilizers and pesticides or their environmental or health impacts. In Sweden for

[57] Demand price elasticity determines the percentage change of demand for any commodity due to a 1% change in price of the same commodity (own price elasticity) or any other commodity (cross-price elasticity). Lower elasticities limit the effectiveness of taxes in achieving pollution reductions. In the case of fertilizers and pesticides estimated values of own price demand elasticities are generally low. Values of own price elasticities are typically higher in the long term.

[58] https://tidsskrift.dk/scandinavian_political_studies/article/view/32930/31309

example, marginal tax rates adopted have not been enough to generate the needed incentives to change behaviour (Sainteny 2011, Lavraut et al 2013). However, the impacts and effectiveness of these taxes varies across countries (see case boxes on Denmark and Norway) and depends on several factors as elaborated below.

Box 8: Norwegian Pesticide Tax (1999)

The Norwegian pesticide tax is strongly aligned with the polluter pays principle. The tax was adopted in 1988 and subsequently updated in 1999. The new tax is area-based and differentiates between 7 bands of pesticides, based on their health and environmental risks. The human health criteria are based on the intrinsic properties of the pesticide and the exposure during mixing, while the environmental criteria consider toxicity of the pesticide in aquatic and terrestrial ecosystems and the leaching potential amongst others.

The base tax rate is fixed and uniform for all products; it started at NOK 20 and then increased to NOK 25. The base rate is then multiplied by a factor that varies by band—the factor increases proportionally to the risk the product poses. This tax design reflects the objective of reducing the use of pesticides that represent the greatest risk to human health and the environment (Institute for European Environmental Policy 2014).

However, the environmental impact and the effectiveness of Norway’s pesticide tax have been challenging to measure as many variables influence the amount of pesticide sales. For example, both stockpiling (after announcement of a tax) and exceptions to sowing patterns obscured the effects of the tax on pesticide sales. Nevertheless, health and environmental risks were also assessed based on the trade of pesticides and are estimated to have reduced by approximately 35 percent compared to the 1996-1997 baseline period. (Rorstad 2005 as cited in IEEP 2014). Moreover, the annual income from the pesticide tax was around NOK 20 million and has increased to about NOK 60 million (EUR 7.2 million) a year (PAN Europe 2005 as cited in IIEP 2014). Overall, the banded tax system is considered effective as it not only encourages the more conservative use of pesticides but also provides an incentive to use less harmful products (OECD, 2010).

The **effectiveness of pesticide taxes in reducing the use of harmful products depends on various factors including price elasticities which vary depending on the product type, timeframe and type of farming.** As illustrated in Table 7 below, demand elasticities of pesticides are generally low (‘relatively inelastic’) and thus not very responsive to price changes. However, elasticities are typically higher in the longer term, thus, taxes are more likely to lead to a change in behaviour in the longer term as demand becomes less inelastic and farmers/consumers become more responsive to price changes. Demand elasticities for pesticides also vary across different types of farming, with arable farming generating the most elastic demand for pesticides while special crops growers have significantly less elastic demand compared to aggregate pesticide demand Böcker and Finger (2016). This suggests **taxes will lead to a reduction in pesticide use in the long-term (as elasticities increase),** with more of a reduction expected in arable farming compared to special crop production, (although pesticide application intensity is higher in the latter).

Table 7: Review of demand own price elasticities for pesticides

Study	Country	Elasticity value	Demand	Remarks
Aaltink (1992)	Netherlands	-0.21 (short run) -0.22 (long run)	all pesticides	
Dubberke and Schmitz (1993)	Germany Schleswig-Holstein Lower Saxony North Rhine Westphalia Hesse Rhineland-Platinate	-0.78 (long run) -1.78 (long run) -0,50 (long run) -1.60 (long run) -1.38 (long run) -1.90 (long run) -1.42 (long run)	all pesticides	

	Baden-Württenberg Bavaria Saarland	-1.53 (long run) -1.37 (long run)		
Dubgaard (1987) Dubgaard (1991)	Denmark	-0.3 -0.7 (long term) -0.8 (long term)	Pesticides Herbicides Fungicides / insecticides	 1971 – 1985 1971 – 1985
Ecotec (1997)	UK	-0.5 to -0.7 (long term)	Herbicides	for cereal grass weed
Green (1994)	Sweden	 -0.93 (long run) -0.52 (long run) -0.39 (long run)	 Herbicides Fungicides Insecticides	
Johnsson (1991)	Sweden	-0.30 -0.40	Insecticides fungicides	filed experiments
Oskam (1997)	EU	-0.2 to -0.5	pesticides	
Randleman (1993)	US	-1.74	aggregate for pesticides	1948 – 1989 time series
Russel, Smith, Goodwin (1997)	UK	-1.12 (medium run) -1.09 (medium run)		1989 – 1993 panel data
Schulze (1983)	Germany	-0.50	Fungicides	LP model

Sources: Agne 2000, Bocker and Finger 2017.

It is **even more challenging to assess the impacts of fertilizer taxes** since environmental damage caused by fertilizer run-off varies strongly depending on the receiving environment at local level. The effectiveness of fertilizer taxes in addressing local nitrogen (N) problems has also been questioned as the weak relationship between N and P surpluses in agriculture and actual N and P losses from agriculture reduces the effectiveness of a fertilizer tax in achieving reductions in nutrient surpluses (van Zeijts (1999*)*. Nonetheless, there is **some evidence that using taxes (or phasing out VAT exemptions) on chemical fertilizers decreases their overall use.** An evaluation of programs in Austria, Finland and Sweden to institute a levy on nitrogen revealed they led to an overall reduction in use of 15 percent (Rougoor, Zeijts, Hofreither, and Backman 2001). The greatest reductions were achieved when the taxes were combined with other policy instruments and when the revenues raised were reinvested to promote sustainable alternatives. Some improvements in groundwater quality were associated with fertilizer taxes implemented in the Netherlands and Sweden (Westhoek et al. 2004). The Swedish fertilizer tax also led to a reduction in the excessive application of fertilizers and reductions in phosphorus and cadmium content.

As noted above, the effectiveness of pesticide and fertilizer taxes depends on their design. However, the **design of such instruments faces several challenges including setting the right tax rate and tax base**. Taxes which are set too high may encourage an increase in illicit imports / smuggling, while taxes which are too low may not have any effect on behaviour. Most countries levy specific rates per kg of active substance (e.g. Sweden, France). However, taxing on a per-volume basis of active substance does not differentiate for pesticide load and ignores new, low-dose products which are effective at lower quantities though potentially more toxic (Söderholm, 2009); thus, reductions in sales or use quantity are not a sufficient indicator of the effectiveness of a tax.

The effective design of taxes is further complicated by the fact that both pesticides and fertilizers are dispersed non-point pollutants. The approach to taxing diffuse pollutants is still quite recent with most countries relying on **command and control measures** given difficulties in implementing a tax that reflects damage from non-point source emissions, such as pesticides or pollution caused by nitrate and phosphorus run-off (Segerson, 1988, Hrubovcak et al. 1990, Hansen 2002). Some countries rely on **voluntary measures**, for example Finland and Sweden have adopted voluntary agri-environmental measures through their rural development programs (RDP's) while the EU supports voluntary agri-environmental measures under its Common Agricultural Policy (see Svanbäck, et al., 2019).

Political economy considerations are other critical factors in the effectiveness of pesticide and fertilizer taxes. In all countries where such instruments have been adopted, there have been concerns about the negative impact on competitiveness of farmers on global markets. Addressing such concerns and distributional impacts are critical to ensure political feasibility and often requires close engagement and negotiation with affected stakeholders. For example, in Denmark it took nearly eight years to implement the pesticides tax from the time the topic first appeared on the political agenda (Daugbjerg 1992, Daugbjerg 1998). Experiences in European countries highlight the importance of the revenue re-distribution mechanism in ensuring acceptance of the tax. Such mechanisms enable the compensation of farmers most affected by a tax on pesticides/fertilizers (see Box 6 on Denmark). Communication campaigns financed by tax revenues can also help build public support for policies aimed at decreasing the use of fertilizers and pesticides.

Box 9: Danish tax on pesticides

In Denmark, a tax on pesticides was first introduced in 1996 and increased in 1998. In 2013 the pesticide tax system was reformed so that the level of each approved pesticide is calculated based on the human health risks, environmental load (toxicity to non-target individuals) and environmental fate (bioaccumulation, degradation, leaching to groundwater) as follows:

- Health tax: 107 kr./kg pesticide pr. unit environmental load index
- Environmental effect tax: 107 kr./kg active substance pr. unit environmental load index
- Environmental behaviour tax: 107 kr./kg active substance pr. unit environmental load index
- Basic tax: 50 kr./kg active substance (Kingdom of Denmark, Ministry of Taxation 2017).

The pesticide load indicator is a measure of the load on human health, nature and groundwater. The objective was to reduce the pesticide load by 40 per cent before 2016. With a significant reduction in the sales of pesticides, the largest impact of the reformed tax has been environmental. Overall, the load decreased for all cases except fungicides where the health indicator is positive (Pedersen and Nielsen 2019, Kingdom of Denmark, Ministry of Taxation 2017).

The pesticides tax raises over DKK 650 million annually (EUR 87 million) with revenues reimbursed to the agricultural sector (primarily through reduced land value tax) (Pedersen 2016). This reimbursement mechanism has helped reduce resistance to the tax among farmers. The government also earmarks funds for research on health effects of pesticides with the overarching objective being to limit the use of pesticides, minimise the load of pesticides on nature, the environment and health, and to develop alternative methods to control and prevent plant diseases, weeds, and pests (Kingdom of Denmark, Ministry of Environment and Food 2017).

5. Lessons learnt and policy insights

As set out in this paper, there are various fiscal policies including subsidies and taxes affecting activities in the agriculture sector. Certain types of fiscal policies can support agricultural development, for example through investments in innovation and infrastructure, and/or strengthen capacities to address environmental challenges, for instance by providing incentives for the adoption of climate-smart practices. However, certain types of fiscal policies can be inefficient or ineffective in their design and implementation; and undermine progress on sustainability and climate action. For various political economy considerations, governments often favour input subsidies over investment in public goods such as agricultural research and development. The impacts and effectiveness of these input subsidy programs depend on various factors and the political-economy context in which they operate.

5.1 Lessons from subsidy reform

Many countries have made steps towards reforming their producer subsidy programs. For example, OECD countries have significantly reduced coupled agricultural subsidies over the past two decade. Growing recognition of the high fiscal costs of subsidy programmes and the need to reduce fiscal expenditures have provided the strongest incentive to reform subsidy programs in many countries. Reform efforts have also been driven by increasing awareness of the limitations of central planning approaches, pressure from international organizations such as the World Bank and the IMF, changes in macroeconomic and trade policy, growing recognition of the distributional impacts and limited effectiveness of the subsidy programs.

In **Asia**, the first major reforms of agricultural input programs began in the 1980s. Bangladesh phased out its fertilizer subsidies between 1978 – 1983. Indonesia phased out most pesticide subsidies in 1986-1989 and removed fertilizer subsidies in 1999. The Philippines and Sri Lanka removed fertilizer subsidies in 1988-1990. Turkey removed completely fertilizer and pesticide subsidies in 2001. These reforms were driven by various factors including fiscal pressures (see Box 10 on case of Indonesia).

Box 10: Phasing out pesticide subsidies in Indonesia

During the Green Revolution, Indonesia invested heavily in irrigation infrastructure and production, storage, and distribution facilities for seed, fertilizer and chemical pesticides. It enabled farmers to purchase seed on credit through the Village Cooperative (KUD) if they accepted the entire prescribed package of seeds, fertilizers and pesticides. National expenditures on pesticide subsidies rose from US$50 million per year in the 1970s to over US$150 million per year in the mid-1980s. In 1984, fifteen years after launching the national rice intensification program, Indonesia reached its goal of self-sufficiency in rice, however, it faced overwhelming and resurgent pest outbreaks, in particular of brown planthopper (BPH).

In the 1980s, Indonesia began to reduce support to the agriculture sector, including the removal of pesticide subsidies. The reform was accompanied by a well-funded and widely disseminated national programme of Integrated Pest Management (IPM) to maintain rice production and farm incomes. This program introduced the innovative Farmer Field School model of agro-ecosystem-based experiential learning to promote informed crop management that was radically different from the agricultural intensification and extension approach which characterised the Green Revolution that preceded it.

Following the reform, pesticide applications halved in the country, reducing toxin releases in the environment and negative impacts on biodiversity and human health. At the same time, rice production grew by three million tons over four years. The reform also led to US$ 100 million in fiscal savings.

However, government support for the program wavered after 1999 during the *reformasi* era and between 2000 and 2012, the total value of pesticide imports increased from US$ 50 million to just under US$300 million. By 2014, rice farmers were using more pesticides than ever, correlated with a resurgence of BPH.

Crop losses in high-production areas have been significant, approaching or even surpassing the 1985–1986 outbreak that led to the establishment of the national IPM program. The experience of Indonesia provides an important cautionary note about the sustainability of government supported IPM programs and the importance of designing self-sustaining agronomic practices with a long-term horizon.

Source: Thorburn 2015

Among **sub-Saharan African countries**, implementation of structural adjustments programs in the 1980s provided a major impulse to reform agriculture subsidy programs. However, the sudden dismantling of agricultural input subsidy programmes and liberalised agricultural input markets had a negative impact on smallholder farmers as the disappearance of national supply channels following privatisation of state-controlled commodity boards and the removal of government subsidies led to a significant drop in input use for cash crops, contributing to declines in quality and yields (Crawford et al. 2006, Baltzer and Hansen 2011, Bumb 1995, Bumb and Baanante 1996, IFDC 2001a). This experience highlights the **importance of a well-managed process of phasing out/reforming input subsidies** which offers farmers clear incentives to transition to more sustainable agricultural practices.

With the shift towards market-based development, governments have been turning to other types of support including **better-targeted support**, public investments in infrastructure and research, and soil fertility restoration, among others. For example, as part of the "smart subsidy" programs of the 1990s, some countries—Nigeria, Zambia, and Zimbabwe reconfigured their subsidies to better target intended beneficiaries – see Box 11 on experience in Zambia.[59] Since 2014, several governments have reformed (Malawi and Ghana)[60] or temporarily discontinued (Ghana[61] and Tanzania[62]) their agricultural input subsidy programmes.

Box 11: Reforming fertilizer subsidies in Zambia through better targeting

According to analysis by Xu, Guan, Jayne (2009), recommended fertilizer application rates in two specific years was often unprofitable reflecting a market failure that kept fertilizer use below optimal levels for sustained agricultural productivity growth. However, since 2013, adjustments have been made to the Farmer Input Support Programme (FISP) and other government input subsidy programs to improve household and national food security; raise incomes of small-scale farmers and ensure access to agricultural inputs by small-scale farmers. The program's intended beneficiaries are farmers that work on less than 5ha of land. The subsidy shoulders between 50 and 75 percent of input costs and will be progressively scaled down over time.

The reformed program has been criticised for allocating more subsidized inputs to wealthier households (within the 5ha cut-off, those working on 2+ha). To address this, the program will pilot a system of e-vouchers that have been effective in Nigeria in delivering inputs directly to recipients' mobile phones. The initiative is expected to reduce crowding-out and to promote the development of a private input sector. To address the issue of low maize-fertilizer response rates, studies have recommended promoting other complementary inputs and management practices including conservation farming that could help reduce pressure on fallow land.

Sources: Xu, Guan, Jayne 2009, Mason, Jayne and Mofya-Mukuka 2013, Kato and Greely 2013.

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[59] https://openknowledge.worldbank.org/bitstream/handle/10986/6650/390370AFR0Fert101OFFICIAL0USE0ONLY1.pdf?sequence=1 page 32

[60] Houssou, N., Andam, K., Asante-Addo, C., 2017. "Can Better Targeting Improve the Effectiveness of Ghana's Fertilizer Subsidy Program? Lessons from Ghana and Other Countries South of the Sahara", IFPRI Discussion Paper 1605:<http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/131068 >.

[61] Kato and Greeley (2016)

[62] (Mather and Ndyetabula, 2016)

In some cases, subsidy programs were preventing the development of the private/commercial sector for fertilizers and certain countries undertook **subsidy reforms to correct such market failures.** For example, the Bangladesh Agricultural Development Corporation initiated a reform at the retail level liberalizing prices and removing subsidies. At the same time wholesale prices remained uniform and controlled. As a result, despite the removal of subsidies, the rapid growth of fertilizer use continued[63]. This contrasts to the situation in other countries including Ghana, Nigeria, Poland, Russia, Venezuela, and Zambia where fertilizer use decreased significantly following subsidy removal. The response of the private sector to subsidy reform has generally been weak in Sub-Saharan Africa except for Kenya[64].

5.2 Insights on the design of subsidies and taxes on pesticides and fertilizers

Based on literature reviewed for this paper and country experiences to date, it is apparent that the efficiency and effectiveness of agricultural input subsidies largely depends on how subsidy programs are designed and implemented. A critical first step in the design of subsidy programs is **identifying clear policy objectives.** Adopting conflicting policy objectives or the vague formulation of policy objectives may lead to potential trade-offs (Pan and Christiansen 2012). The approach to subsidy implementation will largely depend on the final policy objective. For example, when the policy goal is to increase agricultural productivity and income, input vouchers could be distributed among poor smallholders who are unable to purchase fertilizers at market prices to minimize crowding out of commercial supplies. However, if the policy goal is to boost aggregate output, the most efficient users of fertilizers should receive priority access to the subsidy program to ensure maximum effect based on a detailed assessment of the most efficient producers.

Overall, **fiscal policies are most effective as part of a toolbox of complementary policies** such as regulations, awareness and communication campaigns. Working together this toolbox can effectively stimulate the systemic and behavioural changes needed to prevent and reduce pollution and associated health impacts. It is particularly important for fiscal instruments addressing fertilizer and pesticide use to incentivize appropriate use and discourage mis- and over-use of such potentially harmful products. Thus, much of the literature (Dreshcel et al 2001, Tittonell and Giller 2012 as cited in Jayne and Rashid 2013) strongly advises linking fiscal instruments with farmer training and education programs to improve the efficiency with which farmers use fertilizers and pesticides, within the context of more comprehensive soil fertility management programs and integrated pest management programs.

Moreover, fiscal policies can play an important role in **broader packages to address wider policy objectives including on climate change**. For example, as part of its contribution to the Paris Climate Agreement, New Zealand's Climate Change Response (Zero Carbon) Amendment Act 2019 introduces several farm-level levies including a producer/importer level levy on fertilizers to reduce nitrogen oxide emissions (N_2O) in particular (FAIRR 2020). A new policy document published in China in response to the 2030 Sustainable Development Agenda sets out a comprehensive vision for agriculture which includes restructuring agricultural subsidies and reducing the use of chemical fertilizers. While the impact of these new policies is still unclear, a study based on 13,000 field experiments across the main agro-ecological zones in China suggests that with the right incentives and training, farmers can improve crop yields by an average of 11 percent, decrease use of fertilizers per crop by 15 percent, saving approximately $1.2 billion on nitrogen (World Economic Forum 2020).

Clear targeting is another critical factor determining effectiveness of subsidies. In certain parts of the world, such as sub-Saharan Africa, where the use of fertilizers remains at suboptimal levels, using well-targeted input subsidies in cases where market failures are well-identified may be justified. Introducing

[63] See Sidhu (1992), IFDC (1994).
[64] https://openknowledge.worldbank.org/bitstream/handle/10986/6650/390370AFR0Fert101OFFICIAL0USE0ONLY1.pdf?sequence=1

subsidies in areas where crop-fertilizer productivity is low may not be justified as greater welfare maximization can be achieved through investment in alternatives such as infrastructure, agricultural R&D, and land conservation. There is thus a need to evaluate the next-best alternative and internalize environmental and health costs in a cost-benefit analysis before the introduction of input subsidy programs.

In general, transitioning from input subsidies to de-coupled agricultural support is associated with reduced environmental degradation and pollution and consequently improved health outcomes. In cases **where the use of subsidies is justified but the current design of subsidies is not effective, a reform/repurposing should be considered.** This should be informed by an analysis of losers and beneficiaries and based on consultations with affected stakeholders. **Support should be repurposed and designed in a way that rewards sustainable behaviour or creates positive incentives**. For example, in contrast to input subsidies, agri-environmental payments for complying with fertiliser application constraints (for cereals and oilseeds) consistently decrease levels of nitrogen application and improves environmental outcomes for water quality and GHG emissions (Henderson and Lankoski 2019).

How subsidy programmes are designed can also lead to distributional impacts with powerful/large farmers benefitting more from the support than smaller farmers (e.g. Bangladesh). For example, subsidy rates differentiated by the final market destination of specific crops, e.g. higher fertilizer subsidies paid to export crops than subsidies paid to food crops such as rice, may result in poor smallholder farmers losing out due to their budgetary constraints. Such distributional impacts should be clearly identified and communicated to build support for reform by debunking myths on the purported beneficiaries of subsidy programs.

In countries suffering from mis- and over- use of pesticides and fertilizers and consequent nutrient surpluses, **taxes on the production/consumption of pesticides and fertilizers could be considered**. Given own price elasticities, analysis suggests such taxes will lead to a reduction in pesticide use in the long-term (as demand elasticities increase) with more of a reduction expected in arable farming compared to special crop production, although in the latter pesticide application rates per hectare are higher. It is worth nothing that even in the countries where fertilizer use is still at suboptimal levels, using **fiscal instruments to incentivize a switch from chemical to organic fertilizer (i.e. tax reductions for organic fertilizers) could yield environmentally positive results** by encouraging the use of the less polluting alternatives.

For such taxes to be effective, attention must be paid to the **design of the tax** including the tax rates applied which should reflect damage/risks to the environment and human health, as in the case of the banded tax system in Norway (see box 5). Some economists propose adopting fertilizer taxes on a graduated scale where a tax is not levied if fertilizer application rates are sufficiently low, however, the tax rises sharply with higher/excessive application levels, which could lead to runoff and leaching. If designed as a sliding scale, the tax would burden the agriculture sector less overall, but would lead to the same reductions in use. Assessing the toxicity of a commodity is also useful for **setting targets and measuring impact of such taxes**. For example, the pesticide load indicator is a measure of the load on human health, nature and groundwater that was used to set objectives of the Danish pesticide tax (see box 6). The objective was to reduce the pesticide load by 40 per cent before 2016 and with the sales of pesticides reducing significantly, the load decreased for all cases except fungicides (Pedersen and Nielsen 2019, Kingdom of Denmark, Ministry of Taxation 2017).

Another critical factor for successful implementation of a tax is careful analysis and effectively addressing **political-economy concerns**. Typically, NGOs and the scientific/academic community are strong supporters of such taxes while farmers associations generally resist proposals to adopt taxes on fertilizers and pesticides. Most concerns are based on competitiveness grounds while distributional aspects also play an important role. As a result of these concerns, current taxes on fertilizers and pesticides often include a **mechanism to redistribute tax revenues** (e.g. in some countries financing export subsidies) as a form of compensation for farmers (e.g. in Austria). Earmarking tax revenue for further environmental uses and/or rebating it to the affected population and/or the sector have been found to increase public acceptance (see Danish pesticide tax, Box 6). Such revenue redistribution mechanisms can help ensure political viability of the tax by addressing its distributional impacts and contribute to policy goals, see e.g. Andersen (1994)[65].

The use of such taxes has been limited to a handful of countries to date, reflecting various concerns including competitiveness and distributional impacts. Nonetheless, growing recognition of the environmental and health costs from uncontrolled use of fertilizers and pesticide will provide further pressure for more efficient policies to address these impacts and well-designed taxes on pesticides and fertilizers can play an important role going forward. When carefully designed such instruments can provide a cost-effective tool to prevent and reduce pollution and associated health impacts from the use of pesticides and fertilizers, complementing other policy measures as part of a wider, comprehensive approach. Such fiscal instruments could also contribute to other policy objectives including on climate change by helping to reduce GHG emissions from the agriculture sector. There is also scope for wider use of other types of fiscal incentives such as reduced tax rates on organic fertilizers to encourage the adoption of sustainable farming practices and reward certain types of activities such as ecosystems restoration, storing carbon, and creating positive incentives through payment for ecosystem services (PES) schemes as part of a comprehensive approach to a sustainable food systems transformation.

[65] Andersen M.S., (1994), Governance by green taxes. Making pollution prevention pay, Manchester University Press

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