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Herbicide use in Africa – towards sustainable intensification:

Use of glyphosate in Kenya

TEGEMEO Institute of Agriculture, Policy and Development at Egerton University &
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Herbicide use in Africa-towards sustainable Intensification: Use of glyphosate in Kenya

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WPS/74/2025

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Executive Summary

Addressing the triple challenge of ensuring food security and nutrition for a growing population, supporting the livelihoods of millions in the food supply chain, and achieving environmental sustainability requires urgent yet sustainable agricultural intensification in Africa. Conservation agriculture, which includes maintaining permanent soil cover, minimising soil disturbance, and diversification of species in cropping systems, is promoted as a sustainable approach in agriculturally intensive environments. Effective weed management, including the use of herbicides, is crucial for conservation agriculture to be successfully implemented.

The early gains of the Green Revolution were driven by intensive input use, leading to environmental challenges. Recent gains in agricultural productivity have been driven by technological innovations, reducing the environmental footprint per unit of food produced. Africa would benefit from Asia's Green Revolution experience by adopting sustainable policies, technologies, and management practices. Sustainable agricultural intensification aims to increase productivity without harmful environmental effects as well as improving soil fertility, reducing greenhouse emissions, and increasing profitable farm income. This approach focuses on desired outcomes and allows flexibility in technologies and agricultural practices.

Herbicide use among African farmers is on the rise, although it remains low compared to international standards. Herbicides play a vital role in reducing reliance on manual weeding and enhancing both land and labour productivity. To fully realise these benefits and promote the adoption of conservation agriculture, it is essential for African governments to implement effective regulatory frameworks and invest in the expansion of extension services that provide ongoing training and support to farmers.

This study evaluated herbicide use among Kenyan maize, wheat, and rice farmers during the 2022/2023 season, with a specific focus on the use of glyphosate.

Glyphosate, first introduced in 1974, is a broad-spectrum herbicide effective against a wide range of weed species. Initially marketed as Roundup®, its use expanded significantly after going off-patent in 2000. The development of glyphosate-tolerant crops has further contributed to its status as the most widely used herbicide globally. Glyphosate supports no-till and reduced-till farming practices, which help prevent soil erosion, enhance soil health, and lower carbon emissions. Because glyphosate breaks down rapidly in the environment and binds tightly to soil particles, it poses a minimal risk of runoff to surface water and groundwater contamination.

Despite ongoing concerns about its widespread use and potential toxicity, numerous regulatory assessments have found glyphosate to be safe when used as directed. The U.S. Environmental Protection Agency (EPA) has reported no significant health risks associated with its current applications and concluded that glyphosate is unlikely to be carcinogenic to humans. Similarly, recent evaluations by the European Food Safety Authority (EFSA) and the European Chemicals Agency (ECHA) have affirmed its safety, leading to the herbicide's renewal in the European Union until December 2033. Australia's Pesticides and Veterinary Medicines Authority (APVMA), along with other international regulatory bodies, has reached the same conclusion.

This study found that:

- Even though Africa is the most tropical continent, with 80% of land falling in the tropical zone between the Tropic of Capricorn and Cancer, pesticide use is comparatively low. Only Eswatini, South Africa and Botswana are within the top 100 pesticide-using countries in the world.
- In 2022, glyphosate was the most commonly used herbicide in Kenya, with 45% of the commercial herbicide products containing glyphosate as an active ingredient, and about one-third (34%) of herbicides using glyphosate as the sole active ingredient.
- Wheat is the biggest herbicide user among staple commodities in Kenyan agriculture, with the total wheat area receiving three herbicide applications on average. Glyphosate is vital for pre-plant weed burndown of weeds while more selective broadleaf herbicides are applied post-emergence. Farmers report that it would be challenging to produce wheat without glyphosate and that they would consider getting out of wheat production if glyphosate is not available.
- Though maize is the crop in Kenya that covers the biggest total area, and is the second biggest herbicide and glyphosate user, only about 16% of the area cultivated to maize receives an herbicide application. About 24% of all herbicides applied to maize contain glyphosate as the active ingredient. Herbicide users have lower labour costs than non-

herbicide users due to more efficient land preparation and planting labour savings. In Kenyan maize production, harvesting requires the most labour.

- About a third of the total rice area in Kenya receives herbicide applications. Glyphosate is the second most important herbicide in rice production and is mainly used for pre-plant weed burndown after seedbed preparation.
- Farmers have indicated that agro-dealers are their primary source of information on herbicide use, followed by agronomists affiliated with agrochemical companies. While these sources are readily accessible, they may not always provide guidance that is tailored to local conditions or aligned with best agronomic practices. The weakening of public extension services, now overseen by County governments, has created a critical gap in independent, science-based support for farmers.

To ensure the sustainable and economically beneficial use of herbicides, it is essential to strengthen training for farmers, farm workers, and service providers on their safe and effective application. Given the fragmentation and under-resourcing of public extension services, there is an urgent need for renewed government investment in revitalising and expanding these systems in close collaboration with the private sector. Strengthening extension services through such partnerships will provide farmers with consistent, independent, and science-based support, while leveraging private-sector expertise, networks, and resources to enhance reach and impact. This collaborative approach will promote more informed decision-making and the adoption of sustainable intensification practices.

1. INTRODUCTION

Addressing the triple challenge of ensuring food security and nutrition for a growing population, supporting the livelihoods of millions of people working in the food supply chain, and doing so in an environmentally sustainable way requires urgent but sustainable agricultural intensification in Africa.

Conservation agriculture is being promoted as a key sustainable intensification approach for African farmers. It is based on, amongst others, the maintenance of a permanent crop cover, minimisation of soil disturbance, and diversification of species in cropping systems. Effective weed management is, therefore, crucial in conservation agriculture, and herbicides are an important part of an integrated weed management system. Though still low by international standards, herbicide use among African farmers is increasing and is applied in both conservation and conventional agricultural systems. Herbicides are important for reducing reliance on manual weeding and improving both land and labour productivity. However, African farmers and governments should proceed with care to avoid some of the unintended consequences observed during the first Green Revolution in Asia, where limited regulation, insufficient extension support, and a lack of continuous training contributed to environmental degradation, water quality concerns, and health risks. A more informed, well-regulated, and farmer-centred approach will be key to ensuring that herbicide use supports sustainable agricultural development.

This report sheds light on the use of herbicides in Africa, with a specific focus on Kenya and glyphosate.

1.1. Need for sustainable intensification in Africa

The intensification of crop production in the developing world began with the Green Revolution in the 1950s and 1960s. This movement encouraged the widespread use of new, input-responsive crop seeds, along with irrigation, chemical fertilisers, and pesticides to boost crop yields. In Asia, the adoption of Green Revolution technologies led to significant increases in production and productivity, which substantially reduced poverty and spurred broader economic growth in many nations (Hazell, 2009; Fujita, 2010). The Green Revolution also successfully spread from North America and Europe to large parts of Latin America, the Middle East, and North Africa, but despite several attempts to introduce the technologies in Africa, uptake has been limited to only a few countries.

To illustrate, the increase in cereal yields in Africa since the 1960s has not been as impressive as that of the developed world or of South America and South Asia (Figure 1). While production has increased in Africa (Figure 2), this has come largely at the cost of turning substantial areas of natural habitats into farmland (Figure 3).

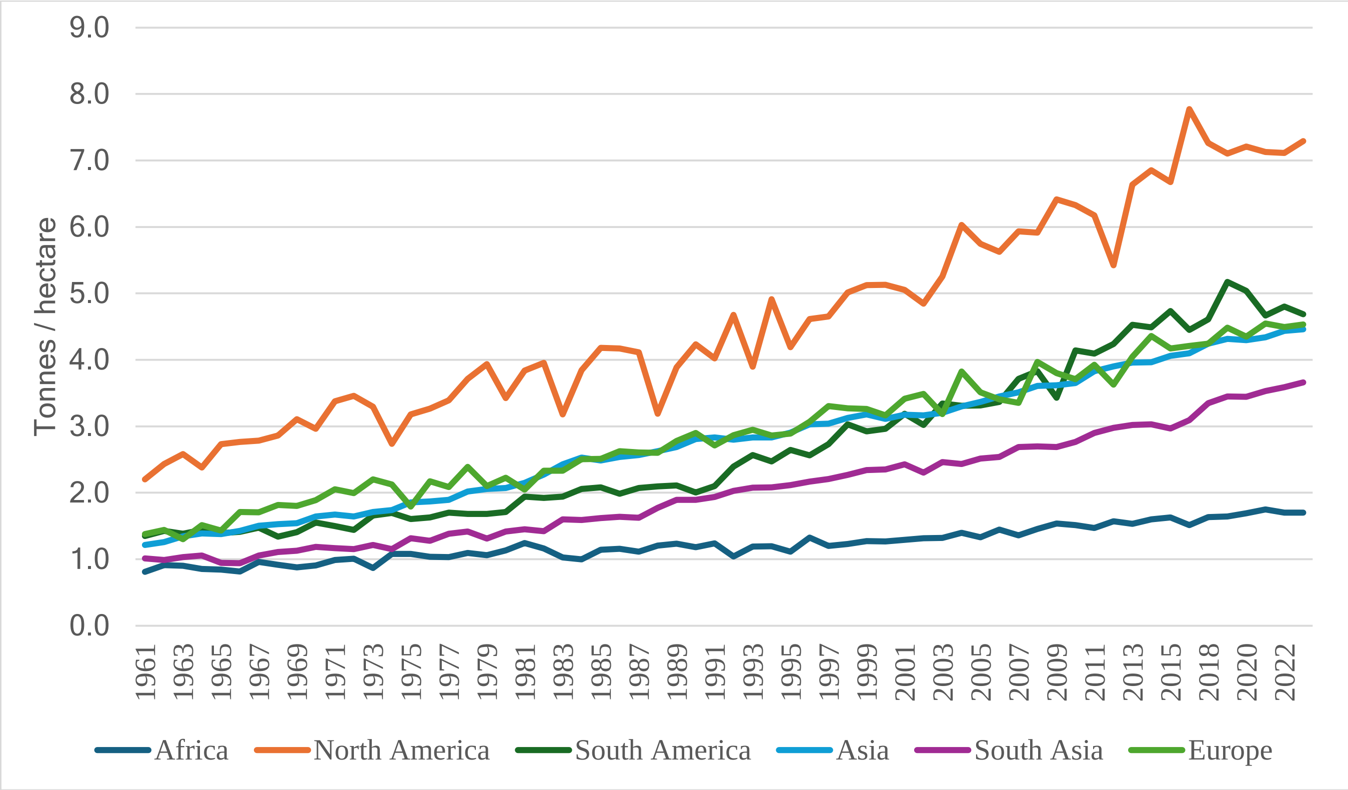

Figure 1: Regional cereal average yield trends 1961-2023
Source: FAOSTAT

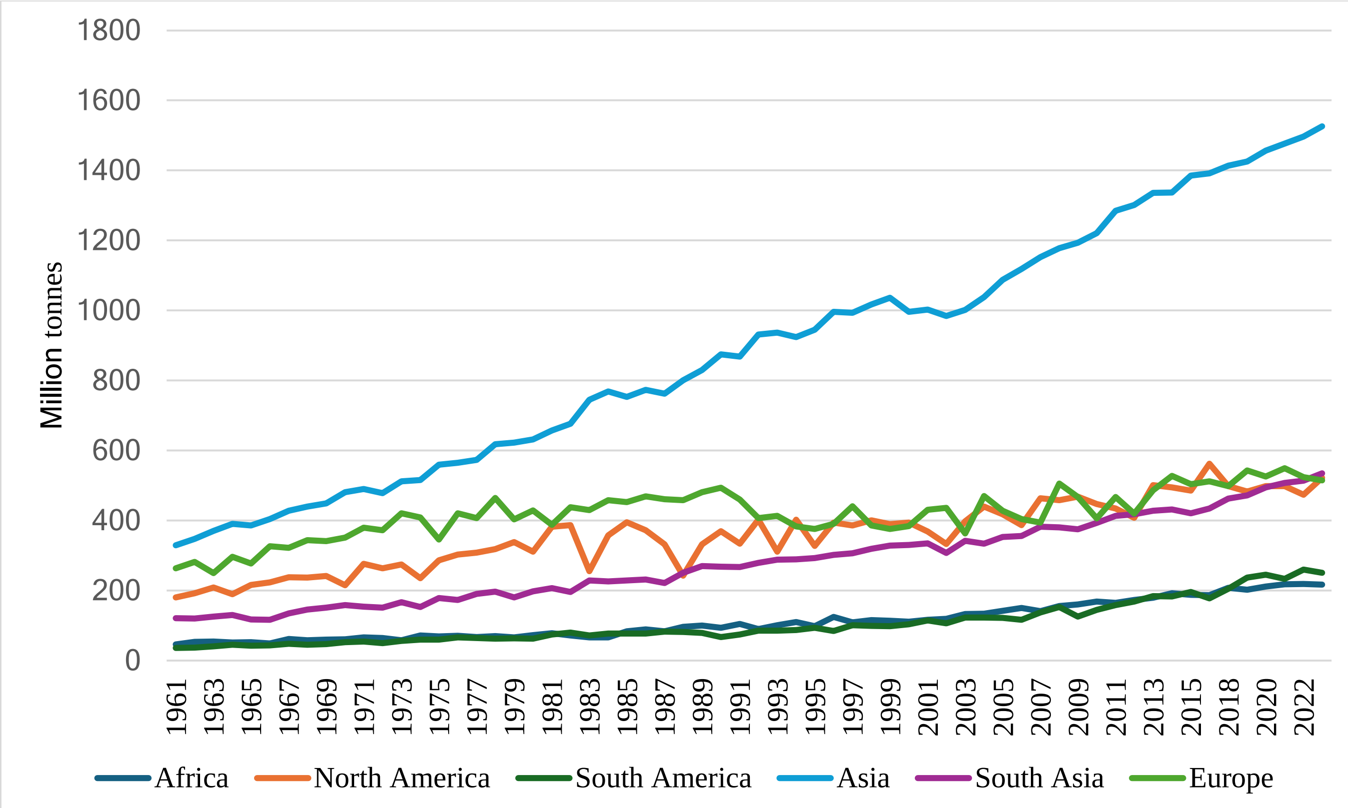

Figure 2: Regional cereal production trends 1961-2023
Source: FAOSTAT

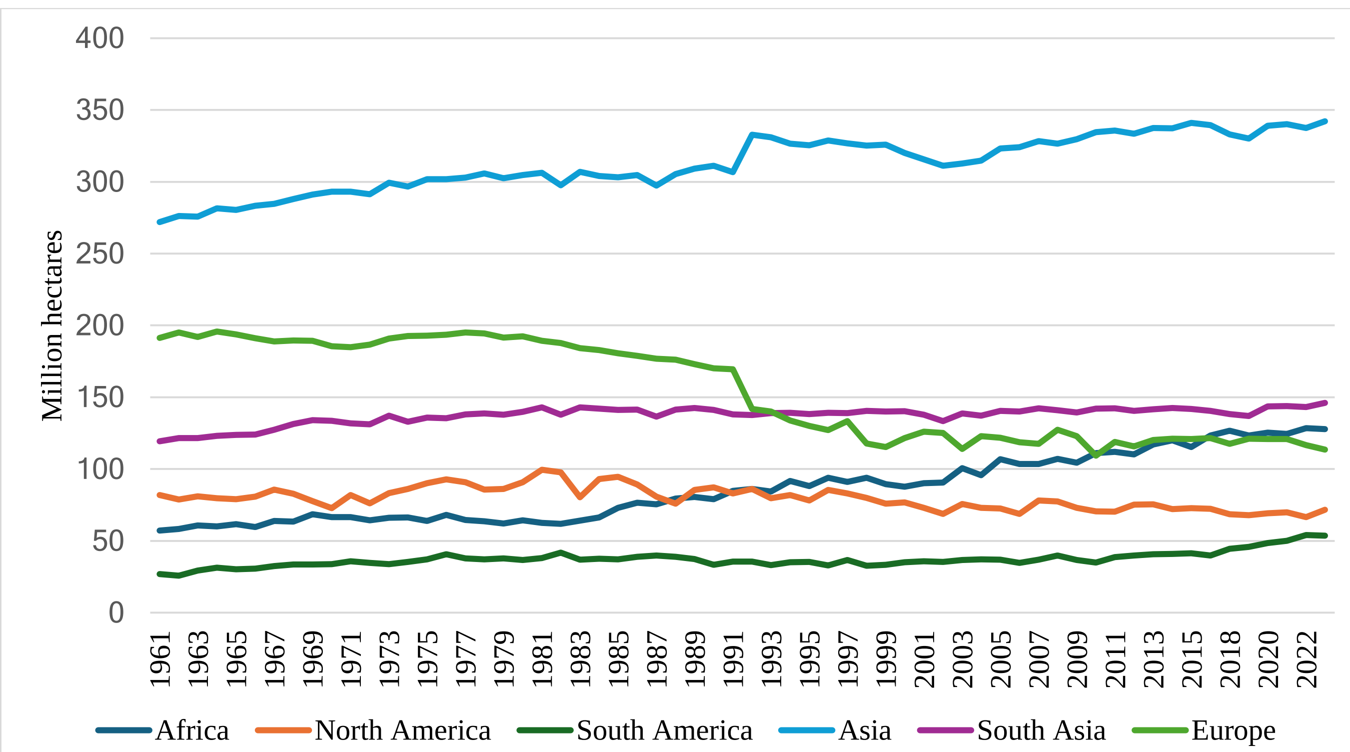

Figure 3: Cereal area harvested trends 1961-2023
Source: FAOSTAT

When comparing the 1961-1980 period with the 2001-2020 period (Figure 4), Africa's cereal output has grown by 172%, which compares well with South America's 214% and Southern Asia's 160% over the same period. However, South America's cereal area only increased by 17% and Asia's by 7%, while Africa's area increased by 74%. Comparing the 1961-1980 period to 2020, Africa's cereal area increased by 99%, with 63 million hectares of natural vegetation or other agricultural land going into cereal production, and yields remaining a fraction of that of the rest of the world.

According to the UN (2017) and subsequent reports, Africa's population is expected to double by 2050, which will increase the immense pressure on the struggling agricultural sector and natural resources. According to Williams et al. (2021), at historical crop yields, the agricultural land area will need to triple in many Sub-Saharan African countries to feed the growing population, and up to 20% of animal habitats will be lost.

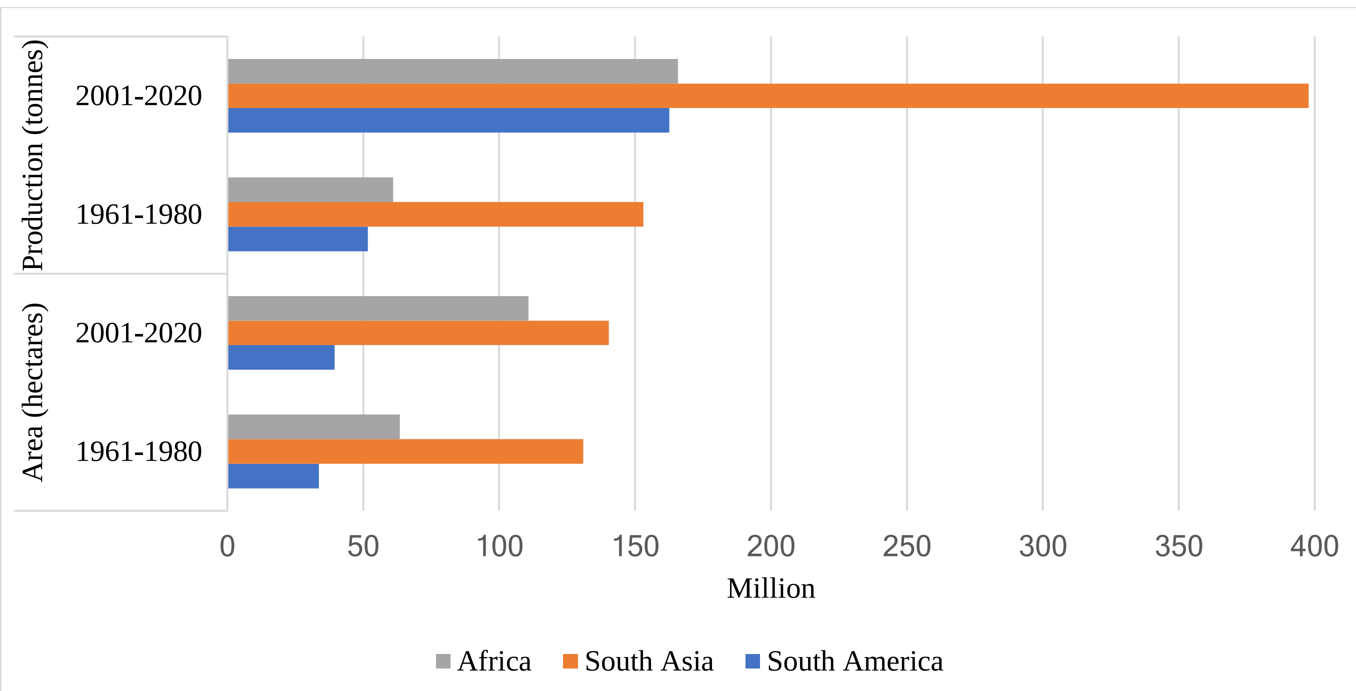

Figure 4: Period-specific cereal area and production comparison for Africa, South Asia and South America

There are numerous reasons why the Green Revolution did not lead to widespread input technology adoption, productivity increases and development in Africa. According to Hazell (2009), some of these include:

- Wheat and rice have historically been less important in Africa, and thus, Africa did not benefit much from the first round of Green Revolution technologies. Africa had to wait for breeding improvements in maize, sorghum, millet and cassava varieties suitable for production under rainfed conditions, whereas South Asia wheat and rice were largely produced under irrigation.
- Africa has invested relatively little in developing rural infrastructure, resulting in high transport and marketing costs for farmers.
- Many African countries are land-locked, thus high-input high-output farming tends to be less profitable.
- Whereas Asian governments took the lead in driving their national green revolutions and implemented supporting policies and investments with widespread donor support, African governments have lagged far behind. On average, public spending on agriculture as a share of total government spending has been consistently low at 5 to 6 percent in Africa for over 40 years, whereas Asian countries spent 15% or more of their total budget on agriculture during the Green Revolution era (Fan & Rao, 2003).
- African farmers have to compete with low-cost food imports from countries whose farmers and exports are often subsidized.

The early gains in agricultural production during the Green Revolution were primarily driven by high-yielding varieties of cereals (e.g., dwarf wheat and rice), more intensive use of inputs such as fertilizers, pesticides, mechanization of cultivation, government-supported infrastructure projects, and irrigation, which, in turn, led to new environmental challenges. However, in recent decades, growth in agricultural output has increasingly been propelled by crop and mechanical technological advancements and efficiency improvements, resulting in a reduced environmental footprint per unit of food produced (OECD, 2021). It is believed that Africa could benefit from Asia's Green Revolution experience, potentially bypassing traditional approaches and directly adopting policies, technologies, and management practices that are both economically and environmentally sustainable.

In light of varying opinions about negative environmental impacts and externalities associated with the first Green Revolution, such as soil fertility degradation, overuse of chemicals, and loss of biodiversity, calls for a Green Revolution in Africa have shifted towards advocating for 'sustainable intensification' (Xie et al., 2019). Sustainable agricultural intensification aims to increase productivity without harmful environmental effects as well as improving soil fertility, reducing greenhouse emissions, and increasing profitable farm income. This approach focuses on desired outcomes and allows flexibility in technologies and agricultural practices (Donovan, 2020). This concept does not prescribe a specific approach or method for agricultural production; rather, it focuses on desired outcomes and allows flexibility in terms of technologies, species mix, and design components (Pretty & Bharucha, 2014).

Globally, conservation agriculture is practiced across some 80 countries and in 2015/16 conservation agriculture area covered over 180 M ha (ECAF, 2020). Initially adoption of conservation agriculture occurred mainly in North and South America and later in Australia, South Africa, United Kingdom and other parts of the world. This had significant economic impacts by enabling increased yields and yield stability especially in semi-arid regions, but also had benefits to the environmental by mitigating the rapid decline in soil loss and quality (Lal, 2001; Beckie et al., 2020; Kassam, 2020). Conservation agriculture, with crop diversification, minimum soil tillage and permanent soil cover as production system fundamentals, is aligned with the sustainable intensification ideology (Sims et al., 2018) and according to CIMMYT (2020), international scientific analysis has found that conservation agriculture can, across various production conditions and climates, play a crucial role towards achieving the United Nations Sustainable Development Goals (Donovan, 2020).

Termination of weeds and/or cover crops prior to crop sowing is one of the most essential uses of glyphosate, and currently, glyphosate use is a critical component to adopt conservation agriculture successfully (Neve et al., 2024). Very few tools in agriculture are indispensable and banning or greatly limiting future use of glyphosate in Kenya will significantly impact the ability of Kenyan farmers to adopt and realize all of the benefits of conservation agriculture. Without glyphosate in Kenya, farmers will have to turn to alternatives that will lead to heavier reliance on soil cultivation for weed control and cover crop termination, and this will ultimately impact sustainable weed management.

1.2. International herbicide use

According to Sharma et al. (2019), around two million tonnes of pesticides are used per year on a global basis, most of which are herbicides (50%), followed by insecticides (30 %), fungicides (18 %) and other types of plant protection products, such as rodenticides and nematicides. Among various crop threats, weeds account for the highest potential monetary losses, estimated at 34%, which is roughly double the losses caused by animal pests and pathogens (Oerke, 2006). As such, weed control plays a critical role in improving land use efficiency. Weeds represent one of the most significant challenges to agricultural productivity, competing with crops for essential resources such as water, nutrients, space, and light. Effective weed management is therefore essential to safeguard crop yields and maintain the quality and purity of harvested produce. Figure 5 presents a comparison of pesticide use for the main pesticide-using countries in 2022. The countries in the world with the highest pesticide usage per production area are smaller countries and islands with highly intensive production systems like the Maldives, the West Indian Islands, and Qatar (these countries use more than 35kg of pesticide per hectare of cropland). Hong Kong is the 18th most intensive user of pesticides in the world, at 16.67kg. Brazil, the first major agricultural country is in 25th position. Eswatini, with a relatively small crop area and intensive sugar, fruit and vegetable production systems in a subtropical climate, is the first African country (excluding the islands), in the 43rd position. South Africa is in the 73rd place at 3.4kg/ha. Kenya sits in the 146th position, with Kenyan farmers using 0.73kg of pesticides per hectare of cropland.

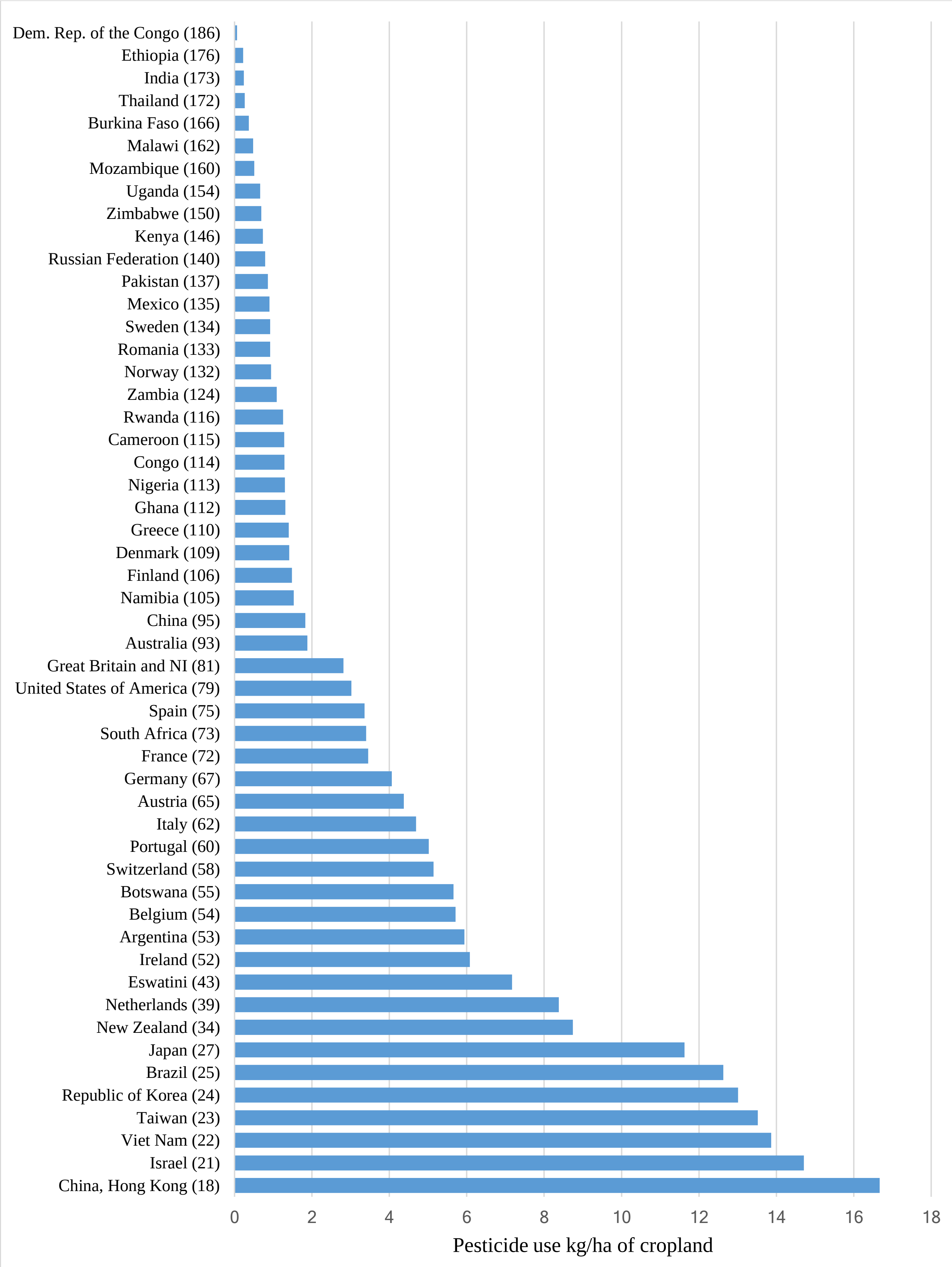
Dem. Rep. of the Congo (186)
Ethiopia (176)
India (173)
Thailand (172)
Burkina Faso (166)
Malawi (162)
Mozambique (160)
Uganda (154)
Zimbabwe (150)
Kenya (146)
Russian Federation (140)
Pakistan (137)
Mexico (135)
Sweden (134)
Romania (133)
Norway (132)
Zambia (124)
Rwanda (116)
Cameroon (115)
Congo (114)
Nigeria (113)
Ghana (112)
Greece (110)
Denmark (109)
Finland (106)
Namibia (105)
China (95)
Australia (93)
Great Britain and NI (81)
United States of America (79)
Spain (75)
South Africa (73)
France (72)
Germany (67)
Austria (65)
Italy (62)
Portugal (60)
Switzerland (58)
Botswana (55)
Belgium (54)
Argentina (53)
Ireland (52)
Eswatini (43)
Netherlands (39)
New Zealand (34)
Japan (27)
Brazil (25)
Republic of Korea (24)
Taiwan (23)
Viet Nam (22)
Israel (21)
China, Hong Kong (18)
0
2
4
6
8
10
12
14
16
18
Pesticide use kg/ha of cropland

Figure 5**:** Pesticide use country comparison (2022)
Source: FAO

Figure 6 presents a comparison of pesticide use by region and sub-region in 2022. Pesticide use is a factor of agricultural intensification and crop type, but also climate, with pest pressure in the warm, humid tropical regions substantially higher than in the temperate regions where generally lower temperatures and cold winters suppress pest populations.

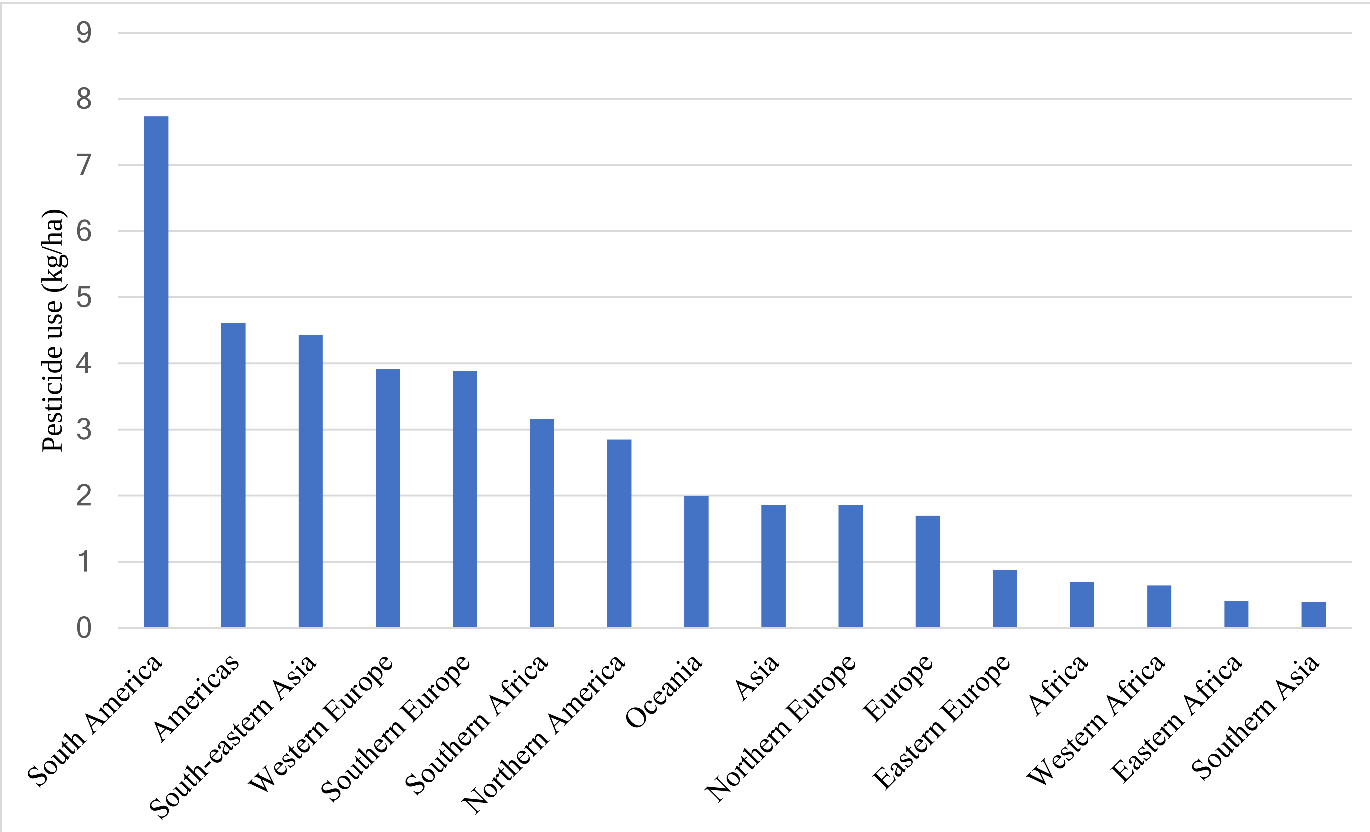

Figure 6: Average pesticide use intensity by region
Source: FAO

Even though Africa is the most tropical continent, with 80% of land falling in the zone between the Tropics of Capricorn and Cancer, pesticide use is comparatively low. Only Eswatini, South Africa and Botswana (included in Southern Africa) are within the top 100 pesticide-using countries in the world, while there are eleven European countries in the top 100 list.

1.3. Weed control and herbicide use in Africa

According to Akobundu (1980), weed problems are more severe in Africa's tropical regions than in Europe and North America because weeds grow more vigorously and regenerate more quickly in the heat and higher light intensity in Africa. Weeds are the most important pest to control in

African agriculture (Sibuga, 1997), and, contrary to the seasonality of other pests, weed pressure tends to be consistent throughout the year.

Weed competition is most serious when the crop is young – the critical period being the first third to half of the life cycle of the crop. If farmers can keep the crop free of weeds during this period, weed damage is minimised (Doll, 2003). Weeds compete with crops for water, nutrients, land, and light. Numerous studies have measured the critical period and associated yield losses in maize and other crops, e.g., (Benson, 1982; Knezevic et al., 2002; Zimdahl, 2004). While the results vary, there is overwhelming experimental and field evidence that confirms that if weeds are not effectively controlled during the critical period, crop yield losses can be staggering. Benson (1982) reviewed close to 500 such studies published over a 30-year period (1950s-1980) and found that grasses and sedge weeds can cause losses up to 92% of the potential yield of maize, while losses from broadleaves can approach 85%. Periods of competition as short as 10 days were found to cause losses of 10% of a potential maize yield, especially when competition occurred within the first four weeks of crop growth. Based on all the experimental evidence accumulated at that time, Benson concluded that for effective control, maize fields must be weeded two or more times during the early weeks after planting. Benson’s general conclusions have since been confirmed by numerous studies in various parts of the world (Kalaitzandonakes et al., 2015). Gianessi (2009) reports that under unweeded conditions, crop losses have been measured for: maize (55-90%), common beans (50%), sorghum (40-80%), cowpeas (40-60%), rice (50-100%), cotton (80%), wheat (50-80%), groundnuts (80%), and cassava (90%).

Hand weeding is the predominant weed control practice on smallholder farms in Africa, and farmers spend 50-70% of their labour time pulling, slashing, and hoeing (Chikoye et al., 2007). Women contribute more than 90% of the hand-weeding labour for most crops (Oniang’o, 2005) and children are often forced to miss school during the peak weeding period to assist (Ishaya et al., 2008). Urban migration in search of employment has exacerbated labour shortages during peak weeding periods (Haggblade et al., 2022).

Despite the obvious need to control weeds, continuous hand hoeing for land preparation and weeding are among the main causes of soil organic matter losses. Trials show that constant ploughing and hoeing can lead to the loss of soil fertility, mainly due to the oxidation of organic matter and the exposure of bare soils to sun, wind and rain that cause run-off and surface erosion of the fertile topsoil (Sims et al., 2018). Conservation agriculture promotes the maintenance of a permanent crop cover, minimum soil disturbance, and diversification of plant species, but weed management in this system is critical. Successful adoption of no- or reduced tillage production systems has been attributed to the use of chemical herbicides to control weeds, reduce yield losses and cope with lack of or expensive labour (Gouse et al., 2016; Phipps & Park, 2002; Micheni et al., 2016; Fernandez-Cornejo et al., 2005) and in many cases in conservation agriculture, herbicides are used as an alternative to primary tillage for pre-planting weed control. Herbicides are a vital tool in the move towards sustainable intensification but need to form part of an integrated weed management system to prevent negative environmental impacts and resistance problems of the Asian Green Revolution.

Data on herbicide use in Africa is limited. FAO-reported data on herbicide use is based on high-level estimates and periodic surveys and, for most African countries, presents an indication of the level of use rather than accurate historical change. Nevertheless, considering the historic value of pesticide imports for East, Southern and West Africa, it is clear that pesticide use is increasing in Africa (Figure 7), with use increasing substantially faster in West Africa. Since herbicides generally make up about 50% of total pesticide use, it is reasonable to deduce that herbicide use is also increasing.

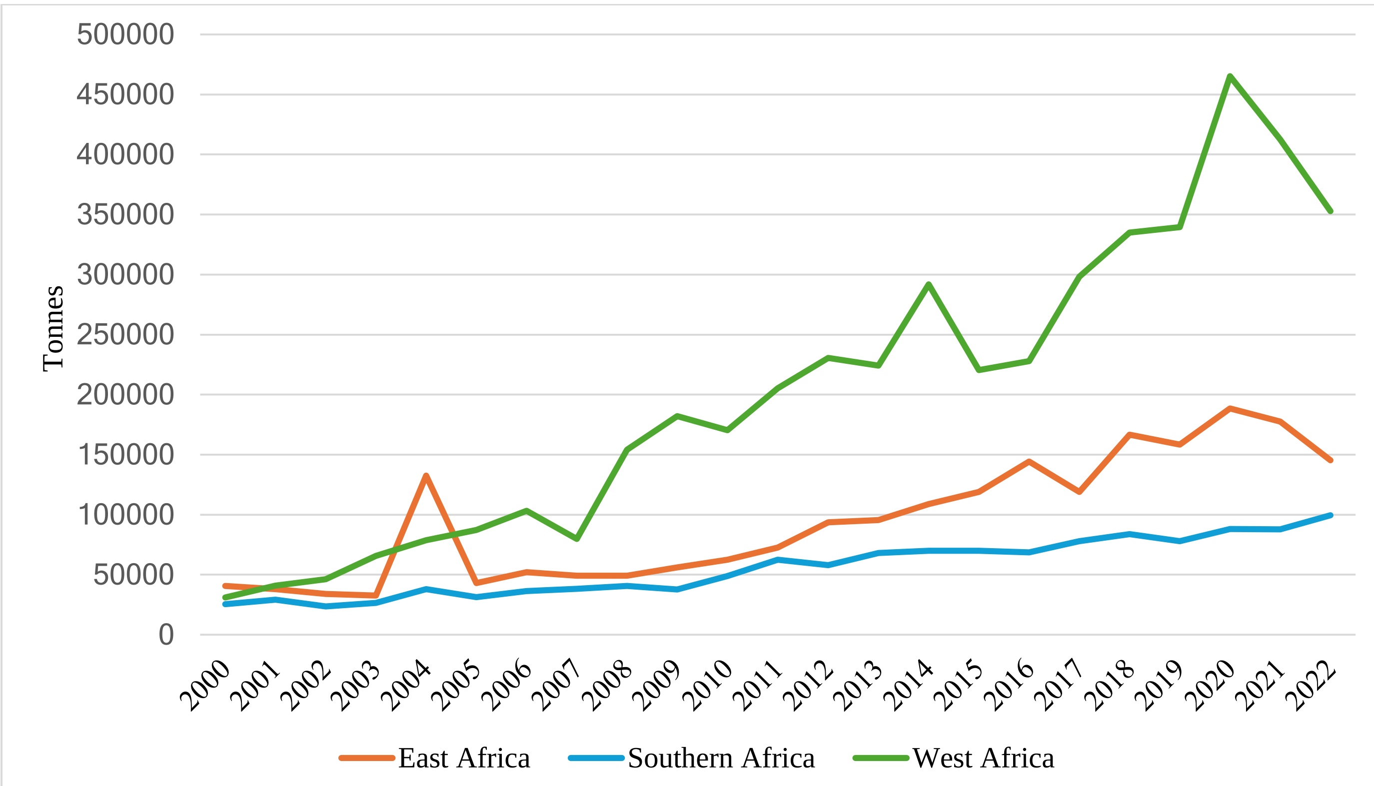

Figure 7: Pesticide Imports

Market analysis by Demeter Dynamics (2022), sheds light on herbicide sales in several African countries. Table 1 provides a summary of herbicide litres sold in 2020, also with specific reference to glyphosate, while Table 2 indicates the use of glyphosate for the main crops. South Africa, with its larger commercial agricultural sector, is by far the biggest herbicide user on the continent. In 2020, 62% of herbicide litres applied in South Africa contained the active ingredient glyphosate. In 2020, just over 78% of South Africa's 2.755 million ha of planted maize was genetically modified herbicide (glyphosate) tolerant maize. A further 786,000 ha of herbicide-tolerant soybeans were planted, as well as about 16,000 ha of herbicide-tolerant cotton. These crops are also the main users of glyphosate in South Africa, with an estimated 86% of glyphosate applied to these three crops in 2020.

Though Ghana only uses about a 10^{th} of South Africa's herbicide volume, its herbicide use is at a relatively high level (112^{th} in the World - Figure 5) but it is not a large glyphosate user. Glyphosate is by far the most important herbicide in the Ivory Coast, with nearly 80% of national herbicide applications being glyphosate, mainly used for pre-plant weed burndown in the production of vegetables, tomatoes, rice and coffee.

Table 1: Herbicide volumes sold in 2020

	Total herbicide volume (litres)	**Glyphosate litres (at 360 g acid equivalents/litre concentrate)**	**Glyphosate share of herbicide volume sold**
South Africa	55 637 236	34 425 751	62%
Ghana	5 895 826	2 028 919	34%
Ivory Coast	4 444 074	3 522 133	79%
Zambia	2 023 947	286 000	14%
Kenya	1 702 771	701 561	41%
Zimbabwe	1 125 210	365 900	33%
Malawi	864 598	481 973	56%
Ethiopia	697 913	588 413	84%
Tanzania	360 023	136 703	38%

Source: Demeter Dynamics, 2022

Glyphosate

Glyphosate, first introduced commercially in 1974, is a broad-spectrum, non-selective herbicide effective against a wide range of annual and perennial weed species, including both broadleaf plants and grasses. Initially marketed as Roundup® by Monsanto, its adoption grew steadily due to its versatility, reliability, and relatively low cost compared to alternative herbicides. Its use expanded dramatically after going off-patent in 2000, when generic production significantly lowered prices and made it more accessible to farmers worldwide. The introduction and rapid adoption of glyphosate-tolerant genetically modified crops, such as soybeans, maize, cotton, and canola, further contributed to its position as the most widely used herbicide globally, with multi-million tonne annual applications reported across major agricultural economies.

Glyphosate plays a pivotal role in integrated weed management strategies. In conservation tillage systems, including no-till and reduced-till farming, glyphosate is used for pre-plant or post-harvest weed control, enabling minimal soil disturbance. These practices help reduce soil erosion, increase water retention, improve soil organic matter, and lower fuel consumption, benefits that contribute both to soil health and to reducing agricultural greenhouse gas emissions. For many farmers, glyphosate has been a key enabler of conservation agriculture practices, where consistent and dependable non-mechanical weed control is essential for long-term sustainability.

Despite sustained public debate over its safety, particularly in relation to human health, extensive reviews by multiple regulatory bodies have consistently concluded that glyphosate is safe when used according to label instructions. The U.S. Environmental Protection Agency (EPA) has reported no significant health risks from current registered uses and classified glyphosate as "unlikely to be carcinogenic to humans." Similarly, the European Food Safety Authority (EFSA) and the European Chemicals Agency (ECHA) reaffirmed its safety following detailed, multi-year assessments, leading to the European Union extending its approval for use until December 2033. Australia's Pesticides and Veterinary Medicines Authority (APVMA), Canada's Pest Management Regulatory Agency (PMRA), and other international regulators have reached comparable conclusions.

Nevertheless, ongoing monitoring, adherence to best management practices, and public transparency remain central to ensuring that glyphosate's benefits to agricultural productivity and soil conservation continue to outweigh potential risks.

Table 2: Crop-specific glyphosate use (% of total country volume) for selected countries in 2020

	South Africa	**Ghana**	**Ivory Coast**	**Zambia**	**Kenya**	**Zim.**	**Malawi**	**Ethiopia**	**Tanzania**
Maize	66.3%	53.7%		62.3%	21.2%	19.9%	83.7%	14.1%	23.0%
Soybeans	14.6%			34.3%					
Cotton	5.4%								1.0%
Citrus	3.0%			0.2%	0.4%	5.3%		0.1%	
Wheat	1.8%				9.3%	15.9%		35.6%	11.1%
Wine Grapes	1.2%								
Sugarcane	1.2%				0.5%		14.4%		3.2%
Barley	1.0%				5.0%	4.5%		35.5%	3.3%
Nuts	0.9%				0.2%		1.9%		0.5%
Pome Fruit	0.8%								
Oats	0.7%								
Vegetables	0.6%	4.1%	9.9%	1.8%	0.2%	1.4%		0.1%	1.9%
Other	0.5%								
Table Grapes	0.4%								
Groundnut	0.4%								
Industrial	0.4%								
Forestry	0.3%								
Stone Fruit	0.1%								
Avocado	0.1%					2.1%			1.0%
Banana	0.0%				0.9%				6.8%
Sweet Lupins	0.02%								
Canola	0.02%								

	South Africa	**Ghana**	**Ivory Coast**	**Zambia**	**Kenya**	**Zim.**	**Malawi**	**Ethiopia**	**Tanzania**
Sunflower	0.02%								
Tomatoes	0.02%	3.2%	18.3%	1.3%	0.2%				
Sub-Tropical	0.01%	2.1%	4.4%	0.1%				1.0%	5.1%
Dry Beans	0.01%								
Tobacco	0.01%					22.6%			
Pineapple	0.004%								
Capsicums		0.8%	3.3%			0.4%		0.2%	
Carrots									
Rice		36.0%	48.3%		28.7%	15.9%		2.0%	1.0%
Coffee		0.1%	15.8%		25.5%	11.9%		11.3%	30.3%
Non-Crop									2.0%
Tea									9.8%

Source: Demeter Dynamics, 2022

While Zambia is a significant maize and soybean producer in Southern Africa, genetically modified crops are not approved for cultivation, and glyphosate is only used for pre-plant weed removal. Glyphosate is relatively more important in Kenya, with glyphosate making up 41% of herbicides applied in 2020, mainly in producing maize, wheat, rice and coffee. In Malawi, glyphosate is primarily used in the production of maize, and in Ethiopia, glyphosate is important in the production of maize, wheat and barley. In Tanzania, 38% of the herbicide volume sold is glyphosate, and producers use it mainly in producing maize, wheat, tea and coffee.

2. Study objectives and methodology

2.1. Study objectives

This study explored the importance of glyphosate-based pesticide products on essential staple commodities, i.e., maize, wheat, and rice in Kenya. Consumption of these commodities is critical for food security and livelihoods. However, the production environment necessitates using plant protection products to minimise damage and losses due to pests. As part of the study, the drivers of herbicide use were explored to understand the impacts of usage or non-usage, available products and their effectiveness, substitutes for glyphosate-based products, and patterns of use – specifically whether safety and disposal protocols are followed. Additionally, the study estimated the potential implications for maize, rice, and wheat production in a scenario where glyphosate-based products are not available.

2.2. Methodology

A mixed-methods approach was used to investigate the factors influencing glyphosate-based product use and impact and determine the implications for rice, maize, and wheat production if glyphosate-based products were withdrawn from the market. A mixed-methods design provides several advantages for addressing such complex research problems. First, it integrates the philosophical frameworks of post-positivism and interpretivism, thereby combining qualitative and quantitative data to explain research issues meaningfully (Molina-Azorin & Fetters, 2016). Second, they provide a logical basis, methodological flexibility, and a deep understanding of more minor cases (Maxwell, 2016). In essence, using mixed methods allows researchers to answer research questions with both sufficient depth and breadth (Enosh, et al., 2015).

In implementing this approach, the following activities were undertaken to collect data:

Desk Review: A content analysis of available literature was conducted, examining the role of agricultural production in Kenya's economy, the policy and regulatory framework governing pesticide use, and trends in pesticide and herbicide use.

Focus Group Discussions (FGDs): Fourteen FGDs were held with farmers cultivating maize, wheat, and rice, covering small, medium, and large-scale operations. Twelve FGDs focused on the maize and wheat value chains, and two focused on the rice value chain. The participants in the FGDs were carefully selected to ensure inclusion of women and young people; technical experts such as county extension officers; and other value chain actors such as agro-dealers.

Participants in FGDs were expected to incorporate the scale of production and inclusivity considerations explained earlier. Farmers' varying size in the maize, rice, and wheat value chains affect their capabilities and herbicide use levels. A purposive approach was deployed to select participants for these focus groups. This was done in stages. First, the location of the FGDs was identified based on their importance in production. For example, Uasin Gishu, Trans-Nzoia, and Bungoma counties were chosen for the maize value chain. Uasin Gishu, Trans-Nzoia Counties included small and large farmers, while Bungoma only had small-scale farmers. Table 1 shows the distribution of FGD participants by production scale by county and commodity. A total of 163 participants participated through FGDs in the eight counties.

Table 3: FGD participants

	Large/Medium scale		Small scale		
	Maize	**Wheat**	**Maize**	**Rice**	**Wheat**
Nakuru	-	12	-	-	12
Narok	-	9	-	-	12
Meru	-	6	-	-	9
Kisumu	-	-	-	15	-
Kirinyaga	-	-	-	11	-
Bungoma	-	-	15	-	-
Uasin Gishu	15	-	16	-	-
Trans-Nzoia	14	-	17	-	-
Total	**29**	**27**	**48**	**26**	**33**

3. Overview of Kenyan Agriculture and the relevance of maize, wheat and rice

The agricultural sector is the cornerstone of the Kenyan economy, offering significant room for growth and transformation. It directly contributes approximately 21% to the total GDP and indirectly contributes through other sectors like manufacturing, wholesale, retail, and services (KNBS, 2024). The sector employs over 40% of the population, covering both formal and informal employment, and supports about 70% of the rural populace. Agricultural products are essential for revenue generation and foreign exchange, with key exports including horticultural products, food crops, tea and coffee (GOK, 2019). Food crops like maize, rice, and wheat are crucial for ensuring national food security. Figure 8 illustrates the different subsectors' contribution to Kenya's GDP (KNBS, 2023).

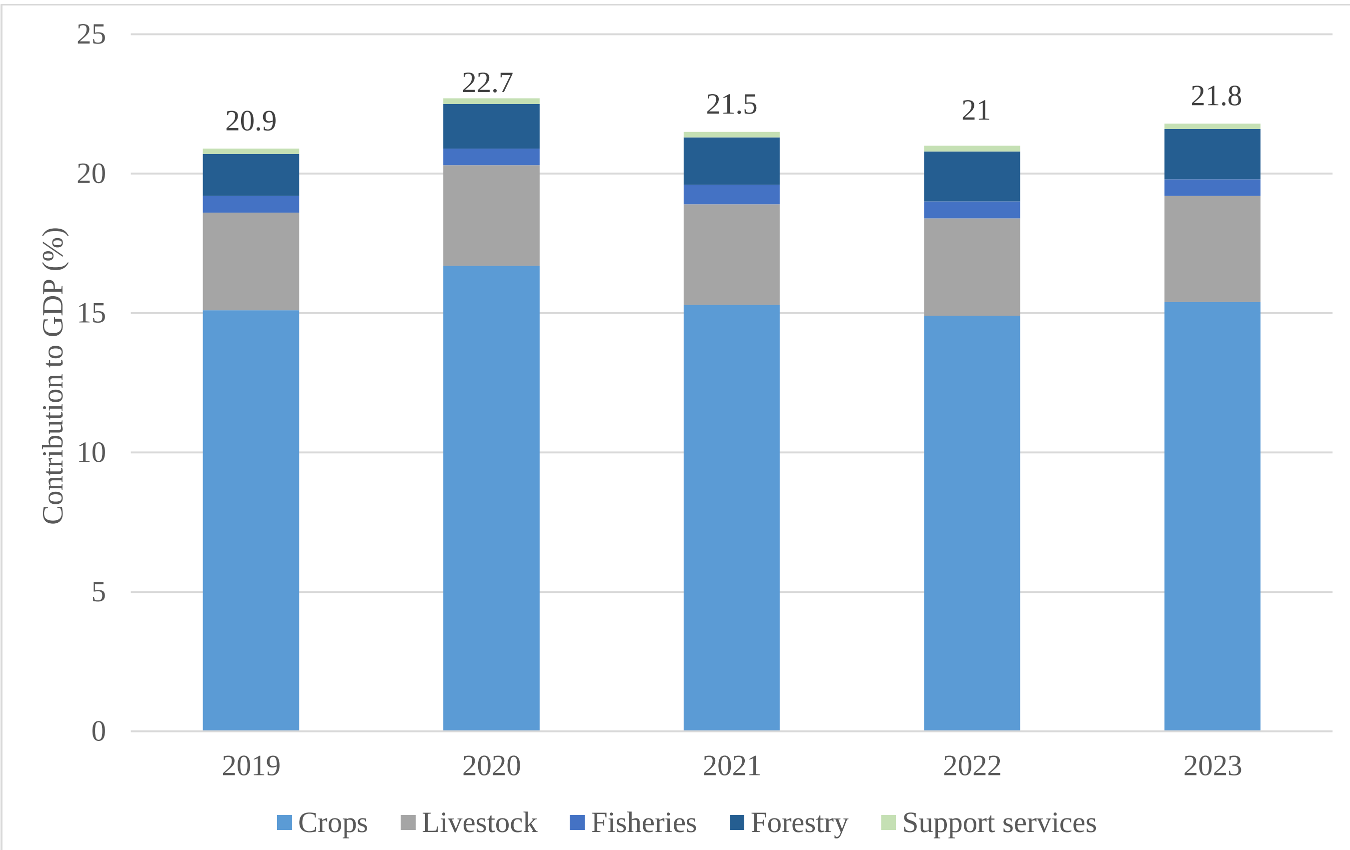

Figure 8: Contribution of agricultural subsectors to GDP 2019-2023
Source: Authors' computation using data from KNBS (2024)

Agriculture stands out as the most viable option for achieving greater food self-sufficiency, ensuring food security, improving nutrition, increasing foreign exchange earnings, and generating more income and employment opportunities (Kalaitzandonakes, et al., 2015). While crop production has been a critical contributor to Kenya's economic growth and has helped meet the food demands of its expanding population, the sector has encountered several challenges.

Approximately 10,000 species of insects and 30,000 species of weeds have a detrimental impact on crop production (GOK, 2022).

Maize is Kenya's most crucial staple cereal and a symbol of food security. Figure 9 shows the trends in maize production and net exports. On average, Kenya imports about 10% of the current consumption. Production is highly volatile due to climate-related factors such as irregular rainfall, rising temperatures, drought, and other related events, despite the country meeting much of the demand from local production. This volatility significantly affects the dietary patterns of many Kenyans, especially vulnerable and marginalised groups, given maize's critical role in their diet. Recognising maize's importance for food security, the government prioritises measures and interventions to ensure a stable supply of this essential commodity (Kirimi, et al., 2018).

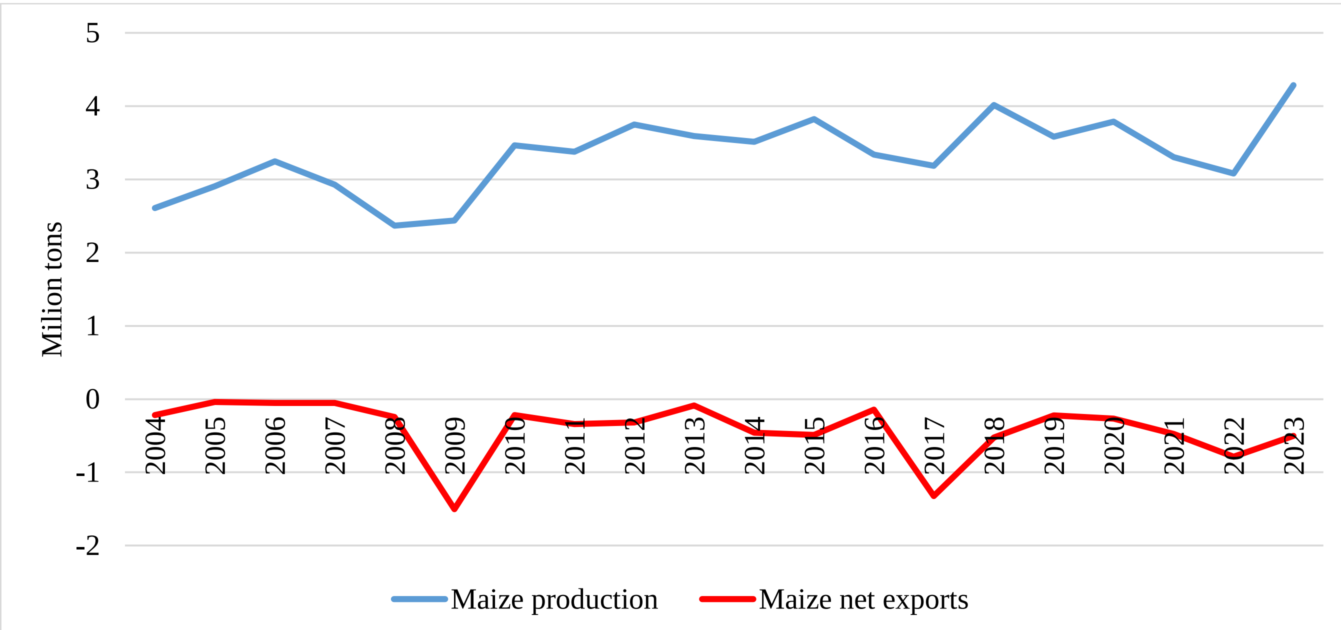

Figure 9: Trends in maize production and net exports
Source: FAO & Trademap, 2025

Wheat is the second most crucial cereal commodity in terms of overall consumption. Figure 10 shows the production and net export trends. Over the past decade, the country has increasingly relied on imports to meet local demand, with local production revolving around 300,000 tons per annum. By 2023, local production would only meet 15% of the total demand. Several challenges affect wheat production in Kenya. These include pests and diseases such as stem rust, blotch, and head smut; post-harvest losses; and effective weed management. Additionally, considerable price volatility creates disincentives for farmers.

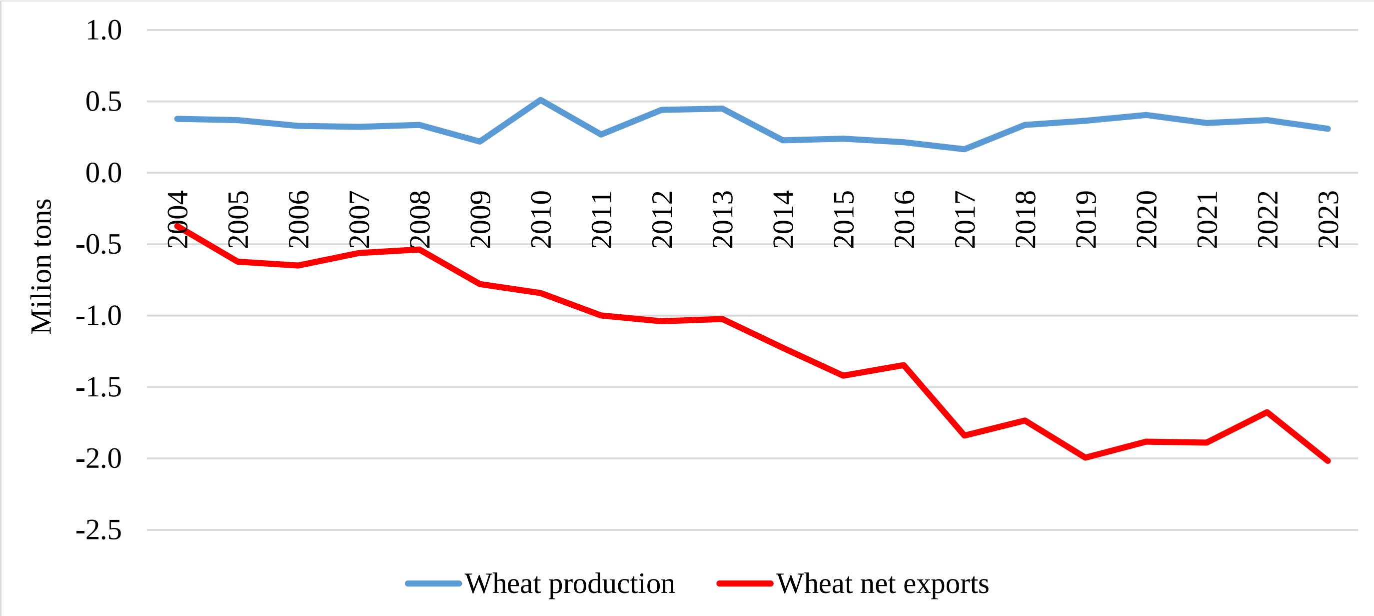

Figure 10: Trends in wheat production and net exports
Source: FAO & Trademap, 2025

Rice is the fastest-growing staple commodity in terms of per capita consumption and constitutes a significant portion of urban dwellers' diets (Matthew & Gitonga, 2024). In recent years, there has been a surge in rice consumption due to evolving consumption trends within the country, highlighting a widening disparity between production and consumption. Figure 11 shows the trends in rice production and net exports. By 2023, the country's annual rice consumption was estimated at 1.2 million metric tonnes. Local production stood at 229,000 metric tonnes (about 20% of total demand). Production shortfall prompts heavy reliance on imports, with approximately 80% of total rice consumption being met through imports (Ministry of Agriculture and Livestock Development, 2018).

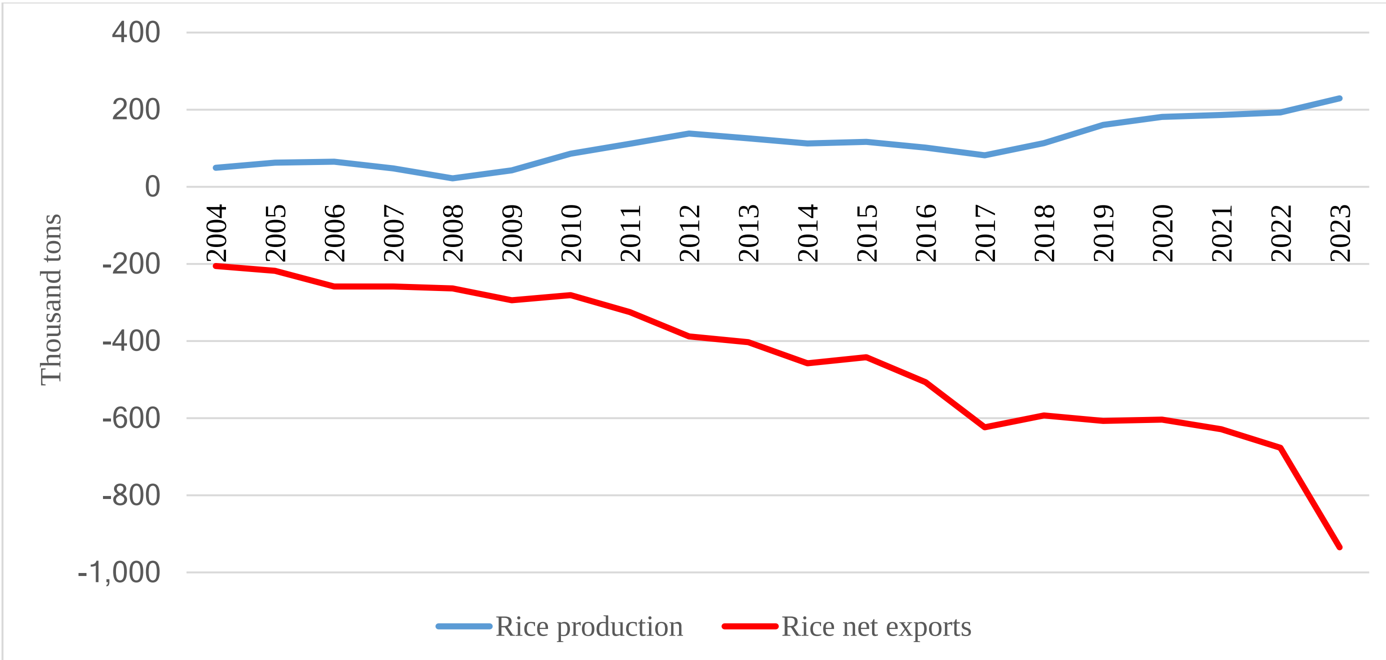

Figure 11: Trends in rice production and net exports
Source: FAO & Trademap, 2025

This study focuses primarily on these three value chains based on their relative importance to diets and herbicide use.

4. Herbicide use in Kenya

Figure 12 illustrates the herbicides used in Kenya in 2022 (kilograms active ingredient). It is important to know that Kenya experienced a severe drought that affected most parts of the country from 2021 to 2022. Though rainfall increased after the short rains of 2022, the unfavourable weather conditions likely slowed down herbicide demand (Demeter Dynamics, 2022). Glyphosate was the most commonly used active ingredient, with 45% of the herbicides containing glyphosate as an active ingredient and about one-third (34%) of herbicides using glyphosate as the sole active ingredient.

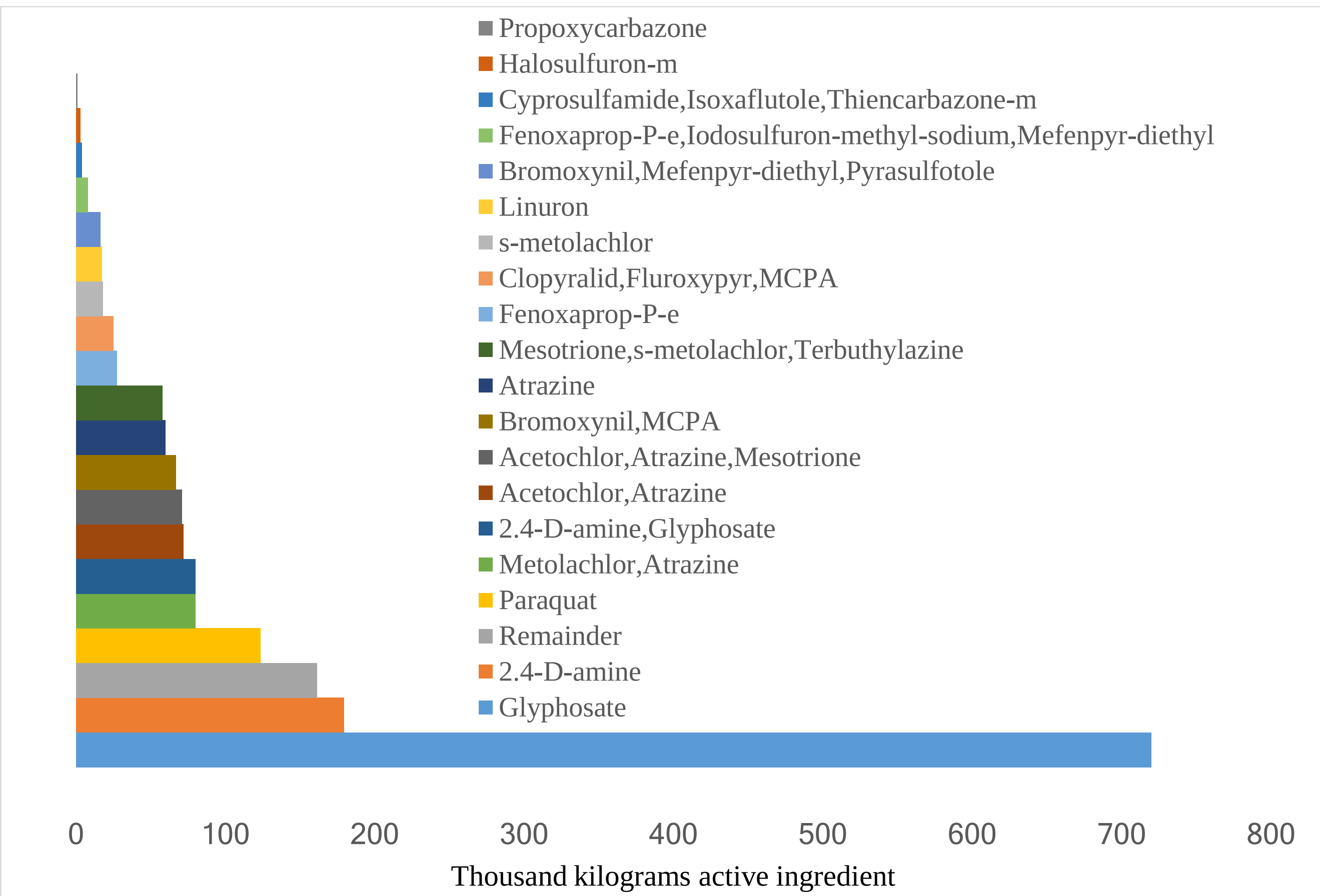

Figure 12: Herbicide use in Kenya 2022 – thousand kilograms active ingredient
Source: Demeter Dynamics (Pty), 2022

Maize and wheat are the main herbicide-using crops based on area, as shown in Figure 13. Kenya planted an estimated 119,664 hectares of wheat in 2022, which means that, on average, the total wheat area received three herbicide applications. In contrast, out of an estimated 2.22 million hectares of maize, only 344,000ha (16%) received an herbicide application. Larger farmers mainly produce wheat in an intensive production system, while maize is largely produced by small-scale farmers.

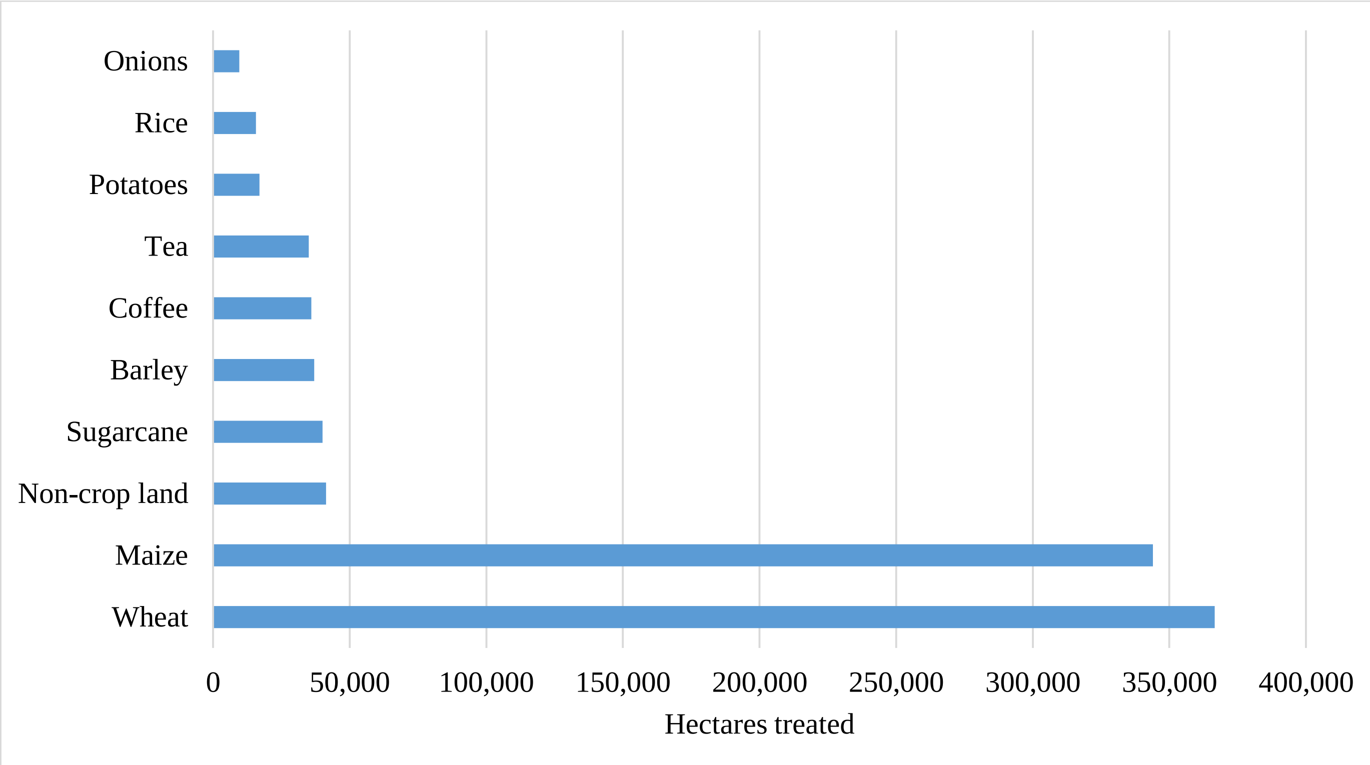

Figure 13: Hectares treated with herbicide according to crop in 2022
Source: Demeter Dynamics (Pty), 2022

The herbicide treatment area for barley is also nearly four times the planted area, with mainly large-scale farmers producing this crop. About a third of the sugarcane, coffee and rice areas are treated with herbicide, while about 16% of the tea area and 7% of the potato hectares receive a herbicide application.

5. Farmers use experience with herbicides

5.1. Weeding

Figure 14 presents farmers' perspectives regarding the benefits of weed control. Farmers unanimously acknowledged the critical importance of weed management on their farms for the three value chains. The most significant advantage identified is the attainment of high-quality grain, particularly in wheat and rice value chains. Farmers attest that crops grown in weed-free conditions yield clean, superior-quality produce, consequently enhancing market value and securing better pricing. Maize farmers noted that weeding enhances crop quality, fostering the development of robust stems that can withstand strong winds.

Moreover, farmers ranked achieving high crop yields as the second most significant advantage of weed control. Neglecting weed management in the wheat value chain could lead to yield reductions ranging from 11 to 17 percent. Similarly, rice value chain participants stressed that failure to weed fields could result in a substantial decrease in production, potentially reducing yields by about 40% of expected production and jeopardising the ratoon crop, a vital source of income. Maize farmers also observed that weed removal enhances crop yields by minimising nutrient competition between maize plants and weeds.

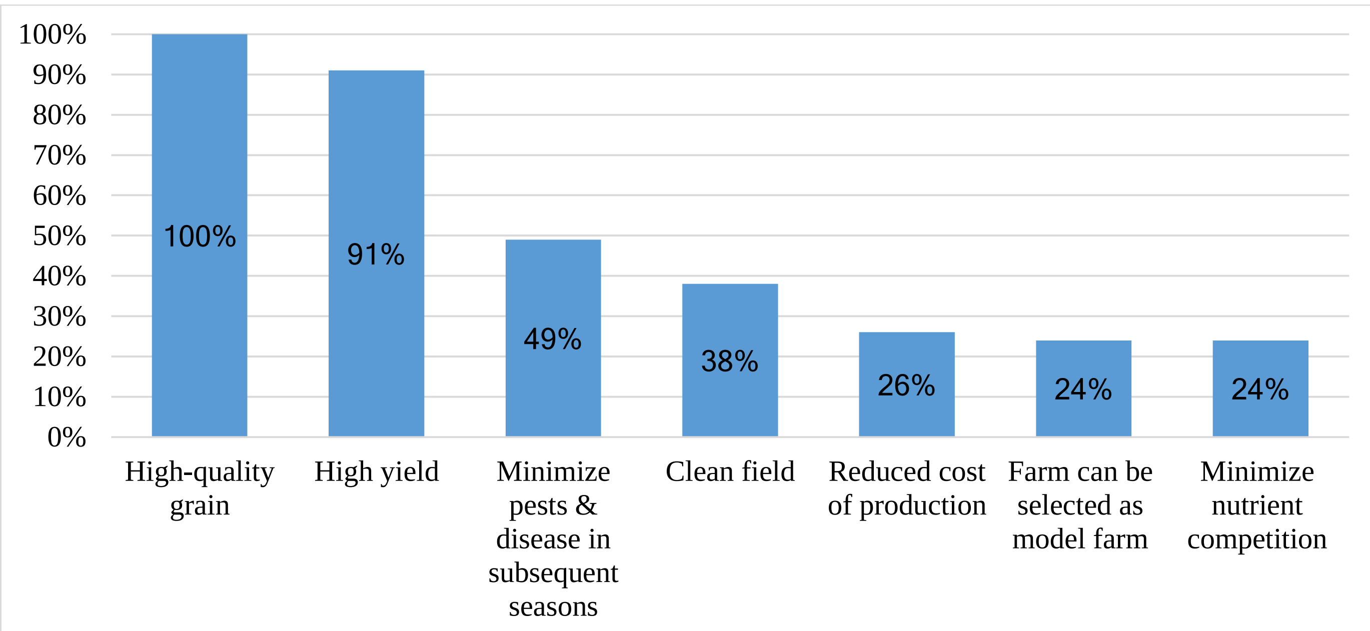

Figure 14: Benefits of weed control
Source: FGD sessions

5.2. Common glyphosate products

Farmers use herbicide products during land preparation (before ploughing) and weeding before and after planting. Most farmers (80%) reported using non-selective herbicides for land preparation for other crops, notably potatoes, vegetables, carrots, and peas.

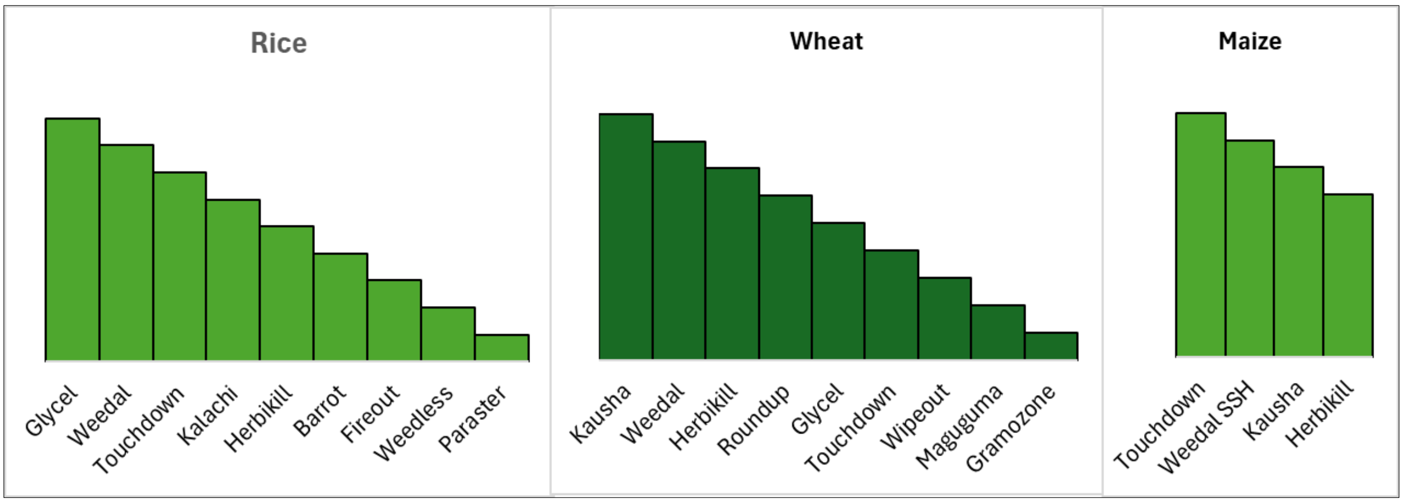

Figure 15 shows the most common non-selective herbicides, containing glyphosate as the active ingredient, used in the production of maize, wheat and rice. There are several generic glyphosate products on the market. Glycel was the most commonly used herbicide brand for rice, Kausha for wheat and Touchdown for maize. Farmers indicated that Touchdown and Roundup were the most effective non-selective herbicides, however they were the priciest, prompting farmers to opt for more affordable alternative brands. Farmers also pointed out that broad-spectrum herbicides were effective because they controlled a wide range of weeds, both grasses and broadleaf weeds.

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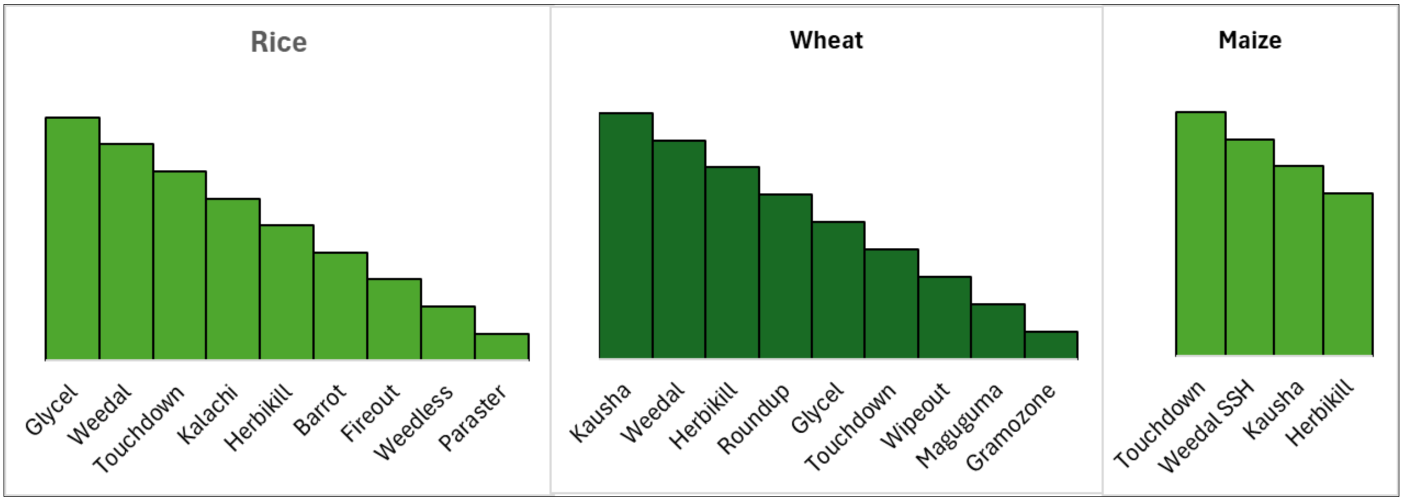


Figure 15: Commonly used non-selective herbicide products for rice, wheat and maize
Source: FGD sessions

5.3. Selective and non-selective herbicides

Figure 16 illustrates the utilisation of selective and non-selective herbicides by farmers across the three value chains. Observations revealed that all categories of wheat farmers (small, medium and large) employed both selective and non-selective herbicides. In the rice value chain, merely three per cent used selective herbicides, with the majority opting for non-selective herbicides, predominantly for post-emergence applications. About 90% of the small-scale farmers in the maize value chain used selective herbicides, as did all medium and large-scale farmers.

The agro-dealers participating in the FGDs explained that glyphosate functions as a broad-spectrum, non-persistent, post-emergent systemic herbicide and crop desiccant. According to these dealers, glyphosate-containing products are mainly purchased by farmers producing annual crops such as maize, rice, wheat, legumes, sugar crops, and horticultural plants. The use of glyphosate products is mainly driven by several agronomic factors:

- In annual cropping systems, glyphosate serves multiple purposes throughout the crop cycle. It is employed to eliminate cover crops before sowing, manage weeds pre-sowing, pre-emergence, or post-harvest, and facilitate desiccation of certain annual crops before harvest.
- Within perennial crops, glyphosate effectively controls weeds within crop rows and between them.
- In grassland management, glyphosate is utilised for terminating temporary grassland, locally eliminating perennial weeds in permanent grassland, and renewing grassland areas.

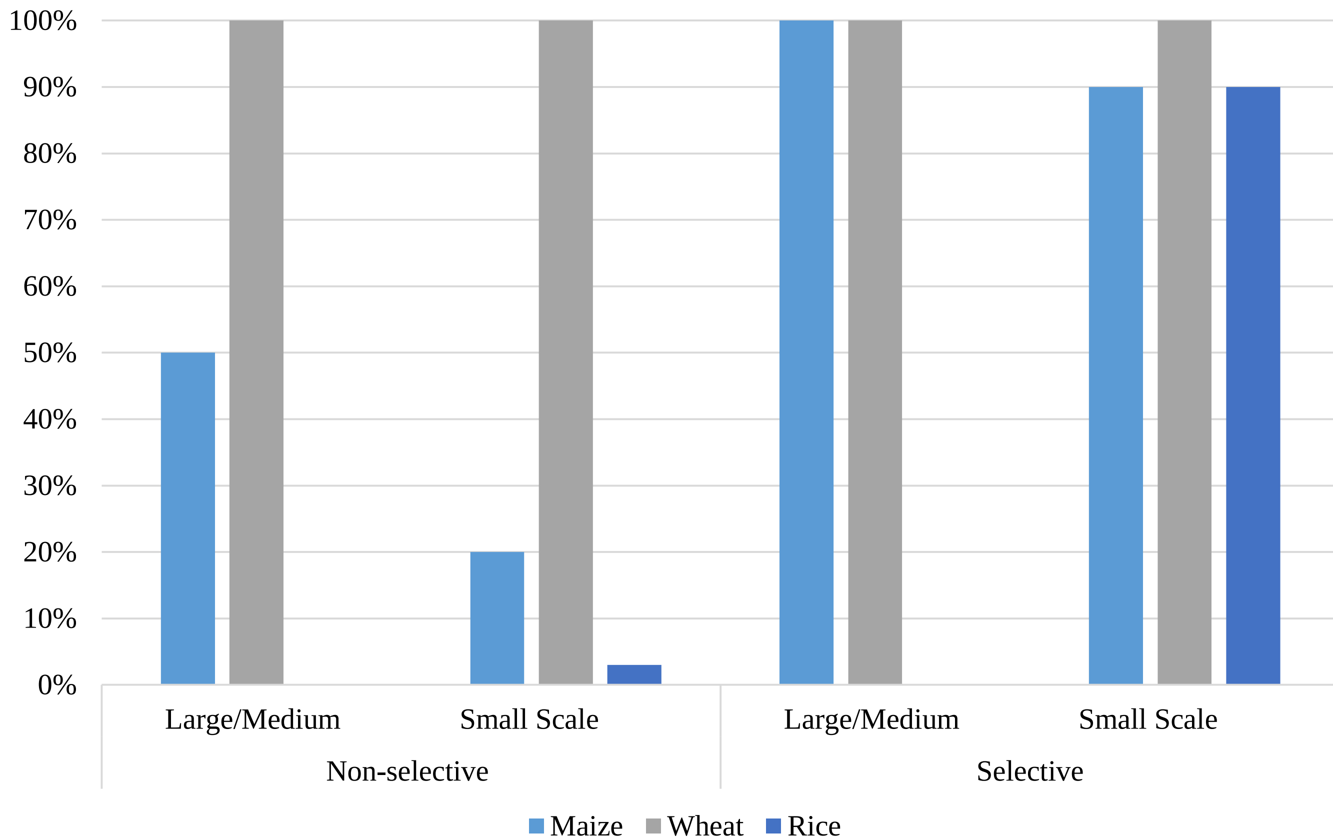


Figure 16: Use of selective and non-selective herbicides
Source: FGD sessions

5.4. Farmers' perceived benefits of glyphosate-based herbicides

The FGD participants articulated the advantages of using glyphosate-based herbicides, including minimum soil disturbance, reduction of stubborn weeds, soil carbon sequestration, and reduction in the cost of weed control. Across the three value chains, most farmers agreed that the real benefit was a reduction in production costs. Specifically, smallholder rice farmers in Kisumu reported that glyphosate-based herbicides were labour-saving and contributed to cost reduction in production. This efficiency stems from the quick application process, which takes less time compared to hand-hoeing and pulling. Farmers highlighted that they required only one person to spray one acre within an hour, in contrast to the labour-intensive process of hand-hoeing weeds, which required six people for two days per acre.

The second most widely recognised benefit of glyphosate herbicides was their efficacy in eradicating stubborn weeds on farms. Farmers in the rice value chain observed that these herbicides were particularly effective in eliminating persistent weeds, especially in paddy farms situated far from the main canal and susceptible to various weed species.

The third significant benefit was their role in minimising soil disturbance. Both small-scale and large-scale farmers noted that herbicides facilitated the adoption of conservation agriculture practices, particularly minimum tillage. Additionally, farmers observed a reduction in weed growth when employing crop rotation alongside herbicide application.

5.5. Herbicide information sources

Figure 17 presents a weighted ranking of farmers' primary sources of information regarding herbicides across the three value chains. Agro dealers emerged as the most common source of information, followed by agronomists representing agrochemical corporations, extension officers and lastly, lead farmers. This scenario creates a conflict of interest where agro-dealers and company-based extension agents are likely to be biased in their recommendations to farmers. A key challenge is the collapse of the public extension system, which is now the responsibility of county governments. Public extension agents are seen to be unbiased because their recommendations do not favour specific companies or products.

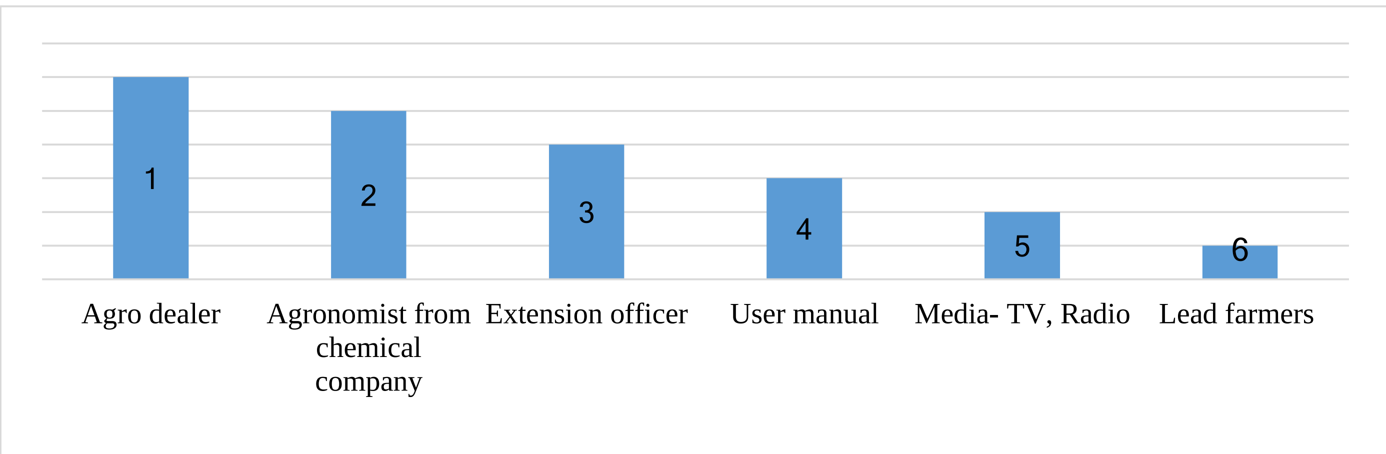


Figure 17: Main sources of Information on herbicides
Source: FGD sessions

5.6. Safe use of herbicides

Figure 18 illustrates the responses from FGD participants regarding the safe use of herbicides. All farmers reported purchasing only the exact quantities of pesticides they needed and avoided bulk purchases. Farmers who were unsure of the required quantities often sought advice from agro-dealers. According to the Kenyan Pest Control Products Board (2022), only 40% of Kenyan farmers read instruction labels on pesticide containers. This can largely be attributed to education levels with Wahome et al., (2024) reporting ‘no formal education’ for 25% of farmers and 34% of farmers only reaching primary school level’. A consistent safety practice across all FGDs was the careful packaging and transportation of pesticides. Farmers ensured pesticides were sealed, packaged, and transported in separate bags from food items. Agro-dealers played a crucial role in ensuring this practice by safely wrapping pesticides for farmers. Safe storage of agrochemicals was also widely observed. Most farmers had designated storage areas to keep remaining agrochemicals out of reach of animals and children. Special mixing containers were also used, although some farmers admitted to mixing in the spraying can. However, the use of protective equipment during spraying was not consistently observed, particularly by contracted service providers.

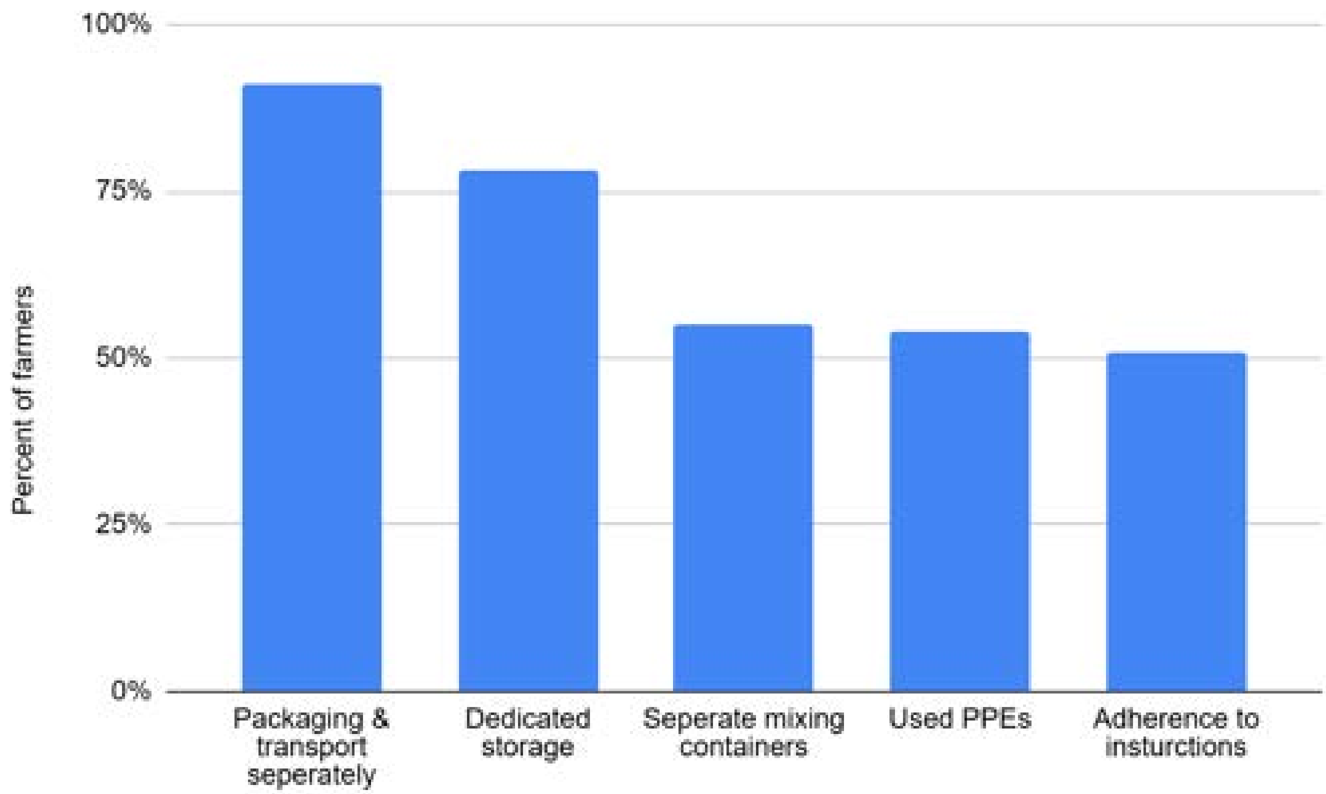


Figure 18: Safe use practices adopted by farmers
Source: FGD sessions

Poor pesticide safety practices in developing countries stem from various factors, including limited knowledge of the safe use and disposal of pesticides, illiteracy, lack of applicable personal protection equipment, a shortage of qualified agricultural extension workers, deficient farming infrastructure and regulation (Onyando et al., 2023). Recognising these challenges, there is a need to improve the capacity of extension workers and farm workers. Such training will minimise pesticide exposure and promote adherence to labelling and packaging instructions (Habib, 2020).

Notably, from the study, large-scale commercial wheat farmers used tractors for pesticide application, presenting lower occupational exposure risks than small-scale farming operations involving knapsacks or hand sprayers.

5.7. Disposal of containers

The common methods farmers use to dispose of agrochemicals are presented in Figure 19, the most prevalent being to leave the containers next to the field to decompose. As most containers are plastics, this is not a good practice. About 54% of farmers recycle containers (an industry initiative), but this is common practice only for containers larger than five litres. Burning and dumping containers in pits were the least utilised disposal methods. It is thus clear that most farmers do not safely dispose of containers after use, and there is a dire need for information and communication on the safe disposal of pesticide containers. Furthermore, industry practices such as collecting pesticide containers for recycling need to be upscaled to smallholders with smaller containers.

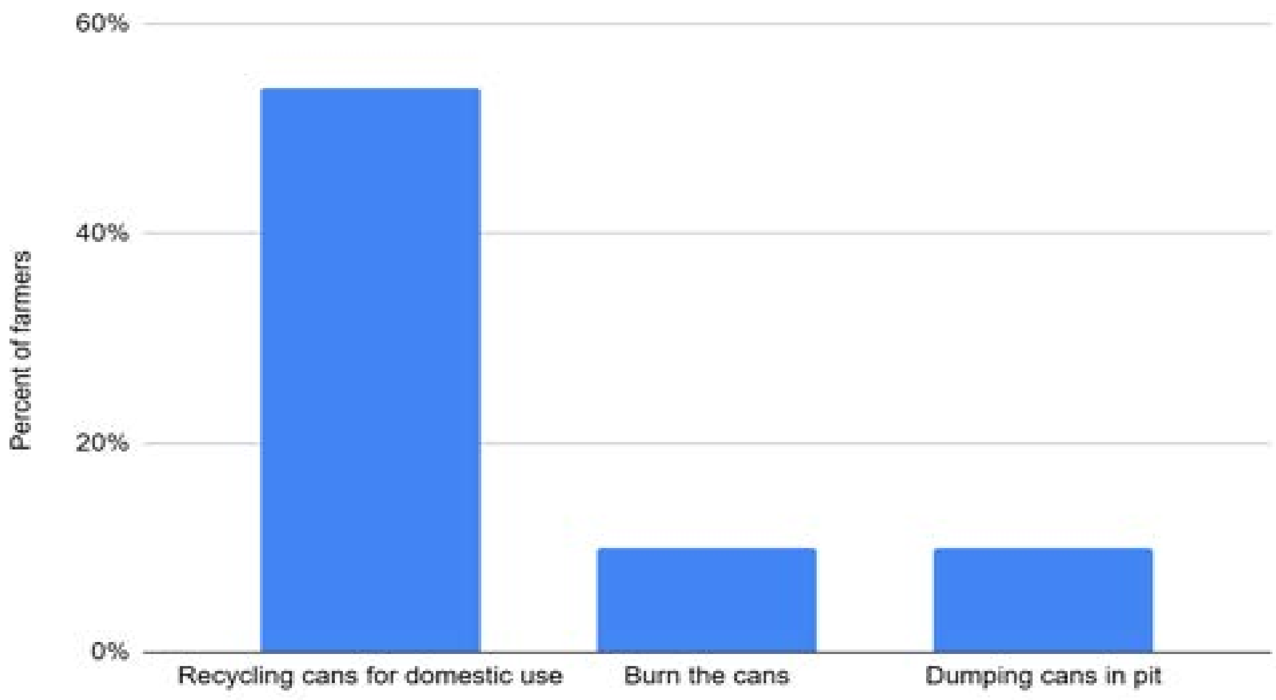


Figure 19: Methods of disposing of pesticide containers
Source: FGD sessions

5.8. Information on safe use

Figure 20 shows the ranking of primary sources of information on the safe use of herbicides. Farmers identified agro-dealers as the most common source of information on the safe use of herbicides. Farmer-to-farmer knowledge exchange, instruction manuals, and pesticide companies were ranked second, third, and fourth, respectively. Farmers ranked traditional media, particularly radio, as the least utilised source of information on the safe use of herbicides.

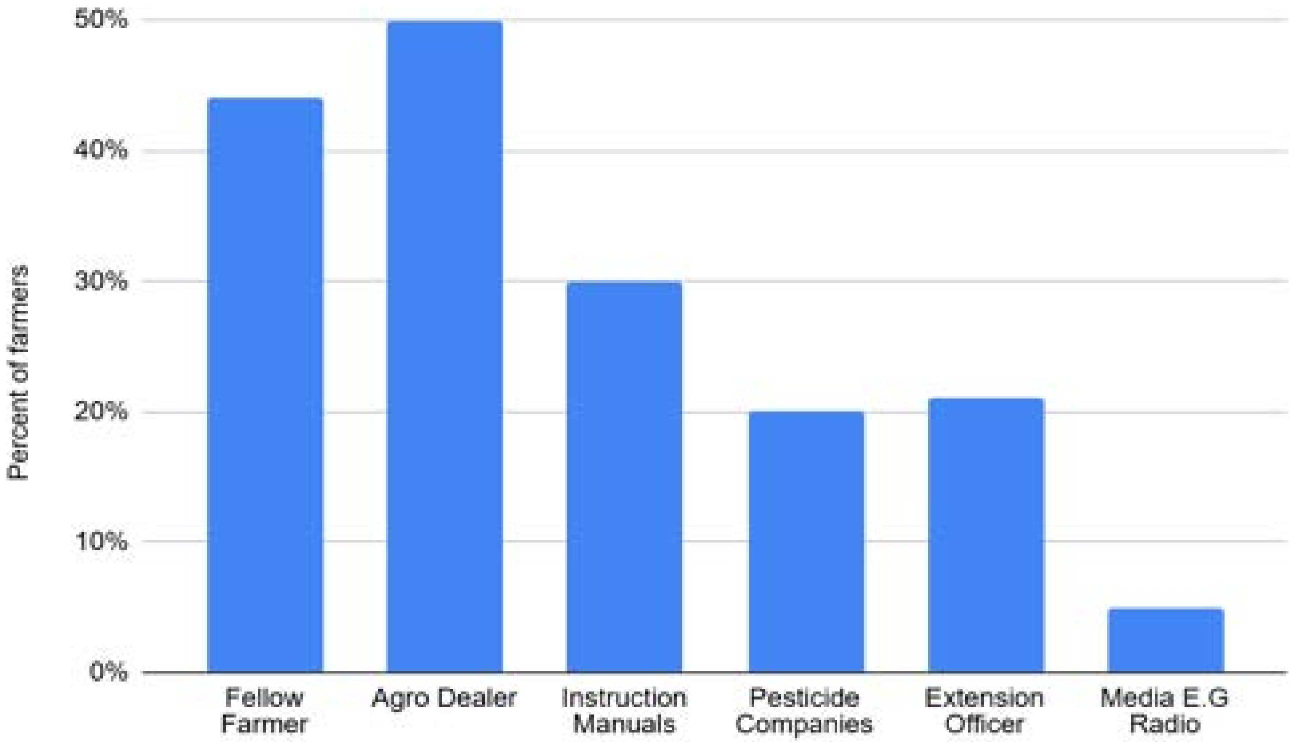


Figure 20: Sources of information on safe herbicide use
Source: FGD sessions

5.9. Main concerns about herbicides

Figure 21 illustrates farmers' perceptions of the adverse effects of pesticide use. Across all value chains, all farmers expressed concern regarding the harmful nature of pesticides, recognising the fact that these chemicals can pose risks to human health if mishandled. Although farmers are not required to conduct residue tests for maize, wheat and rice, they were concerned about pesticide residues in other crops, such as vegetables and pasture, which could affect human health upon direct or indirect consumption.

Farmers were also worried about overdosing (i.e., applying more than the prescribed rate on the label). They noted that it was common to use incorrect dosage measurements, especially when dealing with stubborn weeds. Most farmers are aware of the correct dosage, but some prefer to use higher concentrations to 'enhance the chemical's effectiveness', inadvertently wasting chemicals and risking damage to animal and human health.

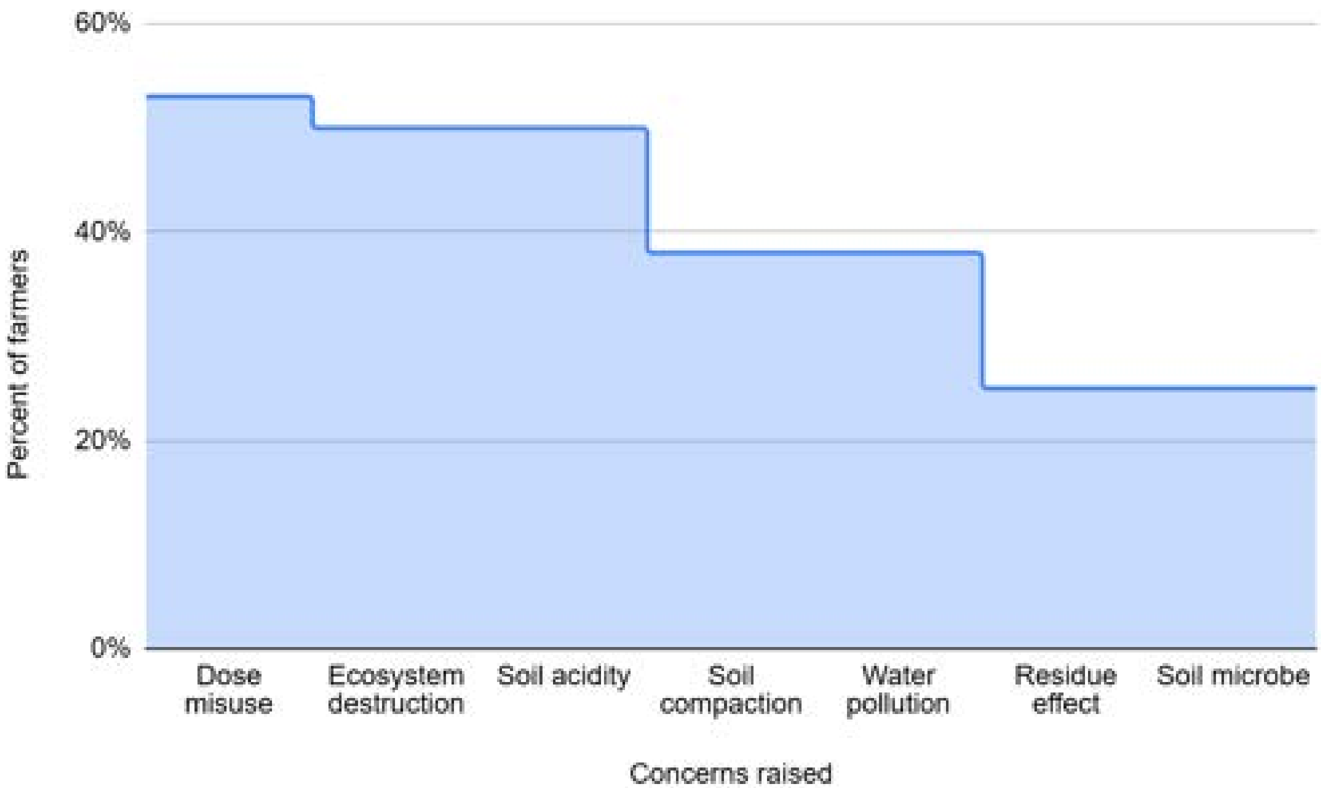


Figure 21: Concerns about the adverse effects of herbicide usage
Source: FGD sessions

Farmers also noted that herbicides could have adverse effects on the ecosystem, such as water pollution, which negatively impacts the quality of drinking water. Farmers also mentioned concerns about the effects of herbicide use on soil quality. In Narok, wheat farmers pointed out that those unaware of the appropriate timing for herbicide application experienced issues with soil compaction during mechanical herbicide application.

5.10. Economic benefits of glyphosate

5.10.1. Rice production

Figure 22 indicates the most commonly used active ingredients in herbicides used in rice production in Kenya. Herbicides containing 2.4-D were the most common for rice. These pesticides are selective post-emergence herbicides mainly used to control broad-leaf weeds. Glyphosate products were the second most commonly used herbicides and are used for pre-plant weed burndown after seedbed preparation.

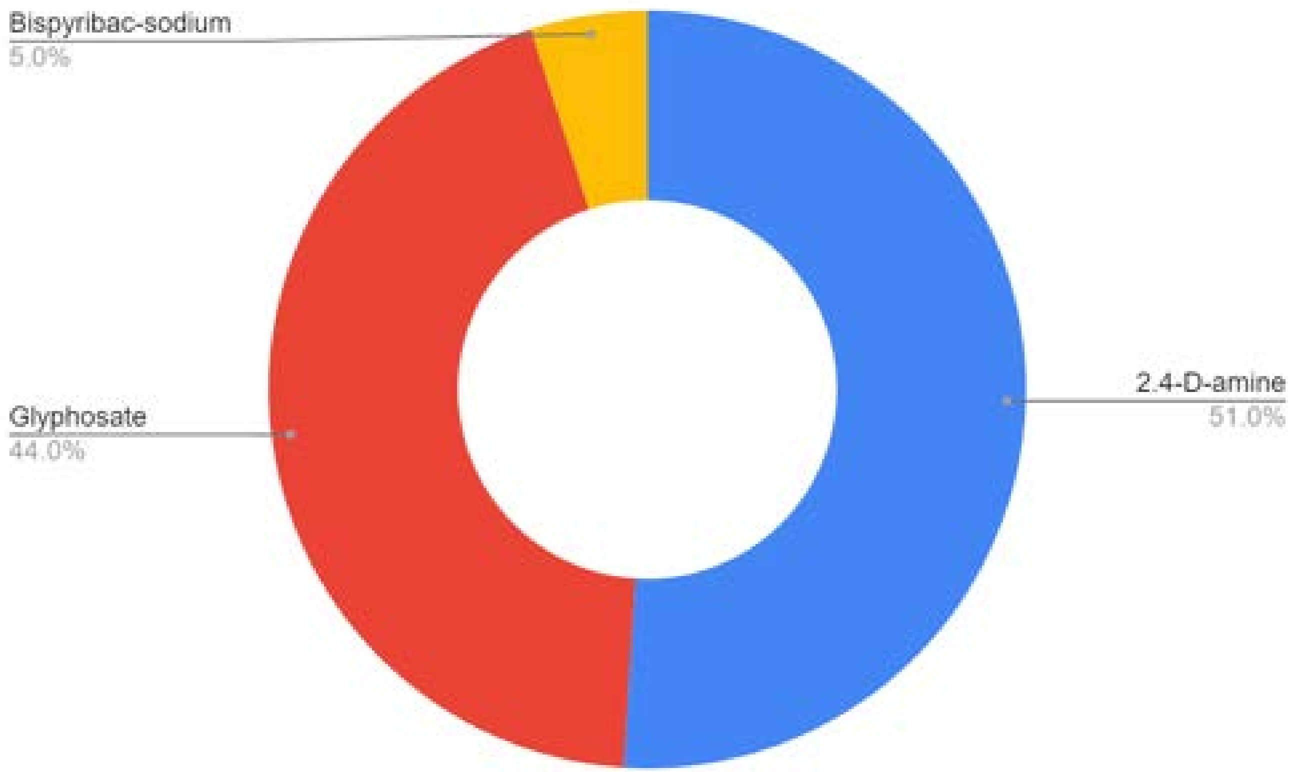


Figure 22: Active ingredients used on rice in 2022
Source: Demeter Dynamics (Pty), 2022

Figure 23 presents the cost breakdown of rice production in 2023 collected from FGD participants, comparing farmers using herbicides with those who do not. The total direct cost of production was 11% lower for farmers using herbicides than non-herbicide users. For herbicide users, the cost of herbicides was 4% of the cost of production. In contrast, non-herbicide users' labour costs were substantially higher as they relied on manual labour for weed control.

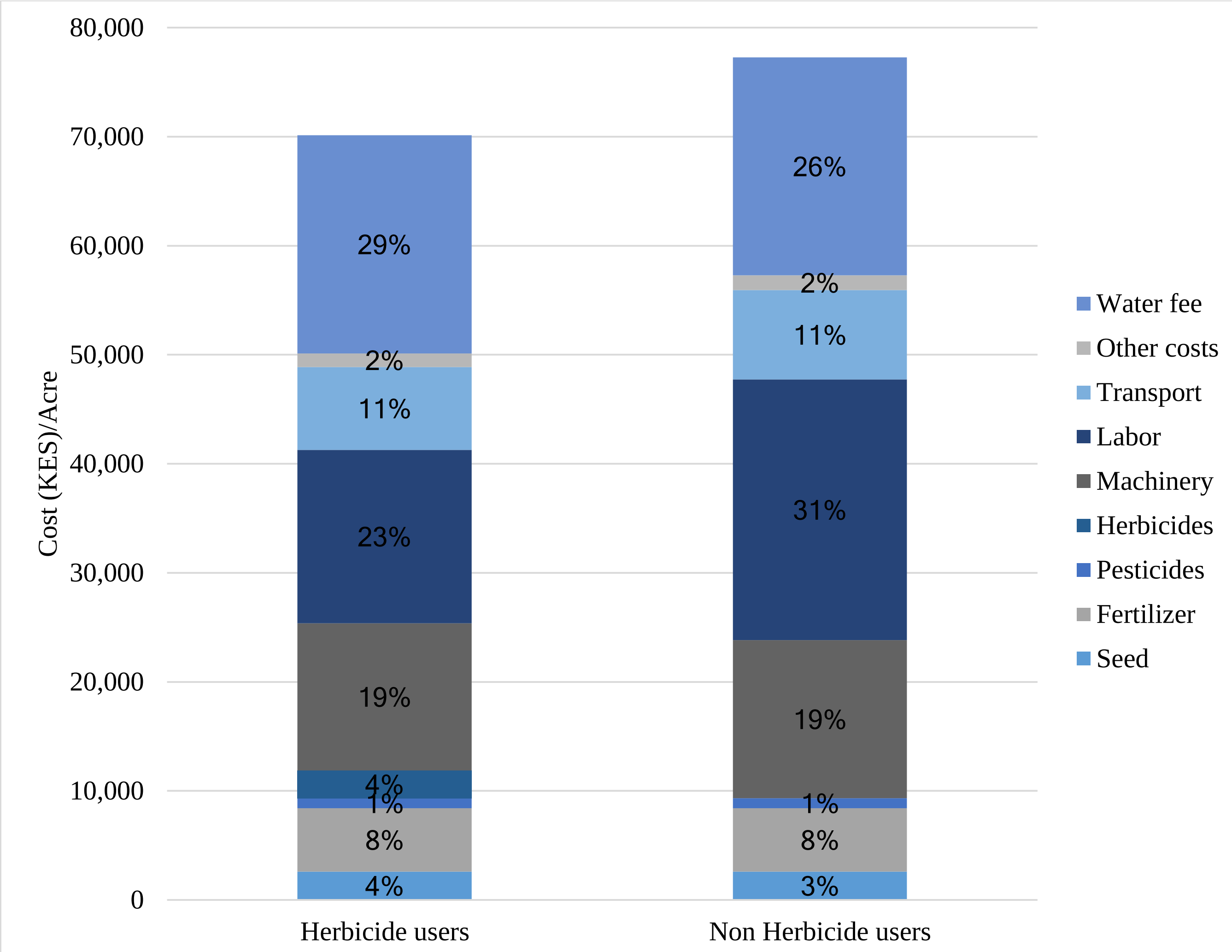


Figure 23: Cost of production comparison for rice farmers
Source: FGD sessions

Glyphosate-based herbicides were mainly used during land preparation and those depending on labour for weed control needed several rounds of weeding that started from land preparation. Figure 24 presents a disaggregated view of labour expenditure for the different activities undertaken in rice production. The total costs for labour per acre were KES 15,900 for herbicide users and KES 23,900 for non-herbicide users. Planting, followed by bird scaring, were the activities that accounted for the highest proportion of labour costs. Non-herbicide users incurred significantly higher costs for weeding (KES 4,800) compared to herbicide users (KES 300). Also, non-herbicide users had higher costs for land preparation because this included weeding which was undertaken using labour. (See comparison numbers in annex)

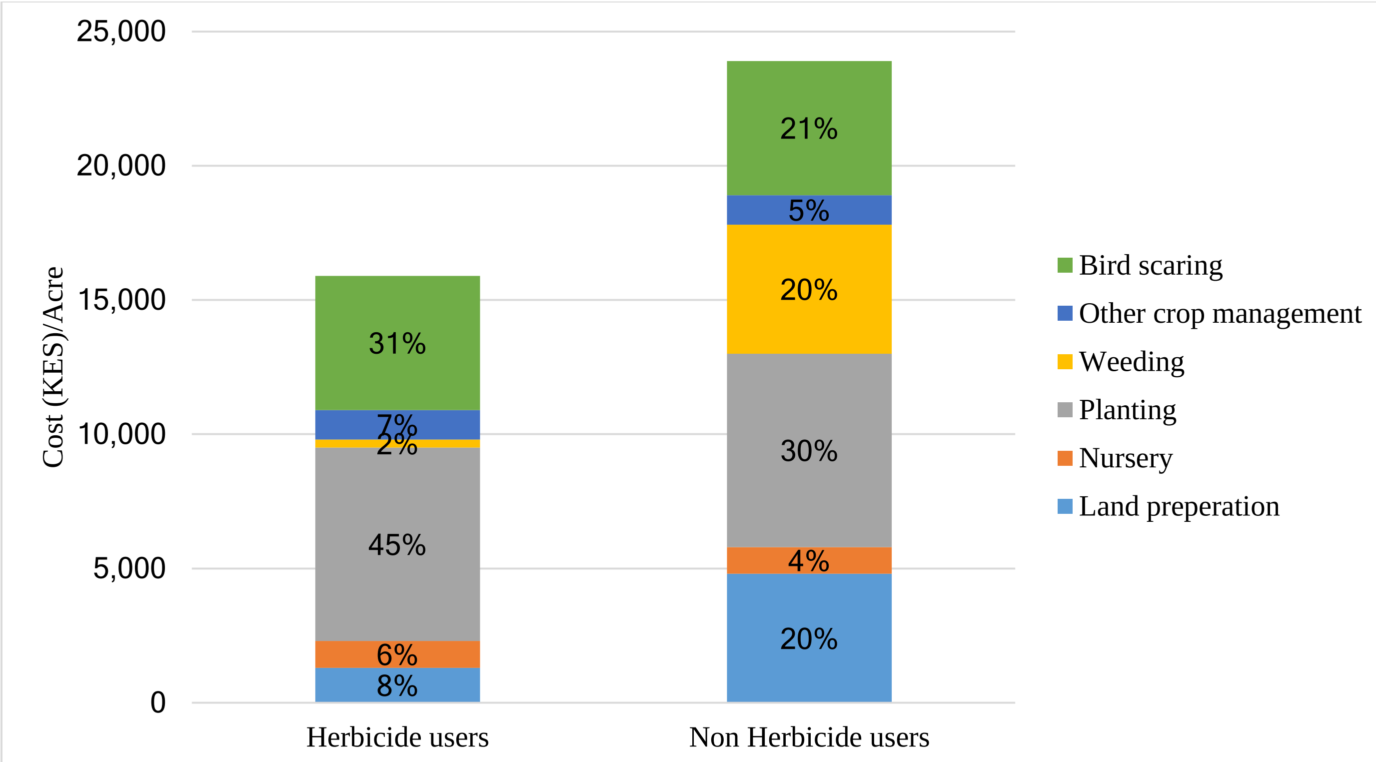


Figure 24: Disaggregation of labour costs per acre for rice production
Source: FGD sessions

5.10.2. Maize production

Figure 25 summarises the most common herbicides by active ingredient used for maize cultivation in 2022. Glyphosate-based herbicides were the most common, followed by Paraquat and 2,4-D-amine. Similar to rice, glyphosate is used in the production of maize as pre-plant chemical burndown. While Paraquat is also used for pre-plant weed control, it is mainly used in post-emergence inter-row weed control. Because maize plants relatively quickly reach a height where full cover herbicide application is difficult, it is common for farmers to use herbicides with residual action. The 2,4-D, and Bromoxynil/MCPA mix are mainly used as post-emergence broadleaf control products. It is common practice to use a product with two or more active ingredients for improved control of grass and broadleaf weeds. For example, Atrazine is for broad leaves and Metolachlor, Acetochlor, and s-Metolachlor are better known for their effectiveness on grass weeds and some broad-leaf weeds. The above mentioned four products have a residual action and must be sprayed pre-weed emergence or very soon after that.

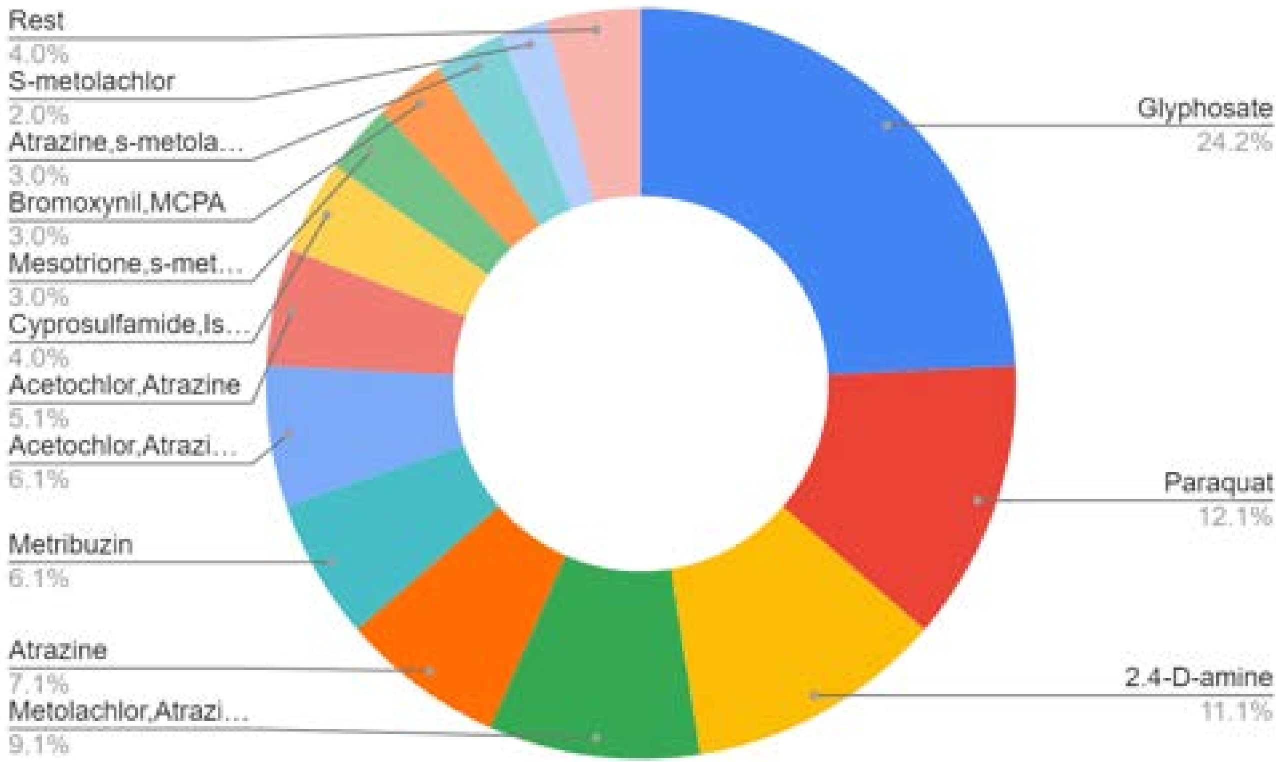


Figure 25: Active ingredients used on maize in 2022
Source: Demeter Dynamics (Pty), 2022

Figure 26 compares maize production costs for smallholder maize farmers using herbicides with farmers who do not. The average cost of production for herbicide users was KES 49,705. This ranged from KES 46,405 to KES 50,330 based on the different combinations of herbicides used by smallholder farmers. Medium and large-scale farmers all used herbicides, and their costs per acre averaged KES 46,210. Non-herbicide users' production costs averaged KES 53,480 per acre.

Studies indicate that performing at least two carefully timed hand-weeding rounds within the initial six weeks after planting offers efficient weed control and reduces yield losses in maize (Imoloame, 2021). Nonetheless, challenges such as a declining labour force, high labour costs and the laborious nature of hand weeding have made this approach less practical and affordable, thus making the use of herbicides more appealing.

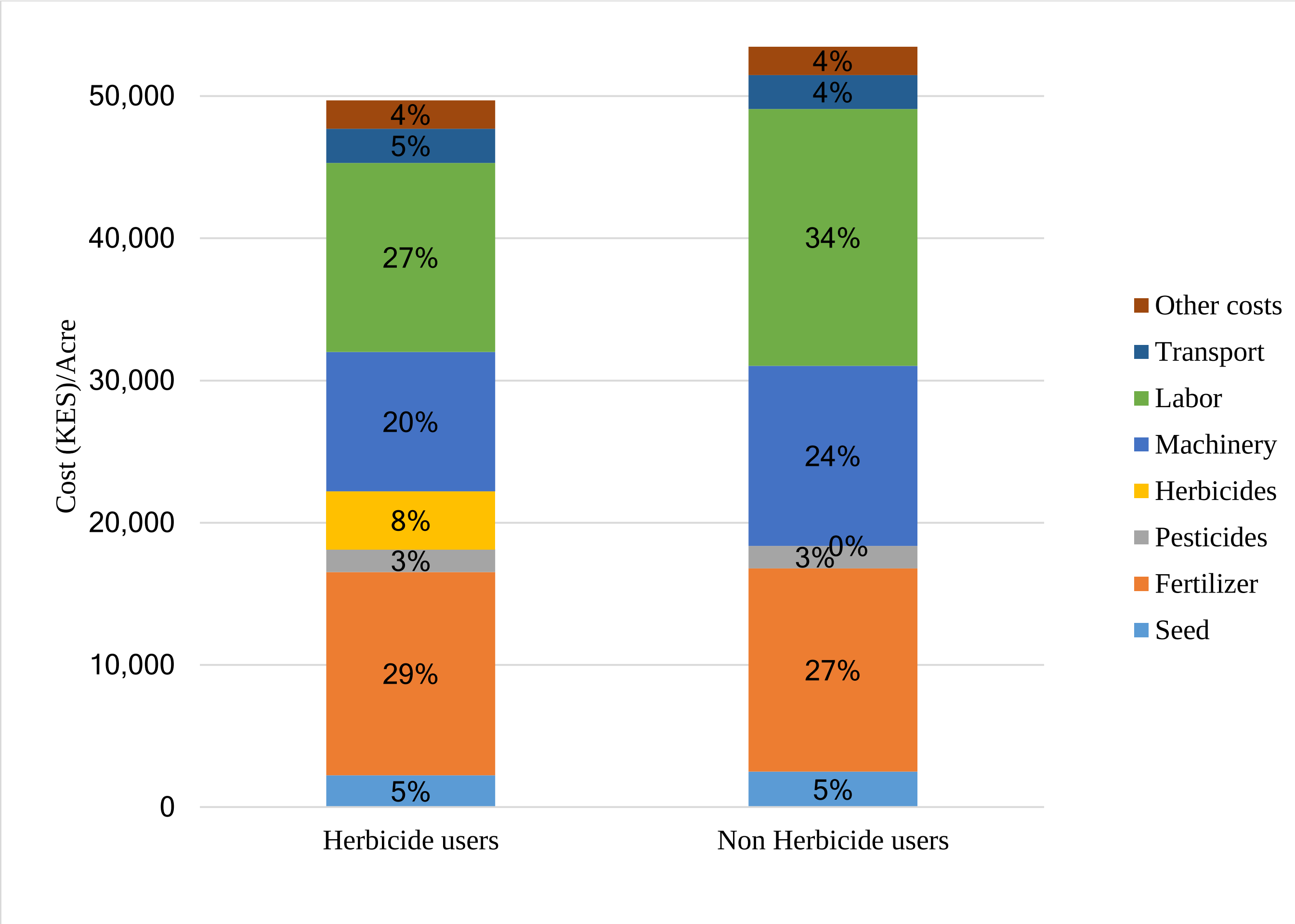
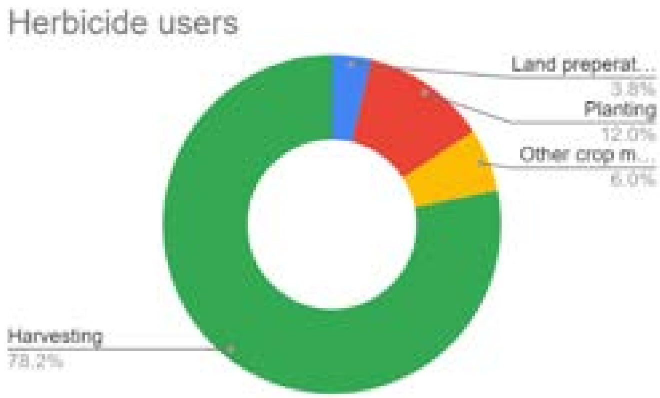


Figure 26: Cost of production comparison for maize farmers
Source: FGD sessions

Expenditure on labour differed between farmers who use herbicides and those who do not (Figure 27). Herbicide users have lower labour costs than non-herbicide users due to savings during land preparation and planting. Among maize farmers, harvesting requires the most labour.



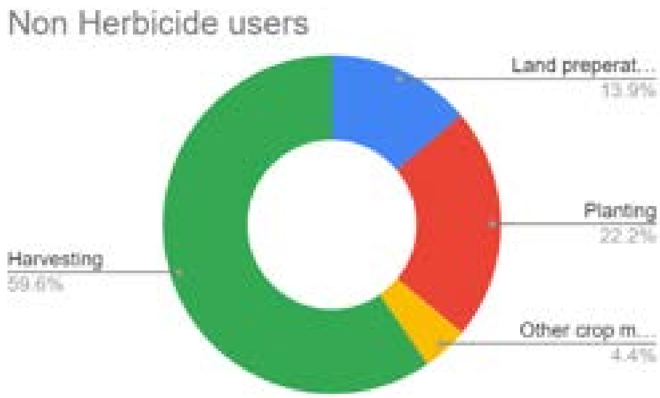


Figure 27: Labour cost by activity and herbicide use for maize farmers
Source: FGD sessions

5.10.3. Wheat production

Both small and large-scale farmers fully mechanise wheat farming in Kenya. We found that all wheat farmers use herbicides. Figure 28 presents the active ingredients used in herbicides for wheat production in 2022. Glyphosate and Halosulfuron were the most commonly used active ingredients. It's important to note that different herbicides are applied at various stages of the plant cycle. For example, all glyphosate applications are used as pre-plant burndown. Most grass weed control must be done pre-emergence, except for Fenoxaprop and Pinoxaden. Propoxycarbazone and Chlorsulfuron are applied pre-emergence for grass weeds, although Chlorsulfuron can also control broadleaf weeds. The remaining active ingredients listed in Figure 24 are all post-emergence broadleaf weed killers. While controlling broadleaf weeds in a grass crop like wheat is relatively easy, managing grass weeds in a grass crop is much more challenging. Due to the requirement of pre-plant burndown, pre-emergence grass control, and post-emergence broad leaf and grass control, it is understandable that the average number of herbicide applications on wheat fields in Kenya is three times, making wheat the biggest herbicide user in Kenya despite the relatively small area planted.

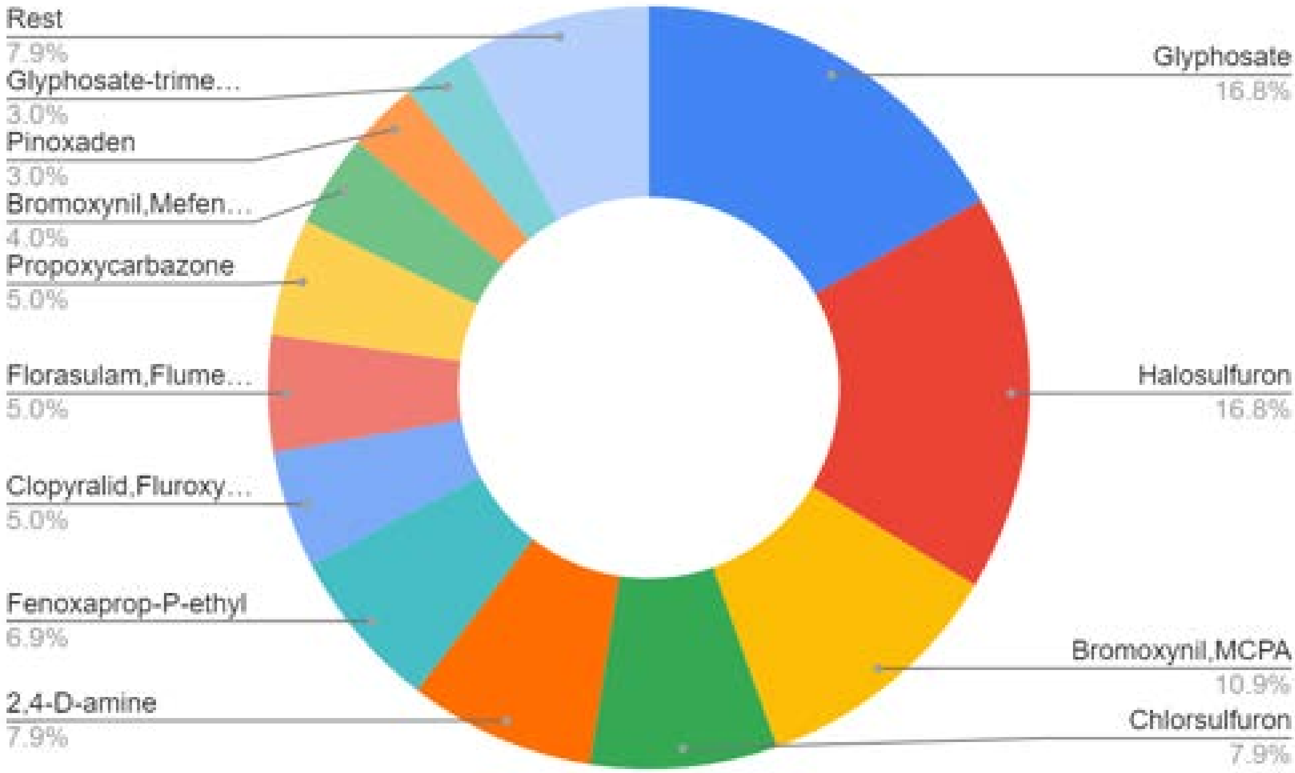


Figure 28: Active ingredients used on wheat in 2022
Source: Demeter Dynamics (Pty), 2022

Figure 29 presents the cost components for producing wheat in 2023. Wheat farmers spend an estimated KES 38,650 per acre to produce wheat. Hire of machinery and fertiliser were the top two most significant cost components in wheat production. Farmers emphasised the necessity of glyphosate herbicides for wheat production, stating that without glyphosate, weeds would outcompete the crop, leading to significant losses. Herbicide expenditure made up about 8% of the total production cost, but this contribution differed by the scale of production due to the different products used and the mode of application.

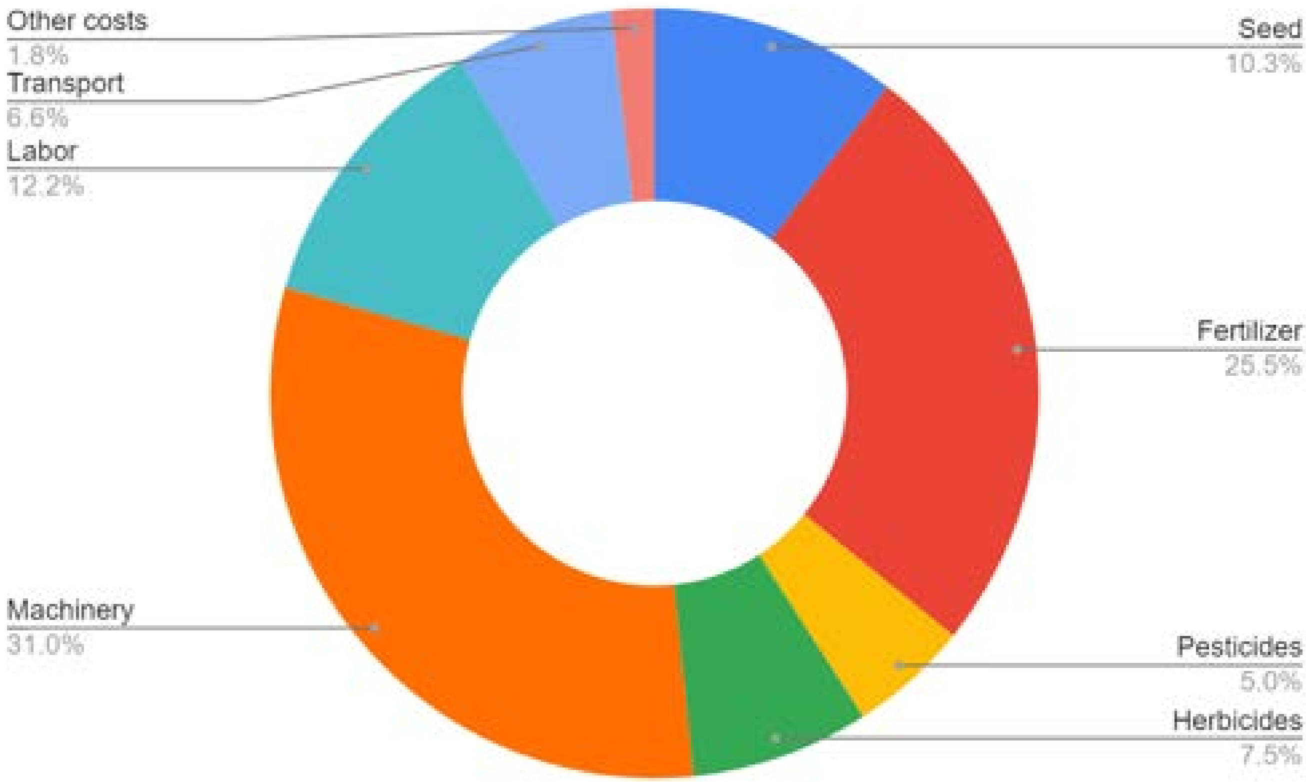


Figure 29: Breakdown of the cost of production of wheat production in Kenya
Source: FGD sessions

6. Conclusion and recommendations

This study underscores the growing importance of herbicides, particularly glyphosate, in Kenya's maize, wheat, and rice production systems. While herbicide use remains relatively low compared to global standards, its adoption is steadily increasing due to its role in enhancing land and labour productivity, reducing production costs, and enabling conservation agriculture practices.

Glyphosate emerged as the most widely used active ingredient, accounting for 45% of all herbicide products sold in Kenya in 2022. Its use is especially critical in wheat production, where farmers reported that its absence would make wheat cultivation economically unviable. In maize and rice systems, glyphosate contributes significantly to labour savings and cost reductions of 7% in maize and 33% in rice, particularly during land preparation and early weed control stages.

Despite these benefits, the study also highlights several challenges:

- Limited access to unbiased, science-based information due to weakened public extension services.
- Inconsistent adoption of safe handling and disposal practices.
- Concerns about environmental and health risks associated with herbicide use.

Farmers rely heavily on agro-dealers and agrochemical company representatives for herbicide-related information, which may not always align with best agronomic practices. There is a clear need for more robust, independent support systems to guide safe and effective herbicide use.

Recommendations to industry and government

- Strengthen extension services

Revitalise public extension systems through increased government investment and strategic partnerships with the private sector. This will ensure farmers receive consistent, science-based guidance on herbicide use, safety, and integrated weed management.

- Promote integrated weed management (IWM)

Encourage farmers to adopt IWM practices that combine herbicides with cultural, mechanical, and biological weed control methods. This approach reduces herbicide dependency, mitigates resistance risks, and enhances long-term sustainability. Industry's launch of the Sustainable Pesticide Management Framework (SPMF) in collaboration with government bodies and civil society is a step in the right direction.

- Enhance farmer training and awareness

Develop targeted training programmes for farmers, farm workers, and service providers on safe herbicide application, dosage calibration, protective equipment use, and container disposal. These programmes should be inclusive and accessible, especially for smallholder farmers.

- Improve access to reliable information

Establish platforms for disseminating unbiased, locally relevant agronomic information. This could include community demonstration plots, and farmer field schools.

- Support safe disposal initiatives

Scale up industry-led container recycling programmes to include smallholder farmers. Introduce incentives and infrastructure for safe disposal of pesticide containers, especially in rural areas.

- Safeguard environmental and human health

Promote research and innovation in low-toxicity herbicide alternatives and precision application technologies. Encourage practices that protect soil health, water quality, and biodiversity.

By implementing these recommendations, Kenya can harness the benefits of herbicides while safeguarding human health and the environment, advancing toward a more resilient and sustainable agricultural future.

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8. Annexes

Annex Table 1: Rice production cost comparison, 2023 (KES/acre)

	Herbicide users	Non-herbicide users
Seed	2,600	2,600
Fertilizer	5,820	5,820
Pesticides	910	910
Herbicides	2,550	
Machinery	13,500	14,500
Labor	15,900	23,900
Transport	7,600	8,200
Other costs	1,250	1,350
Water fee	20,000	20,000
Total production cost per acre	**70,130**	**77,280**

Annex Table 2: Breakdown of labour costs per acre for rice production (KES/acre)

	Herbicide users	Non-herbicide users
Land preparation	1,300	4,800
Nursery	1,000	1,000
Planting	7,200	7,200
Weeding	300	4,800
Other crop management	1,100	1,100
Bird scarring	5,000	5,000
Total Labour per acre	**15,900**	**23,900**

Annex Table 3: Maize production cost comparison, 2023 (KES/acre)

	Herbicide users	Non-herbicide users
Seed	2,250	2,500
Fertilizer	14,280	14,280
Pesticides	1,600	1,600
Herbicides	4,075	0
Machinery	9,800	12,650
Labour	13,300	18,050
Transport	2,400	2,400
Other costs	2,000	2,000

Total production cost per acre	**49,705**	**53,480**

Annex Table 4: Breakdown of labour costs per acre for maize production (KES/acre)

	Herbicide users	**Non-Herbicide users**
Land preparation	500	2,500
Planting	1,600	4,000
Other crop management	800	800
Harvesting	10,400	10,750
Total Labour per acre	**13,300**	**18,050**

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